

**MISSOURI**  
**DEPARTMENT OF**  
**NATURAL RESOURCES**

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# **Solid Waste Management Program**

## **Methane Gas Policy**

**June 2012**

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## APPLICABILITY OF THE GAS POLICY

This policy applies to sanitary and demolition landfills where the Solid Waste Management Program has determined there is a potential threat to public health and safety due to methane gas migration from a landfill and towards neighboring properties.

The Missouri Solid Waste Management Law and implementing regulations require landfill owners/operators control decomposition gases (methane) on site and not endanger occupants of adjacent properties. This has been a regulatory requirement from the date of the first solid waste regulations in Missouri. From their beginning, the purpose of the regulations regarding decomposition gas has been to protect public safety by requiring facilities to control the gas they generate on site. Also, since the earliest solid waste regulations were enacted, the Solid Waste Management Program was given authority to require changes to the design or operation of any landfill when it is necessary to meet this goal (as stated in section (1) General Provisions of the current regulations 10 CSR 80-3.010 and 10 CSR 80-4.010).

## METHANE GENERATION

The breakdown of solid wastes in a landfill results in the generation of methane and other decomposition gases. Landfill gas is comprised roughly of 50 percent methane and 50 percent carbon dioxide. Methane and hydrogen sulfide (a trace constituent) are the two primary constituents of concern in landfill gas. Due to its extremely small concentrations, hydrogen sulfide generation does not normally cause as great of a concern or threat to public safety as does methane gas. Methane concentrations between 5 percent and 15 percent by volume may be flammable or explosive, and higher concentrations of methane gas may pose an asphyxiation threat. Therefore, migration and accumulation of methane into buildings or other confined spaces can pose public health and safety risks. Methane may also kill vegetation (especially trees) by displacing oxygen and asphyxiating the roots.

The department necessarily has a conservative policy when addressing methane gas generation and migration. Methane migration from a landfill onto an adjacent property is a regulatory violation and is always a public safety concern because neither the landfill owner nor the state has control over current or future land uses on the adjacent property. The present situation may not appear to be a safety issue, but future development could create one. Also, it is often difficult to determine the migration pathway(s) and the volume of methane moving through the soil. Therefore, it is essential that the generation and migration of methane be closely monitored and controlled on-site. Methane migration away from the landfill and toward occupied structures on adjacent properties causes an acute threat to the public. When this situation occurs, landfill managers must take immediate action to ensure that methane generated by the decomposing waste does not cause harm to the public.

This policy is intended to clarify what is expected of landfill owners and to expedite the review process for gas control system modifications.

# 1. GAS MONITORING

## A. REGULATORY REQUIREMENTS

The subsections of the Missouri Solid Waste Management Regulations covering decomposition gas were enacted in 1988 authorizing the Solid Waste Management Program to require owner/operators of sanitary and demolition landfills to implement a methane monitoring program and submit the monitoring results to the department. Currently, 10 CSR 80-3.010(14) (B) and 10 CSR 80-4.010(14) (B) require sanitary and demolition landfill owners/operators to design and implement gas monitoring programs capable of detecting gas migration. The programs must include a narrative and plan sheets describing the monitoring program in detail. For specific types of information required to be included in the gas monitoring plan, refer to 10 CSR 80-3.010(14) (B) and 10 CSR 80-4.010(14) (B), respectively.

## B. MONITORING WELL INSTALLATION

Methane monitoring wells must be designed in accordance with the requirements of 10 CSR 23-4.060, the Construction Standards for Monitoring Wells. These requirements are discussed in the technical bulletin titled; “Design and Construction of Landfill Gas Monitoring Wells” (see publication at <http://dnr.mo.gov/pubs/pub2054.htm>).

One of the key aspects of well design is the sampling port. Each monitoring well must be equipped with a sampling port that allows connection of the monitoring instrument without removing the well cap.

In the past, landfill owners/operators have been allowed to use shallow or temporary holes (called bar hole punches) to test for landfill gas migration. This type of monitoring may provide a measurement of methane concentrations in the upper most surface layers of the soils at the landfill. However, the absence of methane in shallow probes does not necessarily mean there is no migration occurring. The use of bar hole punches may miss methane migrating in deeper soil layers (to the bottom elevation of waste). Additionally, due to the temporary nature of their construction, bar holes cannot be relied on for long term monitoring. Due to these inherent limitations, bar hole punches are not allowed for compliance monitoring. Only by monitoring to the lowest elevation of waste, using properly-constructed wells, and employing the appropriate monitoring instruments, will you be assured that your monitoring data is accurate.

The requirement to install deep monitoring wells may be waived in areas where there is a topographic cutoff or a hydrologic cutoff. An example of a topographic cutoff is a valley or ravine located between the landfill footprint and the property line, whose bottom elevation is below the bottom elevation of waste. Methane rises in soil, since it is lighter than air, except when it is under pressure. Therefore, a topographic cutoff will generally serve as an adequate barrier to gas migration. In order to demonstrate that a topographic cutoff exists, landfill owners/operators must provide proof that the elevation of the cutoff feature (ravine, valley, etc.) is below the lowest elevation of any waste. Note: all topographic interpretations of this sort are required to be made by a Missouri Registered Geologist and provided to the department for review and approval.

Methane will not migrate downward through a hydrologic cutoff such as a river or contiguous aquifer. In order to demonstrate that a hydrologic cutoff exists, landfill owners/operators must provide information that a vertically and horizontally contiguous aquifer exists between the landfill footprint and the property boundary. In most cases, the facilities should have this information on file to be able to document this allegation without further site exploration. The hydrologic information must be certified by a Missouri Registered Geologist and submitted to the department for review and approval prior to being granted a waiver for installation.

Gas monitoring wells must be located between the landfill and off-site buildings or other features that may be harmed by landfill gas or may act as conduits and allow gas from the landfill to migrate. Per 10 CSR 80-3.010(14) (B) 1.C. and CSR 80-4.010(14) (B) 1.C., well locations on the property boundary shall not be more than 500 feet (500') apart unless the landfill owner/operator can show evidence that the potential for gas migration is low. In cases where conditions necessitate additional wells to protect public health and safety, the Solid Waste Management Program may request installation of additional wells closer than 500 feet apart.

In the absence of gas wells at the property line, the Solid Waste Management Program considers the wells in between the waste mass and the property boundary to be compliance wells. These wells are where the 2.5 percent methane regulatory limit applies and is the location for landfill staff to monitor to ensure methane is not migrating out away from the waste and toward adjoining properties. If at some later date new monitoring wells are placed farther out from the waste toward the property boundary, the new wells become the compliance wells and the location is where the regulatory limit would then apply. Then the older wells (that were formerly the compliance wells) could be used as sentry wells. The regulatory limit would not apply to these sentry wells. Instead, they would serve to give the landfill owner/operator an early warning of gas migration.

### C. CONDUCTING GAS MONITORING

Implementation of facilities' gas monitoring plans is addressed in the regulations at 10 CSR 80-3.010(14)(B)1.C. and (14)(C)4 and 10 CSR 80-4.010(14)(B)1.C. and (14)(C)4. The regulations state that owners/operators of landfills are required to implement monitoring to ensure that landfills do not exceed the regulatory limits provided in 10 CSR 80-3.010(14)(C)2 and 10 CSR 80-4.010(14)(C)2. The limits are 1.25 percent by volume methane in buildings on the landfill property and 2.5 percent by volume methane in the soil at the property boundary.

Sampling of gas monitoring wells should follow the general procedures outlined in the department's technical bulletin titled "Sampling of Landfill Gas Monitoring Wells" (see publication at <http://dnr.mo.gov/pubs/pub2053.htm>). Sampling inside structures should follow the general procedures outlines in the department's technical bulletin titled "Procedures for Sampling Landfill Gas Inside Buildings" (see <http://dnr.mo.gov/pubs/pub2052.htm>).

#### *i. Monitoring Instruments*

The Missouri Solid Waste Management Regulations require owners/operators to use monitoring equipment warranted by the manufacturer to detect explosive gases under the conditions in which the equipment is to be used. Some gas monitoring equipment operates accurately only if methane is being measured in the presence of oxygen because the instrument measures the concentration by burning a sample while taking the reading. Instrumentation for sampling soil gas in monitoring wells shall be capable of providing an accurate methane reading in an oxygen deficient environment. All monitoring equipment shall be certified for use in explosive environments (and rated as "intrinsically safe").

Gas monitoring instruments must also be calibrated to assure the accuracy of the data. Calibration should be performed in accordance with the manufacturer's recommendations. In general, two types of calibration ensure the instruments readings are accurate:

- **Field or Office Calibration:** The instrument should be calibrated before methane samples are collected in the field, using gas cylinders of known concentrations, at temperatures similar to those the instrument will be exposed to in the field. Field calibration, at a minimum, must be conducted prior to taking methane readings from monitoring wells to prove the integrity of the data that is collected.

- **Factory Calibration:** The instrument should be maintained according to the manufacturer's instructions to assure proper operation and accurate data collection. Many manufacturers recommend at least annual factory recalibration. Factory recalibration enables the facilities to be more confident that the data accuracy has not been compromised by instrument failure or malfunction. Sensors that have deteriorated are usually replaced during factory recalibration.

*ii. Parameters to be analyzed*

Although the concentration of methane in any monitoring well should be the greatest importance to both the facilities and the Solid Waste Management Program, in order to fully understand methane migration, or the potential for migration, several other parameters should be considered and studied when monitoring. These parameters include the concentrations of various other gases in the well, the pressure in the monitoring well, and the weather conditions.

- **Methane Gas, CH<sub>4</sub>** – Methane gas is flammable and potentially explosive when confined in concentrations between 5 percent and 15 percent with normal atmospheric oxygen and it is also an asphyxiant at higher concentrations in enclosed spaces as it can displace oxygen. Methane is capable of migrating through soil and fractured rock in concentrations well above the lower explosive limit (5 percent by volume). When methane travels through the soil into a basement, manhole, or other enclosed space, it can mix with oxygen to create an explosive mixture that needs only heat or a spark to ignite. Methane can also create a hazard by displacing oxygen in enclosed structures or spaces.
- **Carbon Dioxide, CO<sub>2</sub>** – Carbon dioxide is also an asphyxiant. High concentrations of carbon dioxide can create a potential hazard to nearby enclosed structures or spaces by displacing oxygen. Carbon dioxide is soluble in water and will be stripped from a gas stream as it flows through the soil, increasing the relative concentration of methane in the soil. Therefore, a gas sample from a monitoring well containing carbon dioxide concentrations equal to methane concentrations suggest that the gas has been generated through decomposition in the landfill recently. Carbon dioxide is also released naturally by the decomposition of plant and animal matter in the soil.
- **Oxygen, O<sub>2</sub>** – Oxygen is present in the atmosphere in concentrations near 21 percent by volume. It is also naturally present in much lower concentrations in the top few feet of soil due to gaseous interchange with the atmosphere. In general, the oxygen concentration in the soil drops off at increasing soil depths due to the decrease of this atmospheric interchange. This decrease in oxygen concentration with increasing depth is quite dramatic in heavy soils such as clays, while more porous soils at the same depth tend to have a higher oxygen concentration. Based upon this tendency, elevated oxygen levels in monitoring wells may indicate damage to a well that is allowing oxygen intrusion. Elevated oxygen levels may also indicate that too much vacuum is being applied to an active gas extraction system, causing atmospheric oxygen to be pulled towards the landfill, increasing the potential for a landfill fire.
- **Hydrogen Sulfide, H<sub>2</sub>S** – Like carbon dioxide and methane, hydrogen sulfide is an asphyxiant. Hydrogen sulfide is hazardous at concentrations as low as 20 parts per million (ppm). In the ambient air, hydrogen sulfide's odor may cause complaints from those nearby. Although it has a strong odor, exposure to hydrogen sulfide will rapidly fatigue the sense of smell, so odor cannot be relied upon to warn of its presence. Also, hydrogen sulfide is more soluble in water than carbon dioxide, so as landfill gases travel through saturated soils, hydrogen sulfide may be stripped from the gases, causing a loss of the odor. Therefore, odor alone should never be relied upon as an indicator of this compound and the other associated landfill gases. In confined spaces near or at the landfill, it may create toxic conditions for employees.

- Pressure – There are two major mechanisms for gas transport:
  1. molecular diffusion, which is movement through a medium caused by a concentration gradient.
  2. pressure-gradient force, which is movement through a medium due to a pressure gradient.

Of the two, pressure-gradient force is the more significant transport mechanism and causes more concern for public safety. Any instrument used to monitor gas concentrations in wells should be capable of sensing the pressure in the monitoring well, and the differential pressure between a well and the atmosphere.

The relative pressures in gas monitoring wells may provide important information to facilities when they are investigating a gas migration incident. Pressure readings should be taken before a well is sampled for gas concentrations so that the act of removing gas for these measurements does not relieve the pressure in the well. Hence the requirement for installing wells with a dedicated sampling port to prevent impact to the well pressure during monitoring.

When monitoring a gas well if the readings reveal that the well contains high pressure compared to the ambient air, this indicates a significant potential for gas migration.

- Weather Conditions –The understanding of soil gas movement also requires an understanding of how the following conditions impact this movement and may impact a facility’s methane gas readings:
  - Barometric pressure: Low barometric pressure events lasting for several days have been documented causing landfill gas to migrate away from a landfill. When the gas pressure in the landfill is higher than the barometric pressure in the atmosphere, flow (in this case, migration) can occur. This is because there is a greater differential between the gas pressure and the barometric pressure in the atmosphere, which increases the pressure-gradient force that pushes the landfill gas, including methane, out of the landfill. The gas will follow a pathway of least resistance away from the landfill and into the atmosphere or along a utility line or other conduit that could lead into a confined space off-site. On days of high barometric pressure, the opposite is true and the larger pressure gradient may act to confine the gas closer to the landfill.
  - Precipitation/soil moisture conditions: Movement of landfill gas through the soil cap and into the atmosphere, or natural venting, is slowed or prevented as the surface soil becomes saturated or frozen. The pathways of migration to the surface through the soil pores may be blocked by water or ice, causing the gas to move horizontally rather than vertically. Gas has been documented migrating long distances from a landfill during the winter and spring when the soil is saturated or frozen. Conversely, when soil is dry and cracked during the summer months, landfill gas can vent more easily vertically through the earth’s surface and horizontal migration is less likely to occur.
  - Temperature: Temperature of the ambient air is important because it may affect operation of monitoring instruments. When conducting gas monitoring, the sampler shall ensure that the sampling instrument is within its valid temperature operating range. Extreme high or low temperature may cause invalid results. It is also important to field calibrate instruments as close to the temperature of the gas being sampled as possible. This is due to a shift in the ability for most sensors to detect gases when there are temperature differences, which may cause higher or lower monitoring results than may truly exist at the location.

To help interpret and understand methane gas data, the facility should observe and record information on each of these parameters when sampling monitoring wells for each monitoring event.

#### D. MONITORING FREQUENCY

As required by 10 CSR 80-3.010(14) (C) 4 and 10 CSR 80-4.010(14) (C) 4, owners/ operators of sanitary and demolition landfills shall collect samples from gas monitoring wells at least quarterly. The data shall be submitted to the department (see Submission of Results, Subsection E below). If methane is detected in excess of regulatory limits, the monitoring frequency will be increased to a) protect public health and safety and b) provide information to assist facilities in implementing corrective actions to stop the migration. The monitoring frequency is discussed further in sections 2-4 (Response to Initial Discovery of Methane, Investigating the Extent of Methane Migration, and Remediation or Corrective Actions to Resolve Methane Migration).

#### E. SUBMISSION OF MONITORING RESULTS TO THE SOLID WASTE MANAGEMENT PROGRAM

Per 10 CSR 80-3.010(14) (C) 4 and 10 CSR 80-4.010(14) (C) 4, monitoring results must be submitted electronically to the Solid Waste Management Program. Submit monitoring data within one week of sample collection. The electronic mail address to submit the methane monitoring results is: [swgasmon@dnr.mo.gov](mailto:swgasmon@dnr.mo.gov). The regulation also requires the data be submitted in a format prescribed by the department, which is an e-mail attachment in Comma Separated Value (CSV) format. The CSV file format is as follows:

Column	Description*
A.	Highest permit number for the facility (without any preceding zeros)
B.	Well ID Number (as approved by the Solid Waste Management Program)
C.	Sample collection date (using one of the approved formats)
D.	Methane (record in percent by volume)
E.	Carbon dioxide (record in percent by volume)
F.	Oxygen (record in percent by volume)
G.	Balance gas (record in percent by volume)
H.	Barometric pressure (record inches Hg)
I.	Carbon monoxide (record in parts per million)
J.	Hydrogen sulfide (record in parts per million)
K.	Relative pressure (record in inches water)
L.	Comments
M.	Water level in well (depth in feet below surface of well)

\* For a detailed description of the data submission process and the CSV format for the monitoring data, please see the guidance document for submitting landfill gas monitoring data. Only items identified in Columns A through D are required to be submitted. The Solid Waste Management Program requests facilities submit the additional data information identified in Columns E through M, if available.

An example of a spreadsheet which meets the formatting requirements is provided below:

Column B  
Well ID  
Number  
Column C  
Sample  
Collection Date  
Column D  
% Methane  
by volume  
Column E  
% CO2  
(optional)  
Column F  
% O2  
(optional)  
Column G  
% Balance  
(optional)  
Column H  
Pressure  
Inches Hg  
(optional)  
Column I  
CO ppm  
(optional)  
Column J  
H2S ppm  
(optional)  
Column K  
Relative  
Pressure  
(optional)  
Column L  
Inches H2O  
(optional)  
Column M  
Comments  
of well  
(optional)  
Column N  
Ft. Below top  
of well  
(optional)

Microsoft Excel - ABC Landfill Gas Monitoring Data

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Type a question for help

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1	123456	LGP-1R	1/6/2010	0									
2	123456	LGP-2	1/6/2010	0									
3	123456	LGP-3	1/6/2010	1.6									
4	123456	LGP-4	1/6/2010	35.7									
5	123456	LGP-5	1/6/2010	0									
6	123456	LGP-6	1/6/2010	0.2									
7	123456	LGP-7	1/6/2010	0									
8	123456	LGP-7R	1/6/2010	0									
9	123456	LGP-1R	1/15/2010	0									
10	123456	LGP-2	1/15/2010	0									
11	123456	LGP-3	1/15/2010	2.7									
12	123456	LGP-4	1/15/2010	47.8									
13	123456	LGP-5	1/15/2010	0									
14	123456	LGP-6	1/15/2010	0.3									
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## 2. RESPONSE TO INITIAL DISCOVERY OF METHANE MIGRATION

### A. REGULATORY REQUIREMENTS

For sanitary and demolition landfill owners/operators, 10 CSR 80-3.010(14) (C) 5.A and 10 CSR 80-4.010(14) (C) 5.A set out requirements and actions to be considered when methane is detected above regulatory limits in structures or in soil at the property boundary. The actions a facility must take in these two scenarios shall be in direct response to any immediate threat to public health and safety caused by methane migration. Once that threat has been removed, the action steps are the same whether the exceedance of methane is found in a structure or in a well at the property boundary.

### B. NOTIFICATION PROCEDURES

#### *i. Methane Exceeding Regulatory Limit in Buildings: Immediate Threat to Public Health and Safety*

When landfill owners/operators (or their representatives) discover methane in concentrations above regulatory limits in any structure on or off-site, the first action is to evacuate the structure or area immediately. Persons exiting the structure should be directed not to create any sparks, for example, when turning a light switch off. Once all parties are out of the confined space (i.e., building) or away from the area, notify the fire department and other local emergency management personnel, then contact the Solid Waste Management Program, and then the department's regional office. As in the past, the department will follow the directions of these local agencies for the protection of the public.

Because of the imminent threat to the public involved in this situation, please ensure this notification includes direct contact via telephone with a Solid Waste Management Program representative in Jefferson City in addition to a submission of the gas monitoring results to the Solid Waste Management Program's Gas Monitoring e-mail account ([swgasmon@dnr.mo.gov](mailto:swgasmon@dnr.mo.gov)). Do not leave a message on voice mail or advise a member of the clerical staff, but notify the project engineer, enforcement case manager, or a member of the Solid Waste Management Program management about this situation.

In addition to helping evacuate all structures where methane exceeds the regulatory limit and contacting the fire department, emergency management personnel, and the Solid Waste Management Program, the landfill owner/operator is required to initiate a public notification process. The process consists of landfill representatives notifying all owners and occupants of properties within 1,000 feet of any noncompliant gas well of the potential for gas migration. The notification process is done to ensure that nearby residents, businesses, and property owners are aware of the potential presence of methane gas on their properties so they may implement safety precautions. This also demonstrates that the landfill owner/operator is diligently trying to ensure public safety. Landfill representatives shall make a list of those people they notified of the migration, provide the date they were notified, and list the address and telephone number (when available) of those notified. Utility companies that have enclosed or underground infrastructure within 1,000 feet of the noncompliant well(s) must also be notified of the methane migration.

At the same time, the Solid Waste Management Program will review the information about the migration and the surrounding properties and determine, on a case by case basis, if a press release is needed to better ensure all necessary parties are made aware of the potential for methane migration from the landfill. The Solid Waste Management Program will discuss the need for a press release with the landfill owner/operator to try and provide the most accurate and up-to-date information possible.

*ii. Methane Exceeding Regulatory Limit in the Soil: Potential Threat to Public Health and Safety*

When landfill owners/operators (or their representatives) discover methane in concentrations above the regulatory limit in the soil at the property boundary or in compliance wells designated as the facility's point of compliance for methane control on the site, they will also be required to notify parties of the methane migration. This requirement shall be waived only if the landfill owner/operator provides immediate documentation from a Missouri Registered Geologist or other professional that proves gas migration from the landfill is: a) not occurring or b) prevented from traveling from the landfill property boundary to nearby occupied structures or properties by a geologic or topographic cutoff.

If migration is occurring, in order to protect public health and safety, the Solid Waste Management Program policy requires notification of the local fire department, emergency management agency, or other appropriate public safety authority. As in the case of methane found in structures off of the landfill property, in order to ensure that those who live, work, or conduct activities on properties near the landfill are kept safe, the landfill owner/operator is required to initiate a public notification process.

As described in Subsection B.i. above, the notification process consists of landfill representatives notifying all owners and occupants of properties within 1,000 feet of any noncompliant gas well of the potential for gas migration. The notification process is done to ensure that nearby residents, businesses, and property owners are aware of the potential presence of methane gas on their properties so they may implement safety precautions. This also demonstrates that the landfill owner/operator is diligently trying to ensure public safety. Landfill representatives shall make a list of those people they notified of the migration, provide the date they were notified, and list the address and telephone number (when available) of those notified. Utility companies that have enclosed or underground infrastructure within 1,000 feet of the noncompliant well(s) should also be notified of the methane migration. During the notification process, the landfill owner/operator shall also offer to provide monitoring and other protective services that are discussed in greater detail in Subsection 2.C. below.

At the same time, the Solid Waste Management Program will review the information about the migration and the surrounding properties and determine, on a case by case basis, if a press release is needed to better ensure all necessary parties are made aware of the potential for methane migration from the landfill. The Solid Waste Management Program will discuss the need for a press release with the landfill owner/operator to try and provide the most accurate and up-to-date information possible. If possible, the Solid Waste Management Program will allow the landfill owner/operator to review and comment on the draft press release prior to submitting to the department's public information staff.

## C. FACILITY RESPONSE TO REMOVE IMMEDIATE THREAT TO PUBLIC HEALTH AND SAFETY

*i. Methane in Buildings: Immediate Threat*

In most cases, the local fire department or emergency management agency has the training and authority to conduct necessary monitoring and make a determination whether a structure is safe for use. Once the determination has been made to keep people out of any structure or away from any area, the facility's responsibility will be to begin corrective actions and coordinate any actions with these entities and the department. The first step shall be to safely ventilate any structure deemed necessary and stop the immediate threat to public health and safety. Until such time that the threat is removed, the landfill owners/operators may be required to post warning signs on affected and nearby structures in case people using the affected structures or in the area did not receive notification of the migration.

The structure or confined space shall be monitored until methane concentrations have dropped below levels which threaten public health and safety. This determination shall be made by the local fire department or emergency management agency. The landfill owner/operator shall contact the owners or occupants of those structures where methane was detected and offer to conduct a thorough methane intrusion investigation to determine the location(s) that methane is entering or is likely to enter the structure(s). Buildings/structures shall be checked for methane pathways and entrances into the structures such as cracks in foundations or floors, floor drains, utility conduits into buildings, electrical outlets, circuit breaker boxes, etc. The landfill owner/operator shall then offer to install methane detectors, as needed, to ensure safety of the building occupants.

Once the building/structure has been deemed safe for use, and prior to people returning to the structure, the landfill owner/operator shall properly seal intrusion pathways into the structure and install the detectors in any building/structure where requested by the owner/occupant of the building/structure. Detectors shall be placed in locations where methane is likely to enter the structure, such as underground utility drains or conduits into buildings, cracks in foundations or basements, or through crawl spaces. An instruction sheet describing the use of the detectors and procedures to follow if the detector sounds an alarm shall be given to the occupant(s) of the building/structure and posted next to each detector.

The facility shall make a list of those buildings/structures where detectors were installed, who owns and occupies the buildings/structures, hours of occupancy (if possible), in what room(s) the detectors were installed, on what date, and certify that instructions for the use of the detectors were provided to the occupants of these buildings/structures. This list, a copy of the methane detector instruction sheets provided to occupants of structures, and a report describing all other steps taken to protect public health and safety is required to be submitted to the Solid Waste Management Program within seven days of initial detection of a methane exceedance. A report providing these details should satisfy the requirements for sanitary and demolition landfills given in 10 CSR 80-3.010(14) (C) 5.B and 10 CSR 80-4.010(14) (C) 5.B.

Until methane is controlled at the landfill and migration above the regulatory limit has ceased, the landfill owner/operator shall establish a temporary monitoring program in all buildings/structures where methane had been detected. Where the property owner/occupant grants permission, monitoring shall be conducted at least weekly and in accordance with the department's technical bulletin, "Procedures for Sampling Landfill Gas Inside Buildings." The landfill owner/operator shall submit monitoring data to the Solid Waste Management Program within one week of sample collection.

In the event the migration is uncontrolled over an extended period of time, the landfill owner/operator shall also check methane detectors installed in the buildings/structures to ensure they are operating as designed and to change the batteries. The detectors shall continue to be checked at least semi-annually (every six months) by landfill representatives and remain in place until methane is controlled on-site.

#### *ii. Methane in Soil: Potential Threat*

When owners and occupants of properties within 1,000 feet of any noncompliant well are notified of the potential for migration by landfill representatives, they should also be given the opportunity to have any nearby structure, residence, building, etc. monitored for the presence of methane. Buildings/structures should be checked for methane pathways and entrances into the structures such as cracks in foundations or floors, floor drains, utility conduits into buildings, electrical outlets, circuit breaker boxes, etc.

At the same time, the landfill owner/operator shall offer to install methane detectors in the building/structure, as needed, until such time that it is confirmed that methane is no longer migrating off of the landfill. Detectors shall be placed near locations where methane is likely to enter the structure, such as underground utility drains or conduits into buildings, cracks in foundations or basements, or through crawl spaces. An instruction sheet describing the use of the detector and procedures to follow if the detector sounds an alarm shall be given to the occupant(s) of the building/structure and posted next to each detector.

The landfill owner/operator shall make a list of those buildings/structures where monitoring was conducted and detectors were installed, who owns and occupies the buildings/structures, hours of occupancy (if possible), in what room(s) the detectors were installed, on what date, and certify that instructions for the use of the detectors were provided to the occupants of these buildings/structures. This list, a copy of the methane detector instruction sheets provided to occupants of structures, and a report describing all other steps taken to protect public health and safety is required to be submitted to the Solid Waste Management Program within seven days of initial detection of a methane exceedance. A report providing these details should satisfy the requirements for sanitary and demolition landfills given in 10 CSR 80-3.010(14) (C) 5.B and 10 CSR 80-4.010(14) (C) 5.B.

Until methane is controlled at the landfill and migration above the regulatory limit has ceased, the landfill owner/operator shall establish a temporary monitoring program in all buildings/structures where methane had been detected. See subsection 2.C.i. above if methane has been detected in structures. The landfill owner/operator shall submit monitoring data to the Solid Waste Management Program within one week of sample collection.

To ensure continued safety of the public and to begin the migration investigation process, the frequency of compliance well monitoring is increased from a quarterly to a weekly basis. Upon initial discovery of any of methane concentrations above 2.5 percent by volume, weekly monitoring will be required for all compliance wells. Weekly monitoring will be required for any compliance well as long as it continues to exhibit methane concentrations above 2.5 percent by volume. Once compliance well ceases showing readings above 2.5 percent by volume for four consecutive weeks, the landfill owner/operator may submit a written request to the Solid Waste Management Program to reduce the frequency of sampling from weekly to monthly. Once any compliance well ceases showing readings above 2.5 percent by volume for three consecutive months, the facility may submit a written request to the Solid Waste Management Program to reduce the frequency from monthly to quarterly. However, each time a compliance well has recurring methane concentration above 2.5 percent by volume, the monitoring frequency will again return to a weekly basis for all compliance wells to ensure no new migration is occurring and to focus attention in the area of the migration. The landfill owner/operator shall continue weekly monitoring and submission of results to the Solid Waste Management Program for all noncompliant monitoring wells until the concentrations fall below the regulatory limits.

In cases where a landfill has compliance well(s) with gas readings above the regulatory limit which have displayed a consistent trend in the weekly monitoring for a period of at least three months and the condition of the area around that probe has been established and the information being recorded, related to the cost of obtaining it, is neither new or useful, the facility may submit a written request to the Solid Waste Management Program to reduce the frequency to monthly or quarterly. Any potential threat to public health and safety will be considered and the determining factor in reducing the frequency of the monitoring and as long as the approved corrective actions were ongoing and progress was being made and documented. In the event monthly/quarterly results begin to show a significant change from the current trend, the Solid Waste Management Program may require the facility to return back to weekly monitoring.

In the event the migration is uncontrolled over an extended period of time, the landfill owner/operator shall also check methane detectors installed in the buildings/structures to ensure they are operating as designed and to change the batteries. The detectors shall continue to be checked at least semi-annually (every six months) by landfill representatives and remain in place until methane is controlled on-site.

In the event the landfill owner/operator refuses to notify property owners and occupants of structures within 1,000 feet of any noncompliant well, the Solid Waste Management Program shall initiate notification, which may include on-site visits, phone calls, letters, and publishing a press release to ensure all potentially impacted parties are apprised of the migration of methane from the landfill. The Solid Waste Management Program shall coordinate notification, emergency response and follow-up actions to ensure the public is protected during ongoing methane migration. As needed, enforcement action shall be initiated against the landfill owner/operator to compel compliance with the Missouri Solid Waste Management Law and Regulations with regard to notification, monitoring, emergency response and corrective actions to address methane migration.

#### D. METHANE GAS RESULTS ABOVE REGULATORY STANDARDS DUE TO TEMPORARY GAS SYSTEM MALFUNCTION.

When landfill owners/operators (or their representatives) discover methane in concentrations above regulatory limits in any compliance wells and believe the concentration is due to a temporary gas system malfunction, the landfill owner/operator should immediately contact the Solid Waste Management Program. Do not leave a message on voice mail or advise a member of the clerical staff, but notify the project engineer, enforcement case manager, or a member of the Solid Waste Management Program management about this situation. The landfill owner/operator will be expected to report the sampling result, explain why they believe the result is related to equipment malfunction, what immediate actions are going to be taken to correct the issue, and identify a timeframe to correct the malfunction that must be agreed upon by Solid Waste Management Program staff. Once this course of action is determined, the owner/operator will be expected to update the Solid Waste Management Program on a daily basis to ensure all actions to correct the issue are being taken to return the well in compliance within seven days. In these instances, the Solid Waste Management Program will not require the owner/operator to undertake the procedures as identified in Section C ii above.

If the owner/operator has repeated system malfunction problems which may cause an imminent threat to the public or if the corrective measures fail to achieve compliance within seven days, the Solid Waste Management Program may issue a notice of violation and require the owner/operator to take all the necessary steps as outlined in this policy.

#### E. METHANE GAS RESULTS ABOVE REGULATORY STANDARDS DUE TO PLANNED MAINTENANCE OF GAS SYSTEM.

Landfill owners/operators (or their representatives) should notify the Solid Waste Management Program of any planned maintenance activities that may result in possible odors or non-compliance of regulated wells at the facility. Pre-notification of any such planned maintenance activities should be made to the Solid Waste Management Program as soon as maintenance is scheduled. Information regarding the planned activities and the duration of the planned maintenance should be provided to ensure the Solid Waste Management Program may respond appropriately to any resulting inquiries or environmental concerns by the public.

In these instances, the Solid Waste Management Program will not require the owner/operator to undertake the procedures as identified in Section C ii above as long as the maintenance activity is short in duration (within seven days).

### 3. INVESTIGATING THE EXTENT OF METHANE MIGRATION

#### A. REGULATORY REQUIREMENTS

To develop a remediation or corrective action plan to address migration, you must investigate the migration thoroughly. In order to do that, the landfill owner/operator must characterize the nature and extent of the migration. This will require monitoring the methane in the soil at a sufficient number of locations and to the appropriate depth to discover the migration pathway(s) and boundaries. The focus must be on the pathway(s) by which the methane is flowing to the monitoring wells and off-site. Monitoring wells are simply the sentry points installed to alert you that a problem exists at one point along the property boundary. They may not define the actual pathway by which the methane is travelling off the landfill property.

As stated earlier, 10 CSR 80-3.010(14) (B) and 10 CSR 80-4.010(14) (B) require the sanitary and demolition landfill owners/operators to prepare operating plans which include a monitoring program that is capable of detecting decomposition gas migration. Information gained in the research, design, and construction of the landfill's gas monitoring plan is vital to the investigation plan and must be considered in the subsequent corrective actions taken to regain control of the gas.

#### B. Migration Investigation Plan

##### *i. Designing the investigation workplan*

The success of the methane migration investigation and subsequent corrective actions depends largely upon acquiring accurate information on where the methane is traveling and what procedures and actions put in place will halt the migration. A quick source of information is the landfill's gas monitoring plan.

The Missouri Solid Waste Management Regulations require the gas monitoring plan to be based upon the soil conditions, hydrogeologic and topographic conditions around the facility, and the location of facility structures, property boundaries, and off-site features. The monitoring program is also required to include details about the landfill's current monitoring system, results of any prior gas assessments that have been performed, well design specifications, the design depths and bottom elevations of the wells, and boring logs of the wells. All the information acquired prior to the migration occurring will help to guide the landfill owner/operator in designing a plan to investigate and characterize the migration.

In addition to the information in the monitoring program described above, the landfill owner/operator shall include the following information when developing the methane investigation workplan:

- Preliminary indications of the extent of the problem. Note the location and depth of noncompliant wells. Sample for methane in nearby groundwater monitoring wells or conduct direct-push (i.e. Geoprobe®) monitoring to test for the presence of methane. Examine the groundwater monitoring results from monitoring wells in the vicinity of affected gas monitoring wells. The presence of organics in the groundwater samples may be an indication of gas migration. Look for a physical pattern of stressed vegetation, particularly dead or dying trees or patches of grass, near the noncompliant well(s). Determine the depth of trash in the landfill. This will tell you the maximum downward extent of the exploration. All of these steps may yield useful information to help determine the extent of the migration.

- If applicable, evaluate the efficiency of the landfill’s current methane gas collection system. Review data of the system components or take readings to check the efficiency of the system components. Some items to consider include liquid levels in the extraction system and the efficacy of compressors and blowers. Collect methane concentrations from monitoring wells, at least weekly, when conducting efficiency checks of the collection system to know where problems within the collection system may be and focus corrective actions accordingly.
- Site geology and hydrology. Use existing information, for example, the preliminary and detailed site investigations that were conducted to obtain the landfill permit, to assess site features and characteristics that may impede or allow methane migration. Evaluate site conditions around the noncompliant well(s). Determine if there are sand lenses or fractured bedrock in the area, a perched groundwater table, or other confining geologic layers that would direct the flow of gas in an unexpected direction. Information gained from this part of the investigation may shift or guide your focus in a different direction.
- Site topography. Methane generally migrates up toward higher ground, so look for its presence in areas of higher elevation. Assess the roughness of the terrain in the area and plan for this in determining the type of equipment you will need to explore or monitor in that area.
- Location of all utilities in the area of migration. Contact all the utility companies serving the area and find out the depth of installation, the type of backfill material used, etc. Utility trenches can act as conduits and transmit landfill gas long distances. Sample all valve boxes, junction boxes, manholes, etc. in the suspect area of migration for methane.

Once the proposed investigation plan is prepared, the landfill owner/operator shall submit the plan to the Solid Waste Management Program for review and approval

*ii. Implement the investigation workplan*

In addition to reviewing historical information and observing the site conditions, installing temporary or permanent investigation wells will provide additional information to characterize the site at the area of the migration. Tasks to implement are described below.

- a. Install temporary or permanent monitoring wells.
  - Temporary wells (boreholes) may be installed using direct-push technology (i.e., Geoprobe®), by drilling, or by use of an auger. Wells that are 10 feet or deeper are regulated by the department’s Division of Geology and Land Survey’s Wellhead Protection Section. For specific information regarding these regulations, please contact the Wellhead Protection Section at 573-368-2100.
  - Temporary wells (boreholes) are to be open for only 30 days. If necessary, a 30 day extension may be requested from the Division of Geology and Land Survey’s Wellhead Protection Section. If the temporary boreholes are needed for longer than 60 days, they must be converted to code wells within the 60-day period.
  - In order to determine the horizontal extent of the migration, temporary wells must be installed along the property boundary (or compliance boundary) at 100 foot intervals from the noncompliant well(s), to a point at least halfway between the next monitoring well that is in compliance. Adjustments in spacing may be necessary based upon geology, hydrology, topography, physical obstructions, etc. However, when possible the spacing between investigative probes must be adjusted to be more conservative, not less conservative.

- The owner of the facility must determine the extent of the gas migration.
- All investigative wells shall extend to at least to the lowest elevation of waste in the landfill, or if another depth is proposed, it must be supported by data and information on the site geology, hydrology, or topography.
- In areas of complex geology and varying soil and rock layers around the landfill, installing clusters of wells or several wells in the same approximate location that are screened at various depths, will allow you to target specific zones to determine if migration is occurring in these zones. In order to effectively monitor all unsaturated geologic zones to the lowest elevation of waste in areas where water is perched, it may be necessary to perform a hydrologic/geologic assessment of the area where gas may be migrating. This assessment will determine the appropriate zone(s) to monitor and determine how to construct your investigative monitoring wells.

b. Monitoring the investigative wells.

- During the investigative period, the landfill owner/operator should monitor all investigative wells at least weekly to get detailed information to help design the corrective action plan. Monitor and record the following information:
  - Percent methane by volume (not percent lower explosive limit, or LEL).
  - Percent oxygen by volume.
  - Percent carbon dioxide by volume.
  - Static pressure in the well.
  - Water levels in wells (if applicable).
  - Atmospheric pressure and current weather.

c. Submission of monitoring results.

- Submit monitoring results from investigative wells to the Solid Waste Management Program electronically within one week of sample collection.  
Please see section 1.E. above for information regarding the submission of gas monitoring data.

d. Upgrade the current methane collection system.

- Once the efficiency of the collection system has been evaluated, the landfill owner/operator shall submit a proposal for design changes or equipment upgrades to the Solid Waste Management Program for approval. Once approval is granted, install all infrastructures as approved.

## C. PREPARATION AND SUBMISSION OF THE METHANE GAS INVESTIGATION REPORT

When the Solid Waste Management Program determines additional investigation is needed, the landfill owner/operator shall summarize the results of the migration investigation in a report and submit it to the Solid Waste Management Program. The report shall describe the migration, the actions taken to investigate the migration, and the findings of the investigation in detail. The investigation report shall be accompanied by the proposed methane gas corrective action/remediation plan.

The investigation report must contain, at a minimum, the following information:

- A table listing the permanent gas monitoring wells in the area(s) of the migration, the temporary wells installed for the investigation, the wells' current and historical gas readings. For each well, include historical readings for the 12-month period immediately preceding the initial exceedance of the regulatory limit, or longer if there is evidence of a trend.
- A site plan showing the following details of the affected area:
  - Site topography
  - Property boundary
  - Limits of waste
  - Elevations of landfill footprint
  - Location of all structures within 1,000 feet of the affected wells or probes
  - Location of all existing environmental controls
  - Location of all gas monitoring wells
  - Location of any wells, borings, or test pits used to evaluate the situation
  - Location of all roads
  - Location of all utilities
  - Other relevant information, i.e., areas of stressed vegetation
- Construction logs for all gas monitoring wells in the area(s) of the migration.
- An evaluation of the site geology in the area(s) of the migration, including:
  - The logs of any borings, wells, test pits, etc., used to evaluate the site geology.
  - A detailed description of the stratigraphy and any geologic or hydrologic feature that may affect the depth and pattern of methane migration. A site map showing important geologic or hydrologic features should be included, if necessary. This portion of the report must be prepared by a Missouri Registered Geologist.
  - Cross section drawings showing the depth of waste and any important geologic or hydrologic features within 1,000 feet of the area(s) of migration.
- An evaluation of the weather patterns (precipitation, barometric pressure, temperatures, etc.) corresponding to the historical methane readings in the affected wells.

The landfill owner/operator shall submit the methane gas investigation report to the Solid Waste Management Program for review and approval. In addition, the landfill gas corrective action plan shall be submitted to the Solid Waste Management Program.

## **4. REMEDIATION OR CORRECTIVE ACTIONS TO RESOLVE METHANE MIGRATION**

### **A. REGULATORY REQUIREMENTS**

Per 10 CSR 80-3.010(14)(C)5.C and 10 CSR 80-4.010(14)(C)5.C, within 60 days of the initial detection of methane above the regulatory limit, the owner/operator of a sanitary or demolition landfill shall submit a remediation (corrective action) plan to the Solid Waste Management Program for approval. The plan must be designed by a professional engineer to address the methane gas migration. Additional time to determine the extent of the methane migration pathways may be requested from the Solid Waste Management Program. The Solid Waste Management Program will evaluate the need for additional investigative time based on the content of the investigative work plan as well as any justification(s) provided. The investigative work plan must be submitted prior to the 60-day deadline.

### **B. CONTENT OF REMEDIATION/CORRECTIVE ACTION PLANS**

The proposed remediation/corrective action plan shall be based upon information gathered through the methane gas investigation and include a detailed description of the remedy to stop the migration from occurring, including any necessary calculations, drawings, and supporting documentation. The regulations require the landfill owner/operator to design a plan to address methane migration and prevent methane accumulation in on-site and off-site buildings, reduce methane concentrations in the soil at the property boundary (or in designated compliance wells) to below compliance levels, and reduce methane concentrations off-site to below compliance levels. More specific requirements for various types of gas control systems are outlined below.

#### **i. Active gas control systems**

Active systems are designed to control gas migration by inducing a slight negative pressure within the pore spaces of the waste mass or the soil adjacent to the waste mass, usually through the use of a blower system to create a vacuum. Typical gas control systems include vertical slotted or screened control wells placed into boreholes drilled into the waste mass and connected through a network of piping. In shallow waste, horizontal control trenches with slotted or perforated pipe, backfilled with porous media, can be effective. In active systems, the gas is captured and piped to a flare where it is burned, or to other equipment for use as fuel.

The design documentation included for submittal of active gas control systems shall include:

- Plan sheet(s) showing proposed locations of system components, such as:
  - Extraction wells
  - Trenches
  - Piping
  - Valves
  - Blowers
  - Flares
  - Compressors
  - Condensate knockouts
  - Sumps
  - Cleanouts
  - Monitoring locations

- Cross-section drawings showing gas control well and/or trench construction details.
- A well schedule showing well depths, the bottom elevation of the landfill at that location, number of feet of slotted pipe, number of feet of solid pipe and total well depth.
- The depth of all gas control wells must be at least 75 percent of the depth of trash, but the bottom of the wells must be no closer than 10 feet from the top of the landfill liner.
- Calculations showing the radius of influence of gas control wells and/or trenches.
- Estimates of gas generation rates.
- Design criteria for sizing the blower(s).
- Design criteria for sizing all piping, including gas control wells.
- Operation and maintenance instructions for the entire gas control system.
- Proposed financial assurance for post-closure maintenance of the gas control system.
- For landfills that must comply with the New Source Performance Standards (NSPS) of the Clean Air Act, the proposed gas control system design must also be submitted to the department's Air Pollution Control Program (APCP) for approval. The landfill owner/operator shall include a copy of the cover letter sent to APCP with the submittal to the Solid Waste Management Program.

#### ii. Passive gas venting systems

Passive vents are not an approvable first choice for mitigating a methane migration issue. Passive vents may only be used in addition to an active gas extraction system.

Passive gas systems are pipes installed in the landfill cap to assist in the venting of the methane from the landfill into the atmosphere. The vents are usually constructed of vertical slotted or perforated pipes installed in boreholes through the waste mass. These vents in the waste are intended to relieve the gas pressure to remove the driving force for gas flow. Horizontal interceptor trenches are another type of passive gas system. They are typically installed in between the waste mass and the property boundary or point of compliance to prevent the gas from migrating off-site.

Passive systems rarely are effective in controlling landfill gas migration, particularly for higher methane concentrations. The Solid Waste Management Program does not consider passive venting of methane gas a primary measure of control. The Solid Waste Management Program experience with this type of system is that very little of the methane vents, or if some methane does flow out through the vents, not enough methane flows through them to prevent migration. Prior to proposing the use of passive venting systems as part of a methane gas corrective action plan, the landfill owner/operator shall discuss this option with the Solid Waste Management Program Engineering Section to ensure this option is truly a viable one to implement at the landfill experiencing migration.

In the event the Solid Waste Management Program approves the landfill owner/operator to submit a passive vent system as part of a corrective action at the landfill, the submitted design for the system shall include the following:

- Plan sheet(s) showing proposed locations of system components, such as:
  - Vents
  - Trenches
  - Piping
  - Valves
  - Compressors
  - Condensate knockouts
  - Sumps
  - Cleanouts
  - Monitoring locations
- Estimates of gas generation rates.
- Design criteria for sizing all piping, including gas vents.
- Operation and maintenance instructions for the entire gas control system.
- Provisions for methane sampling.
- Proposed financial assurance for post-closure maintenance of gas venting system.
- For landfills that must comply with the New Source Performance Standards (NSPS) of the Clean Air Act, the proposed gas venting system design must also be submitted to the department's Air Pollution Control Program (APCP) for approval. The landfill owner/operator shall include a copy of the cover letter sent to APCP with the submittal to the Solid Waste Management Program.
- For gas vents installed in the waste, include the following information:
  - a) Cross-section drawings showing detailed vent construction.
  - b) A well schedule showing well depths, the bottom elevation of the landfill at that location, number of feet of slotted pipe, number of feet of solid pipe and total well depth.
- The depth of all gas vents must be at least 75 percent of the lowest elevation of waste, where possible, but the bottom of the vents can be no closer than ten feet from the top of the landfill liner.
- For horizontal interceptor trenches, include the following information:
  - a) Cross-section drawing showing the trench construction detail.
  - b) Provisions for activating the system by creating a negative pressure in the collection trench, should the passive trench prove ineffective at preventing methane migration.
- Trenches shall be installed to the lowest depth of waste.
- Trenches shall be installed with a geomembrane of a minimum thickness of 30 mils on the back side of the trench (away from the landfill).

### iii. Other options to address and mitigate methane migration

#### 1) External Migration Control Wells.

- External wells are active gas control system wells installed outside the waste mass. If this option is proposed, the landfill owner/operator shall submit a corrective action plan to the Solid Waste Management Program. The Solid Waste Management Program will consider allowing this option under the following conditions:
- Control wells must be no closer than 50 feet from the property line.
- Control wells shall be no closer than 50 feet from any permanent gas monitoring well or temporary well.
- Proposed migration control well designs must include:
  - a) Plan sheet(s) showing proposed locations of system components, such as:
    - Trenches
    - Piping
    - Valves
    - Blowers
    - Flares
    - Compressors
    - Condensate knockouts
    - Sumps
    - Cleanouts
    - Monitoring locations
  - b) Cross-section drawings showing gas control well and/or trench with construction details.
  - c) A well schedule showing well depths, the bottom elevation of the landfill at that location, number of feet of slotted pipe, number of feet of solid pipe and total well depth the landfill.
  - d) Estimates of the area of influence of the gas control wells.

#### 2) Purchase of Property

This option to resolve the methane migration involves purchasing property(ies) outside of the landfill property boundary that methane has migrated onto. In order for the Solid Waste Management Program to consider this option, the landfill owner/operator shall completely define the extent of the methane migration onto the adjacent property(ies). This must be done in both horizontal directions along the property line on either side of the noncompliant well(s) as well as inward onto the affected adjacent property(ies). If this option is proposed, the landfill owner/operator shall submit a corrective action plan to the Solid Waste Management Program.

Proposals to mitigate gas migration by purchasing property shall include:

- a) The landfill's Methane Gas Investigation Report.
- b) A request for a permit modification to relocate the landfill property boundary to include the newly-purchased property into the current landfill permit. The modification request shall include a proposed plat of survey prepared by a Registered Land Surveyor that provides the legal description of the property to be added to the permit, as well as a proposed revised Easement, Notice, and Covenant running with the land, pursuant to 10 CSR 80-2.020(2) (B) 2, 10 CSR 80-3.010(20) (C) 2., and 10 CSR 80-4.010(20) (C) 2.
- c) A proposal for the location and design of permanent gas monitoring wells at the new property boundary.

### C. JUDGING THE EFFECTIVENESS OF REMEDIATION/CORRECTIVE ACTIONS

Once the Solid Waste Management Program approves the remediation/corrective action plan submitted by the landfill owner/operator, the plan shall be implemented immediately. After the corrective actions have been completed at the landfill, the Solid Waste Management Program and the landfill owner/operator shall observe the effectiveness of the actions for six months after implementation of the plan. The department may grant additional time to allow gas concentrations to decline further if the monitoring results show a significant downward trend. In that case, the landfill owner/operator shall submit a request for extension of the observation period, including the reason for the extension request. If approved, the Solid Waste Management Program shall send an approval letter to the landfill owner/operator that provides a new date for the end of the observation period. Thirty days after the end of the observation period, the landfill owner/operator shall submit a Corrective Action Summary Report to the Solid Waste Management Program which summarizes the actions taken to stop the methane migration and the results documented over the observation period.

The Solid Waste Management Program shall review the Corrective Action Summary Report submitted by the landfill owner/operator, and if the department determines the corrective actions have not been successful at stopping the gas migration, the Solid Waste Management Program shall send a letter to the landfill owner/operator. This letter will require the landfill owner/operator to submit a new or revised remediation/corrective action plan within 30 days of receipt of the letter.

## **5. ENFORCEMENT ACTIONS**

### **A. REGULATORY REQUIREMENTS**

The Solid Waste Management Program is charged with implementing the Missouri Solid Waste Management Law and Regulations to protect the public health and safety of the citizens of Missouri and the environment. As mentioned earlier, the first Missouri Solid Waste Management Law, Rules, and Regulations, enacted in December of 1973, set out requirements for sanitary and demolition landfills to control decomposition gases on-site, as necessary, to avoid posing a hazard to occupants of adjacent properties. The regulations required the gases to be controlled in such a way that they did not accumulate in explosive or toxic concentrations, especially within structures. Since that time, the regulations have been expanded to require more specific information and actions from landfill owner/operators when methane migrations occur.

Because of the serious nature of methane violations, landfills will be referred to the Solid Waste Management Program's Compliance/ Enforcement Section for enforcement action when: a) methane migrates into building/structures above regulatory limits or b) methane migrates into the soil at the property boundary (or in designated compliance wells) above regulatory limits. The regulatory limits for methane at sanitary and demolition landfills are set out in 10 CSR 80-3.010(14) (C) 2 and 10 CSR 80-4.010(14) (C) 2. Other violations that result in referral for enforcement action include failure to: monitor for methane, submit monitoring results to the Solid Waste Management Program in a timely manner, and notify the Solid Waste Management Program of exceedances of regulatory limits in compliance wells. These violations are considered high priority violations. Solid Waste Management Program staff will review the circumstances surrounding the violations, and determine whether or not the circumstances and violation(s) warrant(s) issuing a notice of violation to the landfill owner/operator. If a notice of violation is issued to the landfill owner/operator, the matter is automatically referred to the Solid Waste Management Program's Compliance/ Enforcement Section for enforcement action.

### **B. ENFORCEMENT ACTIONS**

Most enforcement cases are resolved through the use of a settlement agreement from the Attorney General's Office (but still an out of court legal document). This agreement between the Solid Waste Management Program and the landfill's owner/operator will resolve the landfill's violation(s) by establishing a compliance schedule in which to perform corrective actions and the payment of monetary penalties. The agreement assures the Solid Waste Management Program and the public that a landfill owner/operator is dedicated in resolving the violation(s) and will remain vigilant, diligent, and timely in implementing actions to correct the problem. Corrective actions are tied to timelines for completion, and penalties are assessed against the landfill owner/operator if the deadlines are not met. These stipulated penalties ensure completion of the corrective actions in a diligent and timely fashion. Schedules for completion of corrective actions are discussed and agreed upon between the Solid Waste Management Program and the landfill owner/operator. The intent of settlement agreements is to document the methane gas violations at a facility and formally record the agreement of the facility's owner and/or operator to diligently take action to correct the threat and violation as soon as possible. Although agreements may request actions to be taken within two years of execution, this time period may not be sufficient for the owner and/or operator to propose, implement, and observe any response to a corrective action within that time period. The Solid Waste Management Program will coordinate the cycle of corrective action proposal submission, review, comment, approval, implementation, and observation as necessary until the facility demonstrates continued and uninterrupted compliance with the MWSML&R for methane gas for a period of at least one year. In the event methane violations continue to occur at the facility two years after issuance of the notice of violation, the department may consider issuing a new notice of violation and

requiring additional penalties if the facility owner and/or operator is not diligently designing, constructing, and implementing corrective actions to address ongoing methane violations.

If a landfill owner/operator refuses to take timely measures to address methane violations, the Solid Waste Management Program shall refer the violations to the Attorney General's Office (AGO) to file a lawsuit. The Solid Waste Management Program shall work through the AGO and the court system to acquire compliance from the landfill owner/operator through corrective actions, a schedule for completion of the actions, creation of a corrective action financial assurance instrument (FAI) to ensure landfill compliance, and the payment of penalties for the ongoing violations.

Once a settlement agreement with the Solid Waste Management Program or judgment by the court has set out corrective actions and a schedule of completion, the Solid Waste Management Program Compliance/Enforcement Section shall coordinate corrective actions with the landfill owner/operator and the Solid Waste Management Program Engineering Section to resolve the methane migration and bring the facility back into compliance.

Once all corrective actions have been completed, methane concentrations have decreased to below the regulatory limits, and any upfront penalties have been paid in full, the Solid Waste Management Program shall send a letter to the landfill owner/operator advising that the case has been closed. The letter shall remind the landfill owner/operator of any suspended or stipulated penalty measures that are still in effect.

## **6. CORRECTIVE ACTION FINANCIAL ASSURANCE INSTRUMENTS**

### **A. REGULATORY REQUIREMENTS**

The Missouri Solid Waste Management Law, 260.227.8 through 260.227.11 RSMo, requires a landfill owner/operator to take corrective actions to mitigate threats to the public health or environment. In order to ensure that the corrective actions actually mitigate the threat to public health caused by methane migration, Sections 260.227.9 through 260.227.11 RSMo. set out requirements for the landfill owner/operator to timely design and implement corrective actions for the landfill and for the Solid Waste Management Program to inspect the landfill to ensure corrective actions are mitigating the threat. The Missouri Solid Waste Management Regulations also address corrective actions in 10 CSR 80-2.030(4) (C), 10 CSR 80-3.010(14) (C) 5 and 10 CSR 80-4.010(14) (C) 5.

Section 260.227 of the Missouri Solid Waste Management Law requires a landfill owner/operator to provide a corrective action plan for gas migration, and a financial assurance instrument (FAI) in an amount and form prescribed by the department to ensure implementation of the corrective action plan. Once the department takes formal enforcement action, a corrective action FAI may be required. This FAI must be in the form of an escrow account or an irrevocable letter of credit.

It is difficult to determine at the outset what the ultimate cost of controlling a gas migration problem will be. Based on our experience, the most effective solution has historically been to install an active gas control system. The costs are derived from the department's technical bulletin titled "Preparing Solid Waste Disposal Area Closure and Post-Closure Plans," which identifies several cost worksheets to use.

## **7. APPENDIX**

### **A. SOLID WASTE MANAGEMENT PROGRAM FACT SHEETS**

- Design and Construction of Landfill Gas Monitoring Wells, PUB 002054, 1/2007  
<http://dnr.mo.gov/pubs/pub2054.htm>
- Sampling of Landfill Gas Monitoring Wells, PUB002053, 6/2006  
<http://dnr.mo.gov/pubs/pub2053.htm>
- Procedures for Sampling Landfill Gas Inside Buildings, PUB002052, 6/2006  
<http://dnr.mo.gov/pubs/pub2052.htm>

**B. MISSOURI DEPARTMENT OF NATURAL RESOURCES SOLID WASTE MANAGEMENT PROGRAM  
GUIDANCE FOR SUBMITTING LANDFILL GAS MONITORING DATA, JULY 2011**

Missouri Department of Natural Resources  
Solid Waste Management Program  
Guidance for Submitting Landfill Gas Monitoring Data  
July 2011

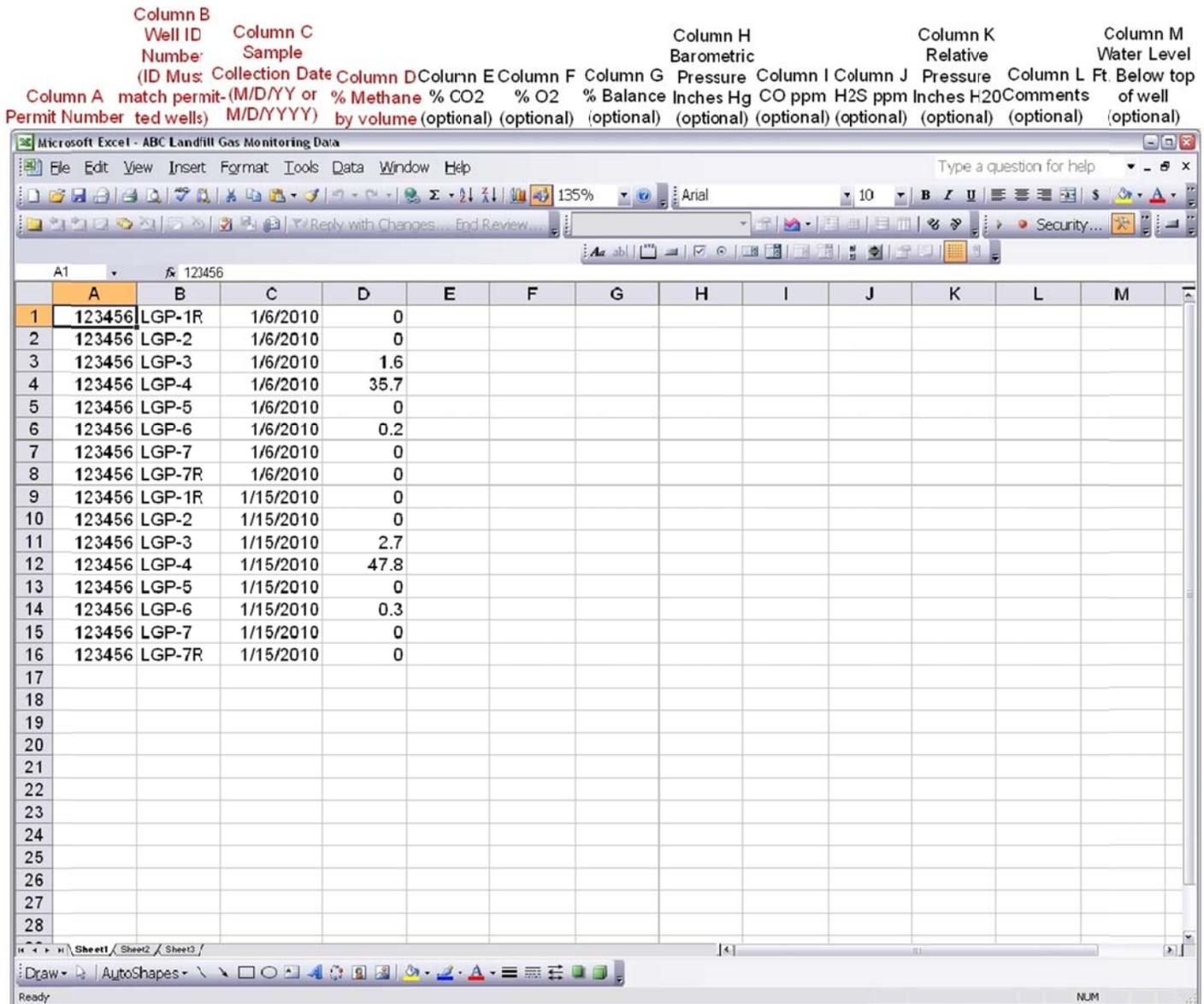
In an effort to improve efficiency and minimize the potential for data entry errors, the Solid Waste Management Program is changing the required format in which landfill gas monitoring data is to be submitted. This change will enable the Solid Waste Management Program to better serve the citizens of the state; yet will minimize the burdens involved with submitting this data as much as possible. The Solid Waste Management Program will work with those individuals who submit gas monitoring data over the next several weeks to phase in the new format. Please follow the guidelines below and contact the Solid Waste Management Program if you have any questions as the process is implemented.

**Formatting the data**

Data must be formatted in a spreadsheet (see figures 1 and 2). When setting up your facility's monitoring results spreadsheet, here are some things to keep in mind:

1. The first row should only contain data and should not be a header for the information or a title.
2. Each row represents one sampling event at one well.
3. The permit number should be the highest superseding number at the facility (the most recent modification) and should be written without any preceding zeros.
4. The well IDs must exactly match the monitoring well IDs that were submitted in the facility's gas monitoring plan and approved by the Solid Waste Management Program. Well IDs must be written exactly the same way every time the data is submitted, including proper spacing. For example, well 01-R is not the same as 1R or 01 r.
5. The database will accept the sample collection date in several formats. Please use one of the following formats when submitting your data:  
m/d/yy  
m/d/yyyy  
m/d/yy 1:56 PM  
m/d/yyyy 1:56 PM  
m/d/yy 13:56  
m/d/yyyy 13:56
6. The data in columns A through D is mandatory. All columns must not contain any extraneous information. In the event a well was not sampled, leave the field blank. Do not enter 0, NS, Not Sampled, a space, etc., or any other explanation in the cell. Only enter the value 0 if the well contained zero methane when sampled. Do not enter units, such as % or ppm after the value recorded. If you would like to explain why the well wasn't sampled, please include this information with the e-mail accompanying the data you submit.

**Figure 1 – Example of spreadsheet**



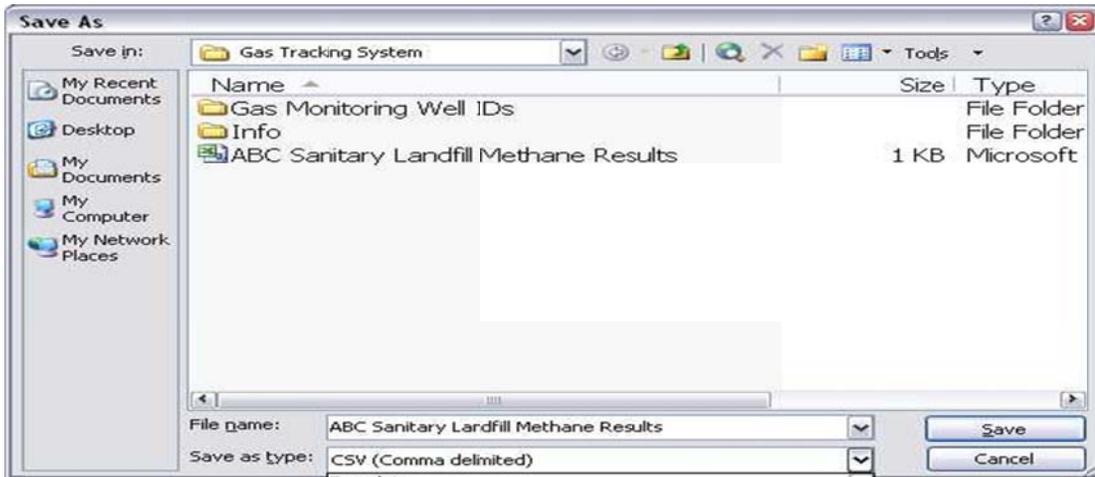
**Figure 2 – Explanation of spreadsheet columns**

Column	Description
A.	Highest permit number for the facility (without any preceding zeros)
B.	Well ID Number (as approved by the Solid Waste Management Program)
C.	Sample collection date (using one of the approved formats)
D.	Methane (record in % by volume)
E.	Carbon dioxide (record in % by volume)
F.	Oxygen (record in % by volume)
G.	Balance gas (record in % by volume)
H.	Barometric pressure (record inches Hg)
I.	Carbon monoxide (record in parts per million)
J.	Hydrogen sulfide (record in parts per million)
K.	Relative pressure (record in inches water)
L.	Comments
M.	Water level in well (depth in feet below surface of well)

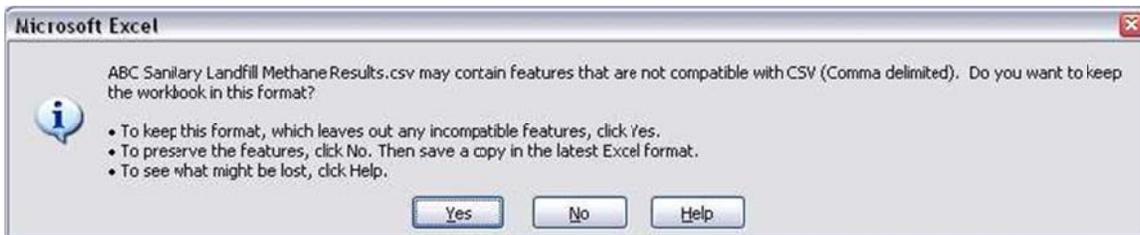
## Saving the Comma Separated Value file type

All gas monitoring data submitted must be in the Comma Separated Value, or CSV, file format. Files can be created from Microsoft Excel®, Apple Numbers®, and many other spreadsheet programs. For users who do not already have a spreadsheet program, openoffice.org contains a free, multi-platform spreadsheet program that can create CSV files. The format was chosen because it will prevent certain types of import errors that can be caused by common spreadsheet programs. The example below shows how to save a spreadsheet in CSV format using Microsoft Excel® on Windows XP®.

1. Go to File and select Save As. Choose a location to save the document.
2. Choose CSV in the Save as file type selection menu at the bottom of the window.



3. Once you click Save, you may see the message below. Select Yes. If you see this message when closing the file, select "Yes" again.



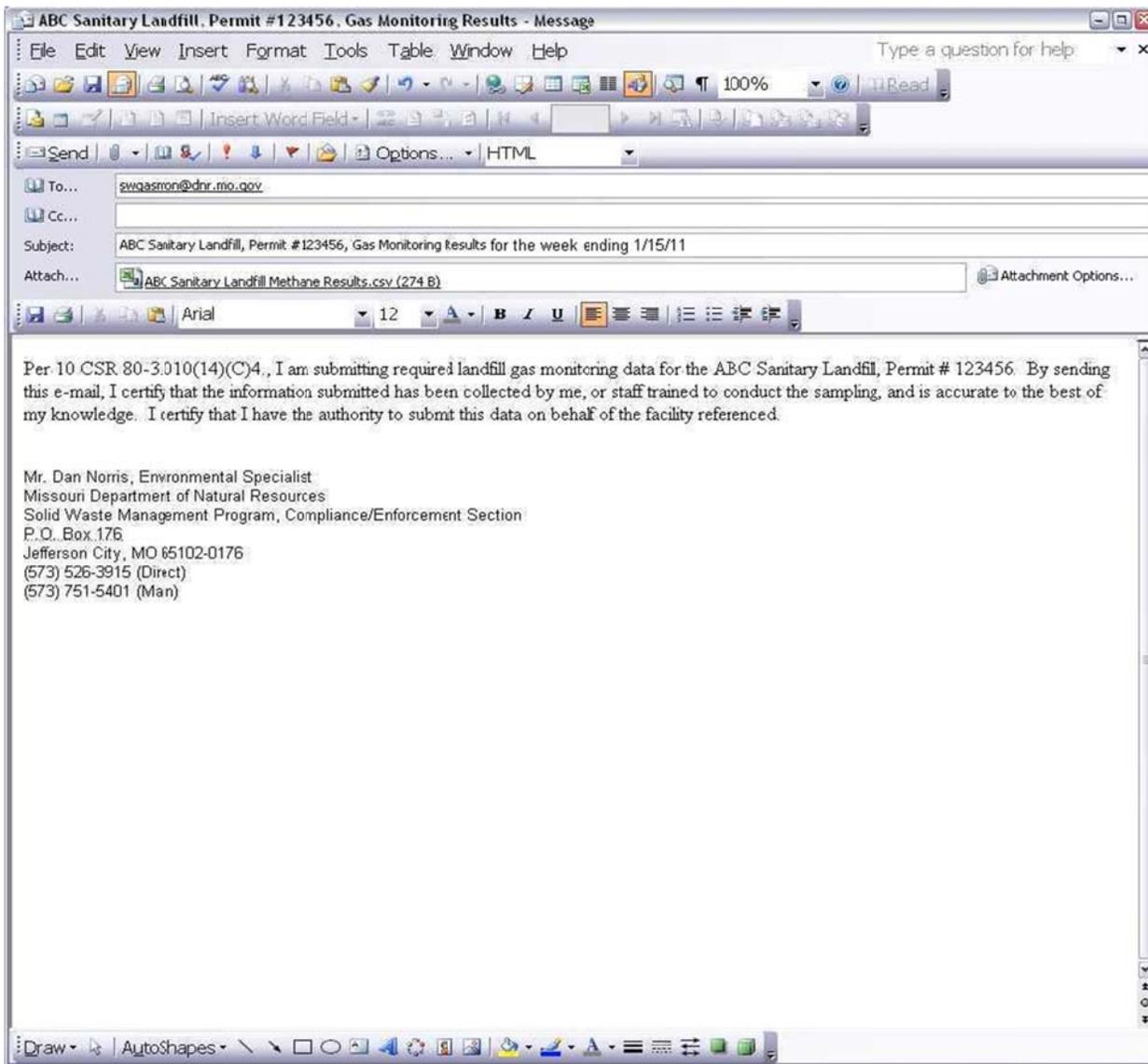
## Emailing the data

After the data has been saved in the CSV format, you will need to email the data, as an attachment, to [swgasmon@dnr.mo.gov](mailto:swgasmon@dnr.mo.gov). Please keep the following guidelines in mind when submitting the data to the Solid Waste Management Program:

1. Use the following subject line in the email you submit to the Solid Waste Management Program: (Approved Landfill Name), Permit # (Most Current and Approved Permit Number) Gas Monitoring Results for (Time Period) (i.e. 1<sup>st</sup> Qtr. 2011, Week Ending 1/7/2011, etc.). For example, ABC Sanitary Landfill, Permit #123456, Gas Monitoring Results for 3<sup>rd</sup> Qtr. 2008.
2. In addition to any comments or a description of the monitoring conducted in the attachment, include the following statement in the body of the transmittal email:  
Per 10 CSR 80-3.010(14) (C) 4. [10 CSR 80-4.010(14) (C) 4 for demolition landfills], I am submitting landfill gas monitoring data for the (Insert Landfill Name), Permit # (Insert Permit Number). By sending this email, I certify that the information submitted has been collected by me, or staff trained to conduct the sampling, and is accurate to the best of my knowledge. I certify that I have the authority to submit this data on behalf of the facility referenced.
3. The body of the email must include the name and contact information of the individual who is submitting the data. Email signature lines are acceptable if they are of the individual who is submitting the data.

4. Attach data for only one facility per email. If you need to submit data for multiple facilities, please send separate emails and attachments for each facility.
5. You may submit data for multiple monitoring dates in the same attachment. However, all data shall be submitted within seven days of sample collection to meet regulatory requirements.
6. Attach the CSV file to the transmittal e-mail.

**Figure 3 – Example e-mail transmitting the monitoring data spreadsheet**



If you have any questions about this process, please contact:

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Solid Waste Management Program, Compliance/Enforcement Section  
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573- 526-3915 (Direct)  
573-751-5401 (Main)  
[dan.norris@dnr.mo.gov](mailto:dan.norris@dnr.mo.gov)

**C. GAS MONITORING FLOW CHART**

