THE EFFECTS OF NEW AIR MODELING STANDARDS ON LANDFILL GAS PROJECTS

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ABSTRACT

The U.S. Environmental Protection Agency (EPA) recently published new ambient standards for air quality modeling for Clean Air Act (CAA) permitting. These include additional short-term (i.e., hourly) standards for nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) as well as a new 24-hour standard for particulate less than 2.5 microns ($PM_{2.5}$). $PM_{2.5}$ has now become an official regulated pollutant under the CAA, and no longer can PM less than 10 microns (PM_{10}) be used as a surrogate. These standards are proving very stringent and difficult to meet during federal Prevention of Significant Deterioration (PSD) and federal/state New Source Review (NSR) modeling. This has affected the permitting of new and expanded landfill gas (LFG) to energy (LFGTE) projects as well as LFG flares and other common emission sources at landfills (e.g., diesel engines, fugitive dust sources, etc.).

BACKGROUND ON AIR MODELING

Introduction

Atmospheric dispersion modeling is the mathematical simulation of the dispersion of air pollutants in the atmosphere. Modeling uses computer programs that solve the mathematical equations, which simulate the pollutant dispersion. The dispersion models calculate the concentration of air pollutants at specified receptor locations due to emissions from sources such as industrial plants, vehicular traffic or accidental chemical releases, including landfills and LFGTE projects.

Air modeling is a tool used to demonstrate that a new facility or a modification to an existing facility neither causes nor contributes to the violation of an air quality standard. EPA requires modeling for permitting of new major sources and major modifications under the CAA. State and local regulatory agencies may also require smaller sources and non-major modifications to do modeling. Models used for regulatory purposes go through lengthy development and validation procedures, and then are updated as necessary during their use.

History

For the better part of a century, if not longer, mathematical relationships have been used to calculate the dilution of gaseous materials in the atmosphere. Studies by Taylor and Richardson (Taylor, 1915) and subsequent work in the 1920s were based on a classical mathematics diffusion approach. Sutton, in his paper "A Theory on Eddy Diffusion in the Atmosphere" (Sutton, 1931) observed that eddies behaved differently with downwind distance, and incorporated empirical observation into his mathematical approach.

The worst air pollution episode in United States history occurred in October 1948 in Donora (near Pittsburgh), Pennsylvania (Lowitz, 2007). Twenty people died and over 7,000 were hospitalized or had air pollution-related illnesses due to an airborne release of contaminants. In December 1952, 4,000 excess deaths in London, England were attributed to an air pollution episode (Stobbs, 2012). Stagnant meteorological conditions associated with an inversion, along with high levels of combustion-related pollutants, were the culprit in both cases.

Scientists, manufacturers and government agencies have been able to reduce pollutant emissions, but not alter meteorology. Therefore, tools were needed to predict the level of emissions reduction necessary to ensure public health while accounting for the effects of meteorology. Dispersion models are one of those tools.

In the 1960s, Briggs developed his methodology for predicting plume rise and downwind concentrations based on Gaussian relationships (Briggs 1969). Gaussian principles were applicable to buoyant and neutral density plumes, which encompassed most industrial exhausts. Turner and others (Turner, 1986) added to the development of predictive atmospheric dispersion models.

The Air Quality Act of 1967, under the Department of Health, Education and Welfare, designated air quality regions throughout the United States and set forth the responsibility of adopting and enforcing air pollution control standards. The CAA of 1970 created nationalized air quality standards and provided deadlines for compliance (Rogers, 1990). The CAA was amended in 1977 and again in 1990. Modeling standards and guidance have also changed over time.

Dispersion Models

The earliest models supported single point source releases and calculated ground level concentrations for an array of wind speeds and atmospheric turbulence conditions. In 1973, EPA released PTMAX, a computer program to calculate the maximum impact from a single point source. PTDIS and PTPLU were later added to what EPA termed the User's Network for Applied Modeling of Air Pollution (UNAMAP) programs (Turner, 1986). Model inputs included stack height, diameter, stack exit velocity, and exhaust gas temperature. Ambient temperature and downwind receptor distances were also input by the user. Concentrations were calculated for a one-hour averaging time, and EPA scaling factors were applied to estimate the concentration for other time intervals.

In the ensuing years, a number of new dispersion models were developed by contractors funded through EPA. Models were developed to: simulate line sources such as roads; calculate concentrations in complex terrain; calculate concentrations from area and volume sources; and calculate concentrations from multiple sources. Other types of models were developed to calculate concentrations from dense gases and to estimate concentrations of hazardous and toxic substances. Instead of a steady plume, models using a series of simulated puffs were developed to better simulate different source release conditions. Some were used for emergency response, while others were applied to regulatory CAA programs.

The Industrial Source Complex (ISC) model (EPA, 1995) was originally developed in the 1970s to incorporate multiple point, area and volume sources into one package capable of calculating concentrations in simple or complex terrain. Hourly historic meteorological surface and upper air data were preprocessed separate from the actual running of the model. A variety of output options was available, including concentrations for periods ranging from one-hour to annual, and for various source groups. Ground level and flagpole receptor options were available. ISC became an EPA regulatory model and was used for the majority of regulatory modeling under the CAA until recently.

In 1991, EPA began the development of the AERMOD dispersion modeling system. It took 14 years, until December 2005, before AERMOD finally replaced ISC as the EPA's regulatory model (EPA, 2004). AERMOD consists of three integrated modules, has more complex inputs than ISC, and better simulates plume flow over and around obstacles, at the inversion boundary, and over various land surfaces. Land use data are incorporated with the surface and upper air meteorological processing, which, like ISC, is performed prior to running the dispersion model. AERMOD is the current regulatory model for CAA permitting at the federal level and most state and local jurisdictions. At the time of this writing, AERMOD was last updated by EPA on the 353rd day of 2011 (Version 11353).

AERMOD is a steady-state dispersion model with a range of 50 kilometers (km). It handles stationary point, area, and volume sources. Special source types, including open pit and poly-area are also handled by AERMOD. It is capable of incorporating facility operating schedules. Time intervals range from one-hour to annual, or through the period of available meteorological data. A number of private vendors have developed user-friendly input and output interfaces for AERMOD. Some of the features and capabilities of AERMOD are:

- Source types: Multiple point, area and volume sources.
- Source releases: Surface, near surface and elevated sources.
- Source locations: Urban or rural locations. Urban effects are scaled by population.
- Plume types: Continuous, buoyant plumes.
- Plume deposition: Dry or wet deposition of particulates and/or gases.
- Plume dispersion treatment: Gaussian model treatment in horizontal and in vertical for stable atmospheres. Non-Gaussian treatment in vertical for unstable atmospheres.
- Terrain types: Simple or complex terrain.
- Building effects: Handled by PRIME downwash algorithms.
- Meteorology data height levels: Accepts meteorology data from multiple heights.
- Meteorological data profiles: Vertical profiles of wind, turbulence and temperature are created.

AERMOD uses a meteorological preprocessor, AERMET, to process hourly surface meteorological data and upper air soundings. AERSURFACE provides the surface characteristics necessary to calculate atmospheric parameters.

With hourly meteorological inputs, calm readings that occurred at the time data was used resulted in a shortened dataset for processing. AERMINUTE, introduced on the

53rd day of 2011 and last updated on the 325th day of the year (Version 11325), uses shorter time intervals, resulting in fewer calms. AERMOD also includes PRIME (Plume Rise Model Enhancements), which is an algorithm for modeling the effects of downwash created by the pollution plume flowing over nearby structures.

The AERMAP processor provides the physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

REGULATORY REQUIREMENTS

NAAQS

National Ambient Air Quality Standards (NAAQS) are standards established by the EPA (42 United States Code 7401 et. seq.) that apply to outdoor air throughout the country. Each state has the ability to establish its own standards, provided they are equal to, or more stringent than, the NAAQS. The pollutants regulated are called "criteria pollutants." There are three classes of NAAQS:

- Class I – National parks and other designated pristine areas.
- Class II - Most of the country, including residential and urban areas.
- Class III – Designated heavy industrial areas. There have been no designated Class III areas as of the writing of this paper.

Two types of Class II standards were established: Primary and Secondary. Primary standards are designed to protect human health with an adequate margin of safety, including sensitive populations such as children, the elderly, and individuals suffering from respiratory diseases. Secondary standards are designed to protect public welfare from any known or anticipated adverse effects of a pollutant. An area meeting a given standard is known as an "attainment area" for that particular standard and otherwise a "non-attainment area," when standards are not met. The standards are listed in Title 40 of the Code of Federal Regulations (CFR) Part 50. Table 1 (attached) shows the primary NAAQS.

Regulatory Modeling Requirements

The requirements that trigger modeling are different depending on the state or regulatory jurisdiction. The EPA requires modeling be performed for major sources or major modifications. Major sources in attainment areas include those emitting 250 tons per year (tpy) of a criteria pollutant, although a 100-tpy threshold applies for 28 specified source categories. These attainment area major sources trigger modeling under the federal PSD program. Major source thresholds in non-attainment areas vary by pollutant and non-attainment status and range between 100 and 10 tpy. Major sources in non-attainment trigger modeling under the non-attainment NSR program.

A major modification is a project at an existing major source which causes an emissions increase as well as a net emissions increase above so-called "significance levels," which include 100 tpy carbon monoxide (CO); 50 tpy non-methane organic compounds (NMOCs); 40 tpy NO_x, volatile organic compounds (VOCs), or SO_2; 15 tpy PM_{10}; or 10 tpy $PM_{2.5}$. The significance levels are even lower in certain non-attainment areas. Note that there are no ambient standards directly applied to NMOCs or VOCs; therefore, no modeling of those pollutants is required under federal PSD or NSR.

Modeling under PSD or NSR is used to demonstrate compliance with ambient air quality standards (AAQS). The compliance demonstration includes not only impacts from the source being considered, but also background air quality and the contribution from nearby sources. State and local air agencies may require modeling for sources with emissions that are less than the major source threshold. State and local agencies may also set ambient air quality standards that are more stringent than the federal standards. It is critical to know the standards and modeling guidelines in every jurisdiction where a project is being considered.

EPA modeling guidance is provided in Appendix W to 40 CFR, Part 51 - Guideline on Air Quality Models, which was last updated on December 30, 2005. Although EPA has a number of suggested approaches for addressing the new standards through modeling, Appendix W has not been updated to incorporate modeling for those new standards. EPA guidance on the new standards is available but is ever-evolving through precedent and trial and error. The current EPA guidances on the new standards are listed below:

- PSD implementation of one-hour NO_2 NAAQS , one-hour NO_2 Significant Impact Level (SIL) and tie to 40 CFR Part 51 Appendix W http://www.epa.gov/nsr/documents/20100629no2guidance.pdf
- PSD implementation of one-hour SO_2 NAAQS , one-hour SO_2 SIL and tie to 40 CFR Part 51 Appendix W http://www.epa.gov/region07/air/nsr/nsrmemos/appwso2.pdf
- 24-hr $PM_{2.5}$ NAAQS modeled attainment test and modeling procedures http://www.epa.gov/ttn/scram/guidance/guide/Update_to_the_24-hour_PM25_Modeled_Attainment_Test.pdf

http://www.epa.gov/scram001/Official%20Signed%20Modeling%20Proc%20for%20Demo%20Compli%20w%20PM2.5.pdf

Sources with emissions that trigger PSD requirements have additional criteria to satisfy. In addition to meeting ambient air quality standards, those sources must also not consume more increment than allowed. The increment consumption analysis does not include background, but does include impacts from other significant PSD sources. A source must demonstrate compliance with both AAQS and increment standards to pass PSD modeling.

Finally, modeling is required to demonstrate that there are no adverse impacts to protected or Class I areas. Such a demonstration may include not only showing compliance with Class I AAQS and increments, but also that visibility impairment and adverse effects to water, soil, fauna and flora are below specified thresholds. The Federal Land Manager has recently revised guidelines to address Class I areas (National Park Service, 2010).

LANDFILL AIR MODELING CHALLENGES

Landfills with or without an energy plant can be challenging to model. The following highlights a few of the aspects of landfill modeling that need to be considered in air dispersion modeling.

Landfill Size

Landfills are large, typically several hundred to several thousand acres; therefore, receptor grids out to the significant impact area (SIA) may constitute many thousands of receptor points. AERMAP, the terrain processor, may take one or more full days to run, as can AERMOD. For AERMOD, using the non-regulatory option, FASTALL, may shorten runtime by half or more. Final modeling runs for regulatory agency submittal should be made without this option, since it takes longer to run. Partitioning receptors using a multi-core processor also will reduce AERMOD runtime. Unfortunately, at the time of this writing there is no similar feature to reduce AERMAP processing time.

Terrain

Many landfills are located in rugged or complex terrain. While it may be convenient from a design and operational perspective to fill a canyon with trash, model results can be high due to plume impacts in elevated terrain relatively close to the source. Prior to finalizing the location of an energy project or even a flare station, preliminary modeling should be conducted to see if there are potential terrain impacts causing problems with meeting the standards.

Location within the Landfill

Energy plants and other stationary sources are located on geologically stable native soil, typically near the landfill boundary, leaving little space for dispersion to take effect before the plume leaves the site. Nearby structures such as the generator building or the maintenance building can cause downwash, resulting in high impacts at the landfill boundary. Taller stacks, reduced building height or relocating the energy plant away from other structures, where feasible, can help. Putting the LFG-fired engines or turbines in low-profile modules rather inside a building is one way downwash has been reduced.

Landfill Sources

Landfill sources, including diesel tippers, diesel emergency generators, diesel light plants, diesel-powered wood and asphalt grinders, and fugitive dust from roads and material handling activities can produce high impacts near the landfill boundary. Also, many of these sources produce maximum short-term emissions, which can have an adverse effect on compliance with the new hourly or daily standards. Accurately representing each source, including emissions, operating hours, and release characteristics, can help. Representing engines that move about the active landfill areas as area or volume sources may better represent source conditions than arbitrarily selecting a single point.

Nearby Sources

For regulatory modeling, nearby sources that might have significant impacts within the SIA must be considered. Typically sources within 50 km of the SIA are considered, and smaller sources are eliminated based on a function of their emissions and distance. The regulatory air quality agency can usually provide a list of potential sources. If the landfill is located near a state line, the air agency of the nearby state or states may need to be contacted to obtain additional sources for consideration. Often source information such as location, emission rates and stack parameters is not complete or may be inaccurate, and further time-consuming investigation is required. Violations from nearby sources may be predicted, especially if they were permitted prior to the implementation of the new one-hour NO_2 and SO_2 standards. Using the source contribution feature, MAXDCONT (in the latest version of AERMOD) may help. Otherwise it may be necessary to discuss the violations of a standard by others with the agency.

Meteorological Data

Often onsite meteorological data are not available, and a suitable meteorological monitoring station may be quite a few kilometers from the landfill, and thus deemed not representative. Meteorological data must be deemed spatially and temporally representative. Nearby meteorological stations may not be considered representative at some project locations due to intervening terrain, ridges or large water bodies that can influence air flow. On the other hand, where there are no such geographic features, representative meteorological stations can be dozens of kilometers from the project.

If a representative meteorological station is not readily available, or if the data are not of suitable quality (e.g., too many calms, missing parameters or missing data), the applicant should look for small airports, military facilities or other nearby industrial facilities for representative meteorological data. Note that typically airport data have a high percentage of calm hours because a key safety concern is during high winds and gusts, and not at times of low wind speeds. Thus, the threshold wind speed typically is set higher for airports than for most regulatory monitoring stations. This may result in poor dispersion characteristics, particularly for the shot-term averaging periods.

A suitable dataset may even be constructed from several nearby monitoring stations. For example, for one project, temperature data were obtained from a nearby power plant, and wind data were obtained from a location being considered for wind turbines. The power plant used temperature information to manage its combustion processes, and the potential wind turbine developer wanted wind speed, direction and persistence information prior to investing in the proposed energy project. The state or local air agency may have access to suitable meteorological data, and should be consulted prior to constructing and operating an onsite meteorological station. In absence of representative data, a regulatory agency can require the use of screening data, which is very conservative, or require the installation of an onsite meteorological station that will cause project delays and costs.

Background Air Quality

It has been our experience that regulatory agencies have monitoring stations throughout the state or district, and can provide background air quality data. The modeler needs to be careful when it comes to obtaining background air quality data for one-hour NO_2, one-hour SO_2 and 24-hour $PM_{2.5}$. The form of these standards is different from that or other standards. A similar form should be used for the background.

New 1-hour NO_2 and SO_2 Standards

The new one-hour NO_2 and SO_2 standards are very stringent. The annual NO_2 standard is 53 parts per billion by volume (ppb) and the new 1-hour standard is 100 ppb, or 1.9 times the annual standard. EPA established concentration scaling factors, as described in the "SCREEN3 Model User's Guide" (EPA, 1995) for estimating concentrations for averaging times ranging from one-hour to a full year. In applying the EPA's scaling factor, the one-hour concentration from a source should be 12.5 times (1,250 percent) higher than the annual concentration. Based on that, the new one-hour NO_2 standard, at 1.9 times the annual standard (190 percent), is substantially more restrictive. Note that this is not an exact comparison since the new one-hour standard is based on the 98th percentile of the highest daily one-hour concentration averaged over a three-year period.

Following a similar rationale, the new one-hour SO_2 standard at 75 ppb is similarly restrictive, given that the annual standard was 140 ppb. Again, the form of the standard is different with the new one-hour standard based on the 99th percentile of the highest daily one-hour concentration averaged over a three-year period.

New $PM_{2.5}$ Standards

The new $PM_{2.5}$ standards are stringent, particularly when considering natural gas combustion sources where virtually all PM is $PM_{2.5}$. The 24-hour PM_{10} standard is 150 µg/m^3, and the 24-hour $PM_{2.5}$ standard is 50 µg/m^3, or three times lower. Yet all PM from LFG combustion is $PM_{2.5}$, so in effect the new requirement is three times more stringent. In addition, some states require that secondary $PM_{2.5}$ formation from emissions of NO_2 and SO_2 be considered, which causes additional contribution to the $PM_{2.5}$. Further, if the $PM_{2.5}$ component of fugitive dust must also be modeled, the new standard is even more restrictive.

Hazardous Air Pollutants

Some states require that hazardous air pollutants (HAP), or toxics, be modeled from a health risk perspective. Pollutants to be considered from LFG combustion include formaldehyde and hydrogen chloride, as well as the various organic toxic compounds in the LFG. Fugitive HAPs and hydrogen sulfide from the landfill may also need to be modeled. The modeler must be knowledgeable of the HAP requirements of the state or district in which the landfill is located.

EXAMPLE PROJECTS

Midwest Landfill

A Midwest landfill currently produces LFG to power eight LFG engine/generator sets (gensets). Recently, a permit application was submitted for an additional ten gensets. The addition of those gensets made the facility a major PSD source for NO_x and CO. Modeling was also required for pollutants with emissions above the significant emissions rate (SER). Thus PM_{10} and SO_2 modeling was also required. At the time of the application, the state had not yet incorporated $PM_{2.5}$ into their state implementation plan (SIP), so $PM_{2.5}$ modeling was not required.

The landfill is located in relatively flat, or simple, terrain. Thus five years of representative meteorological data from the nearby airport was deemed acceptable. Figure 1 is an aerial photograph showing the location of the landfill, the airport and intervening terrain.

Using AERMOD, the SIA was obtained for project sources. For most pollutants and averaging time periods, the Radius of Impact (ROI) was several kilometers or less. However, for the new one-hour NO_2 and SO_2 standards, the ROI was dozens of kilometers. Worse, impacts from the existing energy plant were predicted to exceed the one-hour NO_2 standard. (Note that the one-hour NO_2 standard was effective April 12, 2010, and the existing energy facility was permitted in 2000 and constructed in 2001.)

Modeling was conducted to determine the most effective way to bring the existing energy plant into compliance. Each genset had its own exhaust stack. Various strategies were tested: reduce emissions, increase the stack heights, move nearby structures to reduce downwash and use a combined chimney. The most cost-effective solution was to use a combined chimney.

The proposed power plant also was predicted to have impacts approaching the one-hour NO_2 standard. This might be problematic when background and impacts from nearby sources are added. Various scenarios were examined, including using a combined chimney and re-alignment of the facility. The original design had ten individual genset stacks aligned east to west. When the plant was rotated 90 degrees, the model results were much lower. A combined chimney also showed lower impacts, but rotating the proposed facility proved the most cost-effective option.

NAAQS and PSD modeling require the inclusion of nearby sources that have a significant impact within the ROI. Dozens of sources were identified as having potentially significant impacts within the ROI, and were included in the modeling analysis. Several of these sources, permitted prior to the one-hour NO_2 standard, were shown to violate that standard.

AERMOD, Version 11059, contains output option “MAXDCONT”. This option facilitates comparison of impacts for various source groups. MAXDCONT was invoked to list the contribution from the facility for each hour and receptor where an exceedance was predicted. For each receptor over the entire five-year period of meteorological data processed (43,824 hours and over 10,000 receptors), there were no instances when and where the facility’s impacts were significant at the same receptor location and hour that an exceedance was predicted. Thus, modeling was used to help design, configure and demonstrate that this beneficial renewable energy project neither causes nor contributes to the exceedance of an ambient air quality standard.

California Landfill

The example California landfill is located within the jurisdiction of the Bay Area Air Quality Management District (BAAQMD) and accepts municipal solid waste. LFG is currently being flared to the atmosphere. An LFGTE facility consisting of up to five gensets is planned for this location. Originally six gensets were desired; however, modeling standards could not be met for the six units, so the project was reduced to five. The proposed facility is located several kilometers from the San Francisco Bay, at approximately 10 feet above mean sea level (msl). Within several kilometers to the west and northeast are areas of elevated terrain.

Whereas the terrain in the vicinity of the Midwest landfill was relatively flat, the surrounding terrain in the vicinity of the California landfill created challenges more typically associated with landfills in the Western United States. Modeling challenges for the California landfill LFGTE facility included plume centerline impacts in elevated terrain, channeling of airflow due to terrain, and coastal influences.

For locations similar to the Midwest landfill, representative meteorological monitoring stations can be located a dozen or more kilometers from the project location. However, finding a representative meteorological station in areas with terrain influences can be much more difficult. Fortunately a small airfield is located adjacent to the landfill. A Federal Aviation Administration (FAA) Automated Surface Observing System (ASOS) meteorological station has been collecting meteorological data at the airfield for several years now. The monitoring station is located less than 2 kilometers from the proposed LFGTE facility, at approximately the same elevation and with no intervening terrain. After considerable analysis and negotiation with BAAQMD meteorologists, the FAA station has been deemed representative for the purpose of PSD modeling. Figure 2 shows the relationship between the proposed LFGTE facility and airfield.

Preliminary modeling to determine the SIA was conducted using AERMOD. Due to elevated terrain and channeling, the SIA for various pollutants and averaging times was larger than for similar facilities in relatively flat terrain.

An observed trend of the LFG was increased hydrogen sulfide (H_2S) concentration with time. Therefore, one of the goals of this project was to maximize the SO_2 emissions while still complying with the one-hour SO_2 standard. To accomplish this, modeling was used to determine the optimum plant configuration. Key considerations were: exhaust stack height, stack orientation (south-north or west-east) and downwash. Each played a role in obtaining the best facility configuration.

Increasing stack height increases dispersion, and generally reduces impacts. The design stack height was 30 feet above grade plus three feet, two inches for the silencer, for a total of 33 feet, two inches above grade. However, the benefits of increasing the stack height above 40 feet were marginal due to the plume impacting in elevated terrain. Furthermore, increasing the stack height also increased the SIA, resulting in the need to include additional nearby sources in the analysis. Based on modeling results, stack height was maintained at 33 feet, two inches.

The initial design had five stacks in a line from west to east along the northern side of the generator building. Along the North American west coast, the prevailing winds are generally onshore from the Pacific Ocean in the west. The Petaluma Gap creates a channel that steers the winds from the north, near Petaluma, in a southerly direction towards San Pedro Bay. The airfield wind rose, shown in Figure 3, shows the frequency and direction from which wind was blowing for the period of January 1, 2008 through December 31, 2009. Modeling was conducted with the stacks in a north to south orientation along the eastern wall of the generator building, and more favorable results were obtained.

Generator building design typically calls for a 20-foot single-story building, with a four-foot parapet wall on the roof for aesthetics. When the downwash option was removed from test model runs, results were lower. Therefore, additional test runs were made with a lower building and the elimination of the parapet wall. Maintenance and access considerations required a building of at least 17 feet. An optimal building height of 18.5 feet was decided based on modeling and operational considerations.

Modeling has shown that the proposed LFGTE facility can comply with applicable ambient air quality standards. Currently the project developers are working through other design and regulatory issues, with construction pending their resolution.

Oregon Landfill

The expansion of a landfill located in the northwestern United States triggered State modeling requirements due to increased fugitive PM_{10} emissions. Fugitive emissions, while not regulated by EPA, may be regulated by state and local agencies. Further, in this case the State agency required that not only the impact on the AAQS, but also on the PSD increment, be assessed. Increased emissions included emissions from development of new active landfill areas, additional stockpiling of soils and cover material, a rail yard facility, and additional haul road traffic. Although this project occurred in 2004, prior to designation of AERMOD as a regulatory model, AERMOD was required.

The landfill was located in a rural setting, quite a distance from an established meteorological station. A number of emission sources, including the main haul road, unpaved roads, and a rail car unloading facility, were located near a public road just outside the facility boundary.

Initially, modeling was attempted using ISC and a synthetic meteorological dataset. The results were unacceptably high, and since ISC was not the model of choice by the agency, further pursuit of this option was not considered.

At the time of this project, AERSCREEN, the version of AERMOD that uses a synthetic meteorological dataset, was not available. Representative surface meteorological data were also not available. A workable meteorological dataset was constructed using wind data from instrumentation at the location of a proposed wind farm and temperature data from a power plant (Figure 4). Both locations were more than a dozen kilometers from the landfill, and marginally representative. After examining surface characteristics, intervening geographical features, and regional climatological data, the proposed meteorological data were deemed suitable for this project. A subsequent LFGTE facility was permitted (including modeling) and constructed, with the condition that an onsite meteorological monitoring station be constructed to demonstrate compliance for the energy project, and for future projects. This has been successfully completed.

Problematic as the meteorological data was, the proximity of emission sources to a public road proved to be even more problematic. Haul road emissions were simulated as a series of area sources with a length to width ratio of no greater than 10:1. Area sources were also created to account for emissions from soil and material handling.

Initial modeling runs predicted the 24-hour PM_{10} increment would be exceeded. Mitigation measures were applied, including paving some roads and work areas, initiating increased watering, and moving some activities farther away from the boundary. This helped, but still did not satisfy the increment. Also, the model required almost two days to process one year of meteorological data on the fastest available modeling computer, which limited the frequency of testing various scenarios.

In an attempt to identify the highest contributors, modeling was done for the highest receptor only, and each source was its own source group. Several road segments of the paved haul road entering the landfill that were nearest the boundary were identified as being the most significant contributors at the maximum receptor. It was also observed that the results were lower with a single receptor than when all receptors were included in the model run. This observation was brought to the attention of the agency, and receptors which showed exceedances were evaluated separately.

The project was successful as a result of crafting an acceptable meteorological dataset, identification and application of relatively costly mitigation measures to problematic sources, and working around model developmental issues. Subsequently, a model update was released by EPA that corrected the AERMOD problem. Although modeling was able to show compliance with the 24-hour PM_{10} standard, future modeling at the site against the new 24-hour $PM_{2.5}$ standard will be even more difficult and may require additional facility modifications to reduce dust and other particulate emissions.

IMPLICATIONS ON FUTURE PROJECTS

Clearly, the world of regulatory air dispersion modeling has changed significantly with these new standards. What used to be accomplished using conservative screening models or refined modeling in default mode has now become a significant task for the permitting of LFG projects.

In summary, the new modeling standards are more stringent, and the modeling requirements are much more complex, than in the past. The short-term nature of the standards allows for less flexibility in terms of accepting emission limits or utilizing long-term average meteorological data. As such, worst-case modeling results compared to stringent modeling standards result in a very difficult situation in which to achieve compliance.

Landfill owner/operators and project developers must be prepared to face the difficulties in meeting these standards. Pre-planning is critical, including conducting preliminary modeling to assess potential compliance early on in the process. Modeling efforts should be started right away, since they can be the most time-consuming of the various steps necessary for air permitting, It will also let you know up front whether the design of the project will have to be altered to comply with the modeling criteria.

A high level of modeling expertise will be necessary to not only understand how to manipulate the models, but also to negotiate with regulatory agencies, which are just starting to understand these new standards themselves. A lot of trial and error may be necessary to discover what modeling solutions will be workable on a case-by-case basis. As such, the modeling team will be more critical to the overall success of the project than ever before.

A permittee must also be prepared to alter their project in some way to pass the modeling criteria. This may be a simple facility modification with minimal cost, but could also be a major project change that severely impacts the project economics. In the end, the permittee may have to resign themselves that the project as originally conceived is not permittable.

Finally, because of the newness of the standards and guidance, new precedents are constantly being set. EPA and state/local regulatory agencies are discovering the difficulties with these standards, and some are devising workarounds and flexible options for compliance. It is prudent to keep abreast of these developments, so that you will be up-to-speed on any new development that will assist your modeling efforts. It is also important to work closely with the modeling staff from the regulatory agency in whose jurisdiction you are working.

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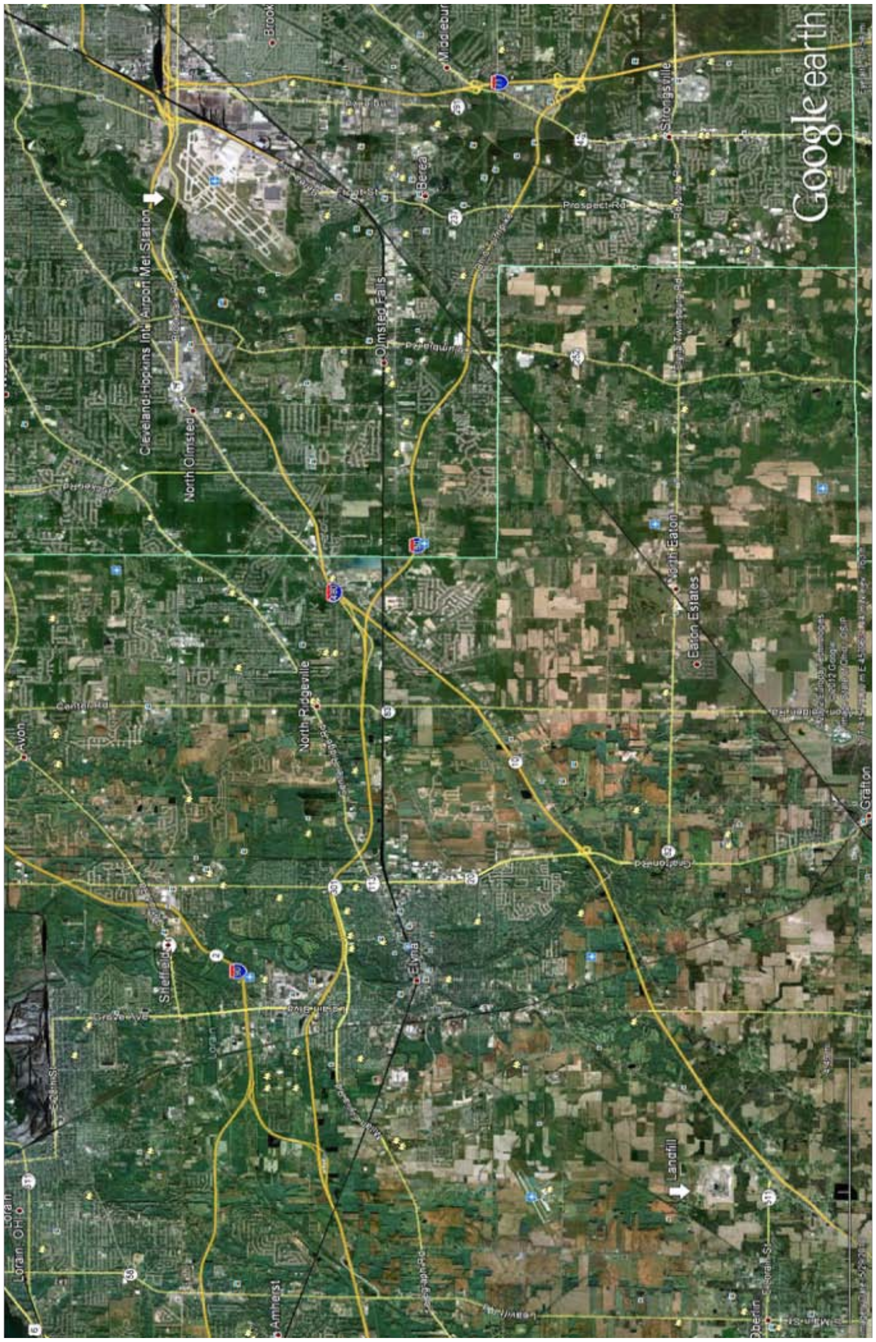
TABLE 1. NAAQS PRIMARY STANDARDS FOR MODELING

NAAQS Primary Standards **40 CFR Part 50**		
Pollutant	**Standard**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour[1]
	35 ppm (40 mg/m^3)	1-hour[1]
Nitrogen Dioxide	53 ppb (100 µg/m^3)[2]	Annual (Arithmetic Average)
	100 ppb (188 µg/m^3)	1-hour[3]
PM_{10}	(150 µg/m^3)	24-hour[4]
$PM_{2.5}$	(15 µg/m^3)	Annual (Arithmetic Average)[5]
	(35 µg/m^3)	24-hour[6]
Sulfur Dioxide	0.03 ppm (1971 std)[7]	Annual (Arithmetic Average)
	0.14 ppm (1971 std)[7]	24-hour[1]
	75 ppb[8]	1-hour

(1) Not to be exceeded more than once per year.
(2) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard
(3) To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
(4) Not to be exceeded more than once per year on average over 3 years.
(5) To attain this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.
(6) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).
(7) The 1971 sulfur dioxide standards remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated non-attainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.
(8) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

FIGURE 1. AERIAL VIEW SHOWING THE LOCATIONS OF THE MIDWEST LANDFILL AND THE NEARBY AIRPORT MET STATION



Note: Source Google Earth Aerial Photograph
Imagery Date: May 31, 2007

FIGURE 2. AIRFIELD METEOROLOGICAL MONITORING STATION LOCATION NEAR CALIFORNIA LANDFILL

Note: Source Google Earth Aerial Photograph
Imagery Date: May 31, 2007

FIGURE 3. CALIFORNIA AIRFIELD WIND ROSE FOR 2008 AND 2009

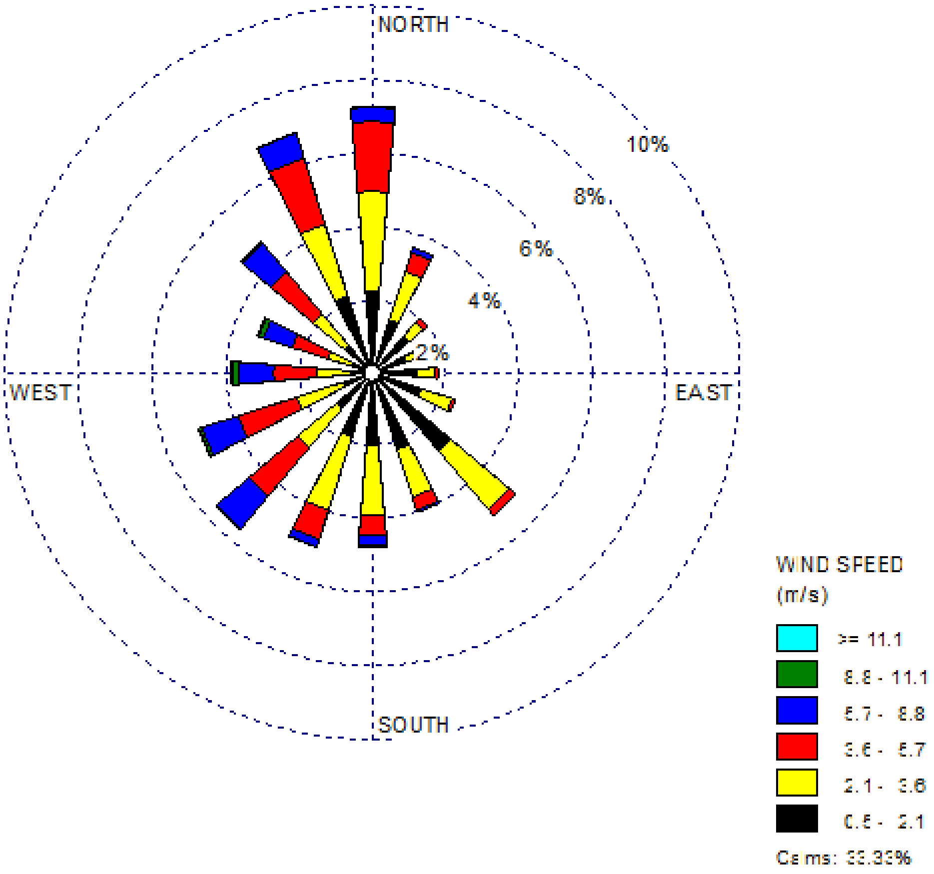
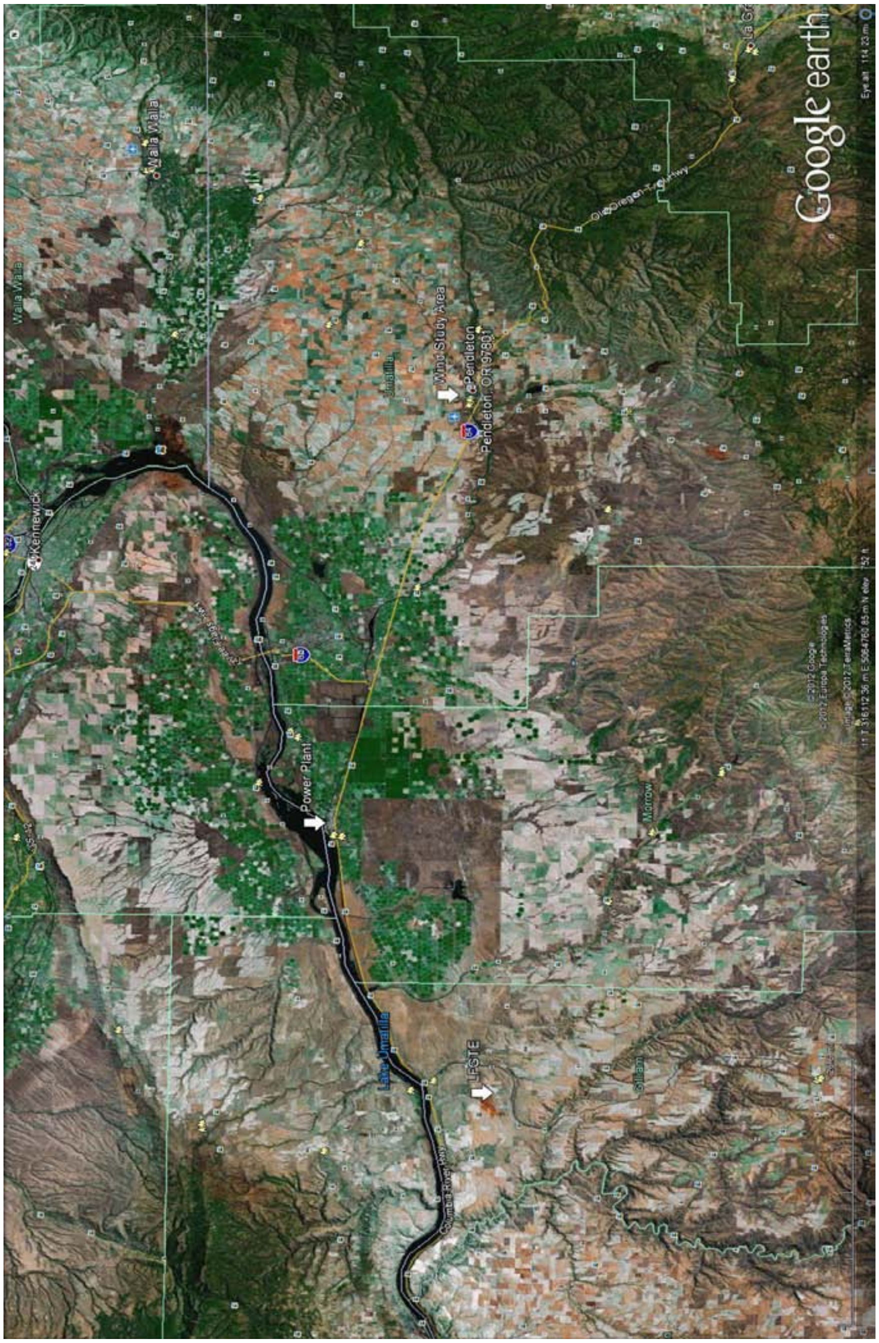


FIGURE 4. LANDFILL AND MET DATA LOCATIONS FOR OREGON LANDFILL EXPANSION PROJECT



Note: Source Google Earth Aerial Photograph
Imagery Date: 2012