
# 8. Best Practices for Landfill Gas Collection System Operation and Maintenance

Photo credit (left): Smith Gardner, Inc.

A landfill's gas collection system (GCS) requires frequent monitoring and operational adjustments to optimize its performance to meet its design and operational goals. Proper operation and maintenance (O&M) can minimize air leaks in the system and reduce the amount of time a system is taken down for repair. Appendix A provides a series of flowcharts presenting typical wellhead monitoring procedures and operational adjustments for oxygen, temperature, methane, flow and vacuum. In addition, proper health and safety considerations and training are necessary to ensure the well-being of GCS operators.

*This chapter provides an overview of GCS O&M best practices. GCS operators can use this information to better understand options to ensure a well-maintained GCS to minimize surface emissions and system downtime and ensure the health and safety of employees. Each best practice may not be suited for a particular landfill so application must be determined on a site-specific basis. Information in this chapter is not official guidance; rather, it provides general information about options and considerations for GCS O&M. Landfill owners and operators are responsible for compliance with applicable regulations.*

## 8.1 System Vacuum

Blowers provide a consistent vacuum, often measured in inches of water column (in. WC), to convey landfill gas (LFG) from individual wells, laterals and headers to a central location for combustion in a flare or energy recovery. Although the vacuum applied to individual wells may vary based on the function and location of each well or collector, the vacuum should remain relatively stable over time at a given point in the collection system. Large fluctuations in vacuum at the same collection point in the system suggest potential concerns with condensate buildup or a blockage in the system.

Commonly, blowers use a pressure sensor and a variable frequency drive (VFD) attached to the blower to control and stabilize the vacuum applied to the GCS. The pressure sensor measures the vacuum on the header which, via a programmable logic controller and VFD, controls the frequency and voltage supplied to the motor. This in turn controls the speed at which the blower impeller(s) operate. The VFD can speed up or slow down the blower to maintain a consistent vacuum on the GCS. With such controls, technicians can more accurately tune each well, knowing that the applied vacuum from the system is relatively consistent. Adjustments to a well should be made in small increments and then re-monitored to assess how those changes affect the operations. Large adjustments can lead to wide swings in operational adjustments at the well and at adjacent extraction points.

The vacuum applied to the GCS by the blower must be sufficient to provide the furthest point of the landfill with a minimum vacuum, typically 5 to 15 in. WC at full flow conditions. However, the vacuum cannot be so high that it becomes difficult to tune the wellfield or compromises the condensate management system. Systems are typically designed for a vacuum ranging from 30 to 60 in. WC or more, depending upon the overall size and number of LFG extraction points in the wellfield. The vacuum that the well applies to the waste is adjusted at each individual wellhead and must balance the need to achieve a high gas collection efficiency to avoid odors and surface emissions, while also avoiding excessive vacuum that can lead to air infiltration.

### Control System Types

Beyond identifying and managing the physical conditions of the wellfield, it is just as important to understand the control goals. Systems are typically set up in one of three control modes: vacuum, flow rate or heat content (in British thermal units or Btu). The control setup is an important consideration in wellfield operation because operators need to understand how tuning a single well can affect the rest of the system and therefore its impact on meeting the overall objective.

- Vacuum control – The control system maintains a constant vacuum while allowing the LFG flow rate and heat content to vary. In this situation, vacuum at every well is controlled individually and does not affect the vacuum at the other wells. Once a wellfield is tuned, the vacuum should stay very stable. Vacuum control, however, requires flexibility of the end use to handle variable flows and heat content levels.
- Flow rate control – The site sets a desired LFG flow rate at a flow meter and the VFD maintains this rate. In this situation, when the flow rate at an individual well is increased, the flow rate at every other well will decrease slightly to maintain constant flow. This operating situation is not ideal and typically occurs only for short periods of time when the system has reached a minimum or maximum limit for the LFG end use.
- Heat content control – This type of system is often used for landfills with an energy project and is the most complicated system for tuning. Every time an individual well is adjusted, the flow and vacuum for other wells in the system also change. For this reason, it is important for operators to work slowly and make small changes. Heat content control systems are the easiest to make significant changes to the gas quality, whether positive or negative. It is the system type typically used for beneficial-use wellfields, because it incorporates not only parameters for regulatory compliance (i.e., vacuum application and gas quality) but also parameters needed for an effective LFG energy recovery project, including volumetric flow and fuel value.

### Well Tuning

Operating a GCS is a balancing act of applying vacuum to a collector to obtain the largest radius of influence possible and thus collecting as much LFG as possible, while not pulling too hard on the collector so as to avoid air intrusion through the cover, into the waste mass and into the LFG collector. Over-pulling (applying excess vacuum) on an LFG collector can lead to excessive oxygen in the waste mass, which could reduce methane production or in severe cases start a subsurface oxidation event (fire). Applying too little vacuum does not create a large enough radius of influence around the collector, preventing overlapping radii of influence with the adjacent collectors and allowing fugitive LFG to escape through the cover.

The operational goals of a wellfield are typically determined during the design of the GCS since the goals of the system will influence both its design and operation. Common end goals of a GCS are:

- Maintain compliance;
- Generate electricity;
- Produce medium-Btu gas; or
- Produce renewable natural gas (RNG).

Because these goals have very different tuning approaches, it is difficult to meet all the goals at the same time. However, with the primary goal in mind, operators can tune the wellfield to meet the needs of the system as a whole.

To maintain compliance by controlling odors and gas migration, operators aim to optimize LFG collection at each well. This may result in a small amount of atmospheric air infiltrating the surface of the landfill during attempts to keep the entire landfill under vacuum and maximize the influence of each well. In a typical landfill, tuning for 48 to 52 percent methane content in the LFG will result in some infiltration of atmospheric air. Balance gas (nitrogen) may constitute 10 to 15 percent of the LFG with 0 to 2 percent oxygen. (See Identifying Air Leaks below for additional information on this topic.)

For the purpose of collecting LFG to supply an energy generation project, it may seem appropriate to increase the vacuum on the system as a whole or at individual wells to collect more gas on a flow basis. However, this approach causes two problems: (1) it pulls air into the landfill, diluting the LFG that is collected and reducing its heat content, and (2) it pulls oxygen into the waste mass, creating aerobic conditions that are not ideal for methane production. Instead, a balanced approach of maximizing the radius of influence without creating aerobic conditions is most effective. This often requires upgrading cover materials, installing new gas collectors and modifying wellfield tuning procedures.

Some types of energy generation facilities or other LFG end uses require a minimum quality of gas to meet either the contract or equipment requirements that further dictate how the system is tuned. The Solid Waste Association of North America (SWANA) developed a range of relative methane concentration target values based upon the goal(s) of GCS operation, as shown in Table 8-1.

**Table 8-1. Example Methane Target Values[1]**

| Target (%) | Application |
|---|---|
| **50-55** | Interior wells for energy recovery |
| **45-50** | Interior wells where environmental control is important |
| **40-45** | Aggressively trying to control LFG migration |
| **30-40** | Interior wells where acute LFG emission problems are occurring (but there may be an increased risk of fires at some sites when operating in this range) |
| **<30** | Perimeter gas wells outside of refuse |

## Identifying Air Leaks

An air leak in a GCS is a problem that must be actively identified and repaired. Air leaks lower the gas quality for beneficial use facilities and can also cause individual wells to underperform by diluting the methane concentration and possibly requiring the applied vacuum to be lowered during well tuning to meet operational goals. To quickly identify these air leaks, operators should look for 4 parts balance gas to 1 part oxygen in all gas readings (4-to-1 ratio), the ratio of balance gas to oxygen in the atmosphere.

Nitrogen is typically not produced during the generation of LFG so any nitrogen present in a gas well has been pulled into the system from the atmosphere. A typical well that is balanced will be operating at 2 to 10 percent nitrogen (monitored and read as balance gas), indicating that the well's vacuum is pulling to

1 Solid Waste Association of North America. Landfill Gas Operation & Maintenance Manual of Practice, Version 1.0, revision September 2002, Table 9.3.

the surface but not introducing excessive atmospheric air. The exact target for nitrogen content should be based on the operational goal of the GCS (e.g., for compliance alone or compliance and a beneficial use project). Nitrogen/balance gas targets assume that the air intrusion is through the waste mass and not an air leak in the collection system itself.

Wells that are operating above 20 percent balance gas should be corrected immediately, because this can affect the methane-producing (anaerobic) bacteria by creating aerobic conditions, thereby reducing methane production. Additionally, the transition from an anaerobic to an aerobic environment is exothermic (i.e., produces heat). If atmospheric air intrusion is allowed to persist, the waste mass may begin to oxidize locally, risking a sub-surface fire. This negatively affects not only local LFG production but also the structural integrity of the GCS and the cover system.

Ranges of residual nitrogen and their likely impacts are provided in Table 8-2. These interpretations can be incorporated into the tuning scheme for the wellfield to increase the effectiveness of GCS operations.

**Table 8-2. Interpretation of Residual Nitrogen in LFG[2]**

| Residual Nitrogen (%) | Interpretation |
|---|---|
| **0-6** | Normal to under-stressed; typical for a wellfield supporting an RNG project where low nitrogen is desirable |
| **6-12** | Normal desirable operating range without compromises for problem areas |
| **16-20** | Excessive nitrogen, may be necessary for aggressive perimeter migration control, side slope emission control or where other compromise is required |
| **>20** | Over-stressed; this level of nitrogen should be avoided if possible, except for aggressive emission control |

### Identifying Vapor Locked Wells

Vapor locked wells are restricted by some means and do not allow for sufficient gas flow as designed. The wells can be full of liquids or be pinched, broken, plugged or fouled and these conditions can be identified by interpretation of collected wellfield data. Vapor locked wells have a header vacuum that is very close to the applied vacuum because flow creates a pressure drop across the wellhead. These wells also typically have high methane quality, showing ample LFG available but minimal flows.

### Issues Due to Waste Settlement

Waste filling practices in areas of the landfill with a GCS already in place can lead to negative impacts on the GCS from damage caused by operations or settlement. Landfills that accept large amounts of waste tend to have more settlement of the waste mass, which can negatively impact GCS components by creating low points in piping or blockages. Typically, the GCS at these sites may require more frequent component inspections and a plan for replacement to maintain operational goals.

Similarly, sites that fill large flat areas across several cells gain airspace from settlement over time, but the GCS tends to have shallow wells, laterals with minimum slopes and high liquid infiltration causing higher GCS operational costs. In these situations, GCS components may become buried and ultimately

[2] Solid Waste Association of North America. Landfill Gas Operation & Maintenance Manual of Practice, Version 1.0, revision September 2002, Table 9.4.

unusable. Portions of the GCS at these sites should be considered sacrificial as they may need to be repaired or replaced multiple times during the life of the landfill.

## 8.2 Managing Excess Liquids in Collection System

Moisture can become a major issue for gas generation, gas collection and slope stability when it becomes free standing liquid within the waste mass. Liquids in wells and within the landfill should be managed and removed regularly, even at sites that are operating under a liquids recirculation plan. If wells or lateral/header piping become flooded with liquids, they will not be able to extract the LFG and convey it to the flare or other equipment. A variety of techniques exist to monitor for flooded wells or piping, including simple observations to more advanced techniques.

The following general observations can indicate "watered-in" wells or piping:

- High well vacuum but low or no flow;
- Drops in header system vacuum from well to well;
- Audible surging of liquids, either at individual wells or in the collection lines between the wells when walking along the surface of the landfill.

More advanced monitoring techniques for liquids include:

- Checking liquid levels periodically in the wells;
- Measuring the liquid recharge rate in wells after pumping;
- Inserting a camera down the well to identify the depth of the water or other well damage;
- Adding submersible or "diver" dataloggers inside of problematic wells to allow a landfill operator to continuously measure and track liquid levels.

Preventing liquids from entering the GCS is the most practical and cost-effective solution. One inch of precipitation over an acre of exposed surface results in more than 27,000 gallons of potential liquid infiltration. A variety of operational techniques are available to reduce surface liquids:

- Apply alternate daily cover such as "Posi-Shell" and tarps in new cells that will not be in service for a long time.[3]
- Consider early partial closure of areas with geomembrane. Place temporary geomembrane caps over areas that will not receive waste for a long time and final cover on final slopes to eliminate rainwater percolation.[4]
- Maintain a smaller and appropriately sloped working face to limit precipitation intrusion.
- Avoid overuse of recirculation practices and consider limiting recirculation to surface spraying of active working face.

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3 Szczepanski, Mallory. 10 Tips for Preventing Landfill Leachate. July 2017. http://www.waste360.com/leachate/10-tips-preventing-landfill-leachate/gallery?slide=5.

4 Szczepanski, Mallory. 10 Tips for Preventing Landfill Leachate. July 2017. http://www.waste360.com/leachate/10-tips-preventing-landfill-leachate/gallery?slide=2.

### Pumps

In some cases, pumping will be required, despite efforts to minimize surface water or other liquids from entering the landfill. Many systems employ pump systems within individual LFG extraction wells to reduce local zones of waste saturation and improve the operations of individual LFG collectors. Because LFG wells are typically the most permeable components within the waste mass, liquids tend to accumulate in these locations.

When liquids accumulate in wells, the elevated liquid levels within the well casing diminish the efficiency of the extraction well. As the liquid level rises within the perforated casing section, vacuum is applied to an increasingly smaller volume of waste. This not only reduces the potential volume of LFG that can be recovered from an individual well, but also increases the potential for air intrusion since more vacuum is applied to the top of the perforated casing section.

Pneumatic pumps are typically used to remove liquids from LFG extraction wells. They provide a slow (less than 2 gallons per minute), steady rate of withdrawal over a wide range of discharge head requirements. By using a slow withdrawal rate, the operator limits the potential for fouling the backfill by keeping the liquid velocity relatively low as it travels through the waste mass, thereby limiting the ability of the flowing fluid to carry fine particles.

Monitoring of the liquid levels, along with comparisons of changes in LFG recovery performance, should be continued on at least a monthly basis until a steady-state condition is achieved. Pumping may be required for an extended period of time, depending upon the degree of local waste saturation and re-charge from precipitation or other liquid addition. If a "maintenance level" of liquid can be achieved that does not require additional pumping, the pumping equipment may be removed for another installation.

### Air Compressors

A pneumatic pumping system requires air compressors designed for continuous, industrial applications. Air compressors for LFG applications are typically oil-free screw compressors with relatively large receivers. The compressed air must also be conditioned to avoid filling the compressed air mains with condensate from the compression process. This requires an industrial-level air dryer and filtration system to maintain a usable air supply. Laboratory-quality compressed air is not required, however a uniform and "clean" air supply will increase the reliability of the pumping system and reduce costly maintenance of both the compressed air supply system as well as pumping components.

If the GCS includes pneumatic components that are critical for GCS operation, such as fail-close valves and a condensate management system at the blower station, then a backup or segregated compressed air system or the use of compressed nitrogen for emergency purposes may be necessary.

## 8.3 GCS Monitoring

A robust and proactive monitoring system, consisting of both physical inspection and analytical data collection techniques, can detect operational problems early and minimize system downtime. State and federal rules prescribe certain monitoring of a GCS, which should be viewed as minimum requirements. State or federal wellhead monitoring requirements may include:

- Surface emissions monitoring for methane;
- Vacuum present at the wellhead (i.e., less than 0.0 in. WC);
- Oxygen and nitrogen content; and
- Wellhead temperature.

For relatively high wellhead temperature readings (i.e., above 62.8ºC (145ºF)), federal rules require enhanced monitoring of other parameters including visual observations for subsurface fires, carbon monoxide content and methane content. For higher wellhead temperatures (i.e., above 73.9ºC (165ºF)), federal rules require monitoring of temperature down in the well in addition to the wellhead temperature.

Exceptions may apply to these thresholds in certain cases, such as when there is concern that applying vacuum to a well may exacerbate conditions where a subsurface fire is suspected. Additionally, positive pressure may be allowed in areas with a geomembrane or synthetic cover, provided that engineering calculations have been performed to determine the amount of allowable pressure that will not pose a risk of uplift and cap failure. Finally, these requirements may not apply to wells that have been permanently decommissioned, if LFG continues to be collected in the area.

Variances, in the form of higher operating values or alternative operating parameters may also be requested for approval to allow operating wells at higher temperatures. These requests must be supported by sufficient data to demonstrate that higher values will not pose a risk of subsurface fire or inhibit the production of methane.

In addition to minimum regulatory parameters above, flow rate should be monitored at all wellheads. A well may be under vacuum but not collecting any gas if leachate or condensate is covering the perforated zone. Total system flow and gas quality at the header should be monitored as well, as significant changes in header flow or quality can alert operators to issues in the wellfield that warrant investigation.

Closed landfills with final cover and a fully built-out GCS do not generally require the same level of attention as an active landfill and may be monitored on a monthly basis at a minimum. Voluntarily operated systems at a closed landfill may be monitored less frequently, although monthly monitoring continues to be recommended. Active landfills with partially installed systems may require more frequent monitoring. These systems are more susceptible to impacts from moisture (e.g., precipitation, leachate recirculation) due to potentially large areas of active filling and/or intermediate cover as well as air infiltration. Gas flow rates and quality may also vary due to atmospheric pressure changes. Additionally, waste filling operations may damage collection wells in active filling areas, requiring repair.

For wellfields supporting an energy recovery project, more frequent monitoring is generally recommended due to the financial incentive to maximize methane flow, not just LFG flow. Energy projects producing RNG require the highest level of wellfield tuning, to minimize air infiltration to the maximum extent possible.

Wellfield data should be collected and maintained in a database following each monitoring activity. Landfills with mandatory GCS operational requirements have as few as five days to initiate corrective action on wells exceeding certain compliance parameters, so early detection is critical. These data should be maintained for a minimum of five years, in order to observe trends over time and understand the impacts of GCS or landfill operations on gas generation and collection over time. For example, a landfill that recirculates leachate may experience a faster generation rate of LFG, as well as a more rapid decline, than predicted by LFG modeling.

Databases for wellfield data may be simple spreadsheets or data reporting tools included in many office software packages such as Microsoft® Excel or Access. Data may be filtered or sorted to view changing conditions and trends by wellhead over time, such as declining flow rates or increasing temperatures. Wellhead vacuum can be compared to header vacuum to identify wells that may be "watered-in." Conditional formatting within spreadsheets can help identify regulatory exceedances at a glance. Landfills with a larger, complex GCS may benefit from more robust data management software packages. These solutions may include Geographic Information Systems (GIS) functionality to generate maps depicting areas of high temperature, declining methane or other operational concerns. Automated graphing and report generation may be included as options for some of these packages to facilitate wellfield data trending and evaluation.

In addition to gas flow and quality trends over time, monitoring data can be used to identify unintended subsurface conditions in landfills that that may be caused in part by GCS operations, including subsurface reactions and subsurface oxidations (fires).

Subsurface reactions are seen in landfills where relatively deeper, wetter areas of waste experience an interruption in the anaerobic production of methane. These conditions tend to cause heat accumulation and inhibit methane production. Certain waste types, including ash and metals, may react exothermically as they corrode to produce additional heat. Rapid dewatering of deep wells may inadvertently introduce oxygen to the surrounding waste mass, further upsetting the anaerobic conditions. This subsurface reaction, not to be confused with subsurface combustion, forms products seen in the early aerobic stages of waste degradation, including fatty acids and hydrogen. These reactions also form positive pressure and carbonation of leachate in the well, leading to wellheads "popping off" and leachate foaming. Rapid localized settlement of several feet may occur around one or multiple wells during these reactions. In addition to enhanced monitoring requirements under regulations, monitoring data, including LFG collection for lab analysis, may indicate that a subsurface reaction is occurring. These data include:

- Elevated temperature;
- Low methane-to-carbon dioxide ratio;
- Positive well pressure;
- Well foaming;
- Low oxygen;
- High hydrogen levels;
- High ammonia levels; and
- Rapid localized settlement around one or several wells.

Hydrogen and ammonia may be read as balance gas and assumed to be nitrogen. Gas samples will need to be collected for laboratory analysis to confirm their presence.

Subsurface fires occur when waste below the landfill surface undergoes combustion. These combustion events may occur when air is introduced into the waste mass as a result of wells placed under excess vacuum, commonly referred to as "over-pulling." These events typically occur from just under the landfill surface to depths of as much as 15 to 20 feet. Parameters that may indicate subsurface fires include:

- High temperature;
- Low methane-to-carbon dioxide ratio;
- Carbon monoxide;
- Visible smoke or discoloration of flexible wellhead hose from heat/smoke;
- Air infiltration and aerobic conditions in waste; and
- Rapid localized settlement around one or several wells.

Subsurface reactions and subsurface fires may exhibit some of the same parameters. Thus, it is important to collect as much data as possible and evaluate all parameters together.

Emerging technologies may improve wellfield operations and improve LFG collection. Remote monitoring of LFG flow rates and quality through telemetry and other methods have been proven technologies at flares and blower skids for several years. In recent years, technologies have been developed to remotely monitor LFG flow rate and gas quality in header pipes and individual gas wells using sensors and radio or cellular transmitters to relay the data to a cloud-based data server. Remotely actuated valves may be installed to control vacuum and flow rates at the individual wellhead based on direct operator input, setpoints for various parameters or complex algorithms which attempt to balance multiple parameters. As of May 2021, approximately 24 U.S. MSW landfills have remote header or well monitoring technologies installed. The objective of these efforts is to reduce costly labor and optimize LFG flow rates and boost overall methane yields. Due to initial capital cost, ongoing maintenance related to sensor replacement and programming, adoption of these technologies is limited and primarily confined to larger landfills able to generate revenue from LFG energy projects. However, some landfills have also employed this technology for odor management.

Emerging technologies have also improved options available to landfills for completing methane surface emissions monitoring requirements, identifying leaks more efficiently and reducing exposures and other health and safety risks for monitoring personnel. New monitor and methane sensor technologies reduce the need to use flammable hydrogen fuel to operate the traditional toxic vapor analyzer monitors. In addition, research with aircraft-based, drone-based and satellite-based sensor technologies is being conducted to detect fugitive methane emissions at landfills. EPA hosted a Landfill Surface Emissions Monitoring and Measurement Virtual Workshop in January 2021 to share information about emerging monitoring and measuring technologies for MSW landfills.

## 8.4 Health and Safety

There are many details associated with GCS health and safety through industry guidance as well as Occupational Safety and Health Administration (OSHA) and National Fire Protection Association (NFPA) requirements for various activities. Personnel working with a GCS should be aware of any site-specific health and safety requirements, including the site-specific Health and Safety Plan (HASP).

*Every employee is responsible for his or her own safety, as well as the safety of those around them.*

Although a comprehensive safety review encompassing all potential impacts is not provided in this document, there are several general items applicable to all GCS facilities, listed below. This list is intended to be an overview and does not take the place of a HASP developed by a trained safety professional. Additional guidance can be obtained from SWANA's *Landfill Gas Operation & Maintenance Manual of Practice*[5] and other industry publications.

1. Do not smoke or allow other sources of ignition within 25 feet of any source of LFG, including LFG components and portions of the leachate and condensate management systems.
2. Use a personal combustible gas meter when working around any GCS components. Meters should have a minimum capability of monitoring for oxygen-deficient conditions, carbon monoxide concentrations and methane concentrations.
3. Understand the potential hazards of working in proximity to LFG and LFG condensate.
4. Wear appropriate personal protective equipment (PPE) for all tasks and be aware of the relative limitation of each level of PPE. Level D is the minimum requirement.
5. Make sure that all PPE is in good, working condition.
6. Make sure that all monitoring equipment is fully charged and calibrated per manufacturer's requirements.

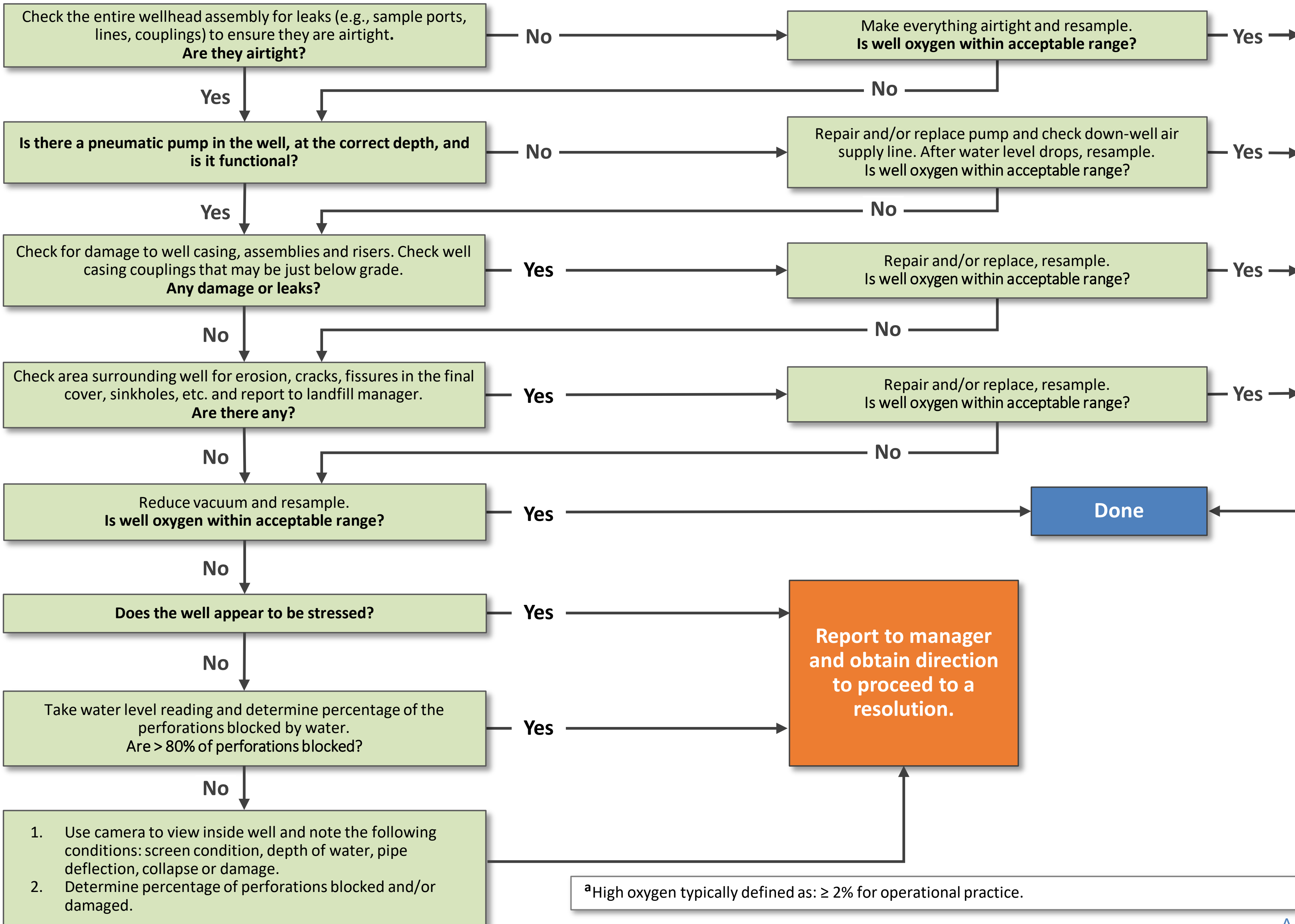
5 Solid Waste Association of North America. Landfill Gas Operation & Maintenance Manual of Practice, Version 1.0, revision September 2002.

7. Verify that all pressures are relieved, and that any potential sources of pressurization are de-energized or locked out, before opening any vessels.
8. Always comply with mechanical, electrical, pneumatic and hydraulic lock-out/tag-out procedures.
9. Have personnel trained to identify and work in permit-required confined spaces.
10. Have personnel trained to identify trenching and excavation activities compliant with OSHA requirements.
11. Never leave open excavations (including well bore holes) unmarked, unsecured or unattended, including the use of grates during well drilling, setting casings, backfilling and well completion.
12. Understand the hazards of working in proximity to flares and associated combustion systems.
13. Understand the hazards of working in proximity to rotating equipment, including blowers, compressors and pumps.

# Appendix A

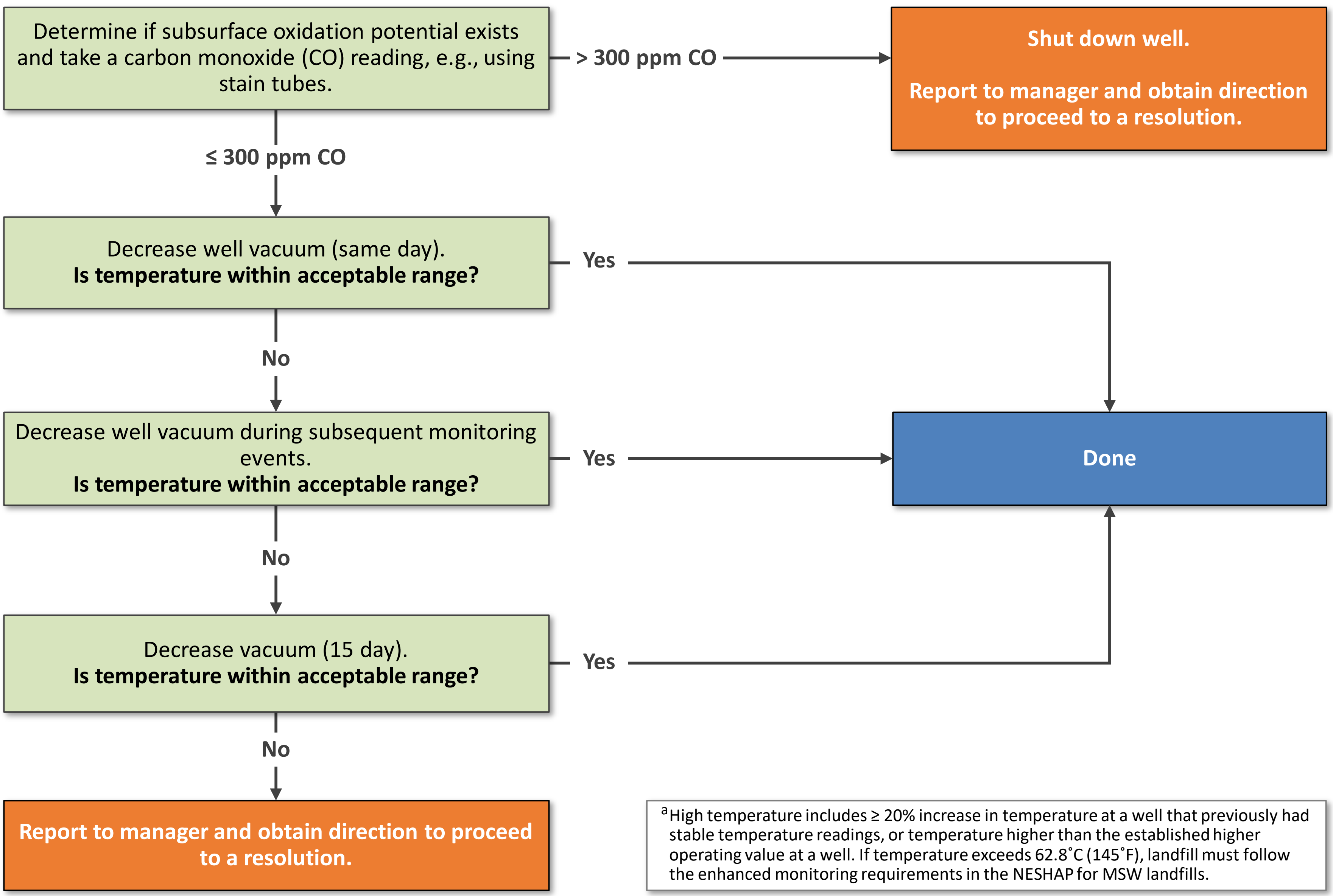
## Typical Wellhead Monitoring Procedures and Operational Adjustments for Oxygen, Temperature, Methane, Flow and Vacuum

# High Oxygen Monitoring Procedure[a]



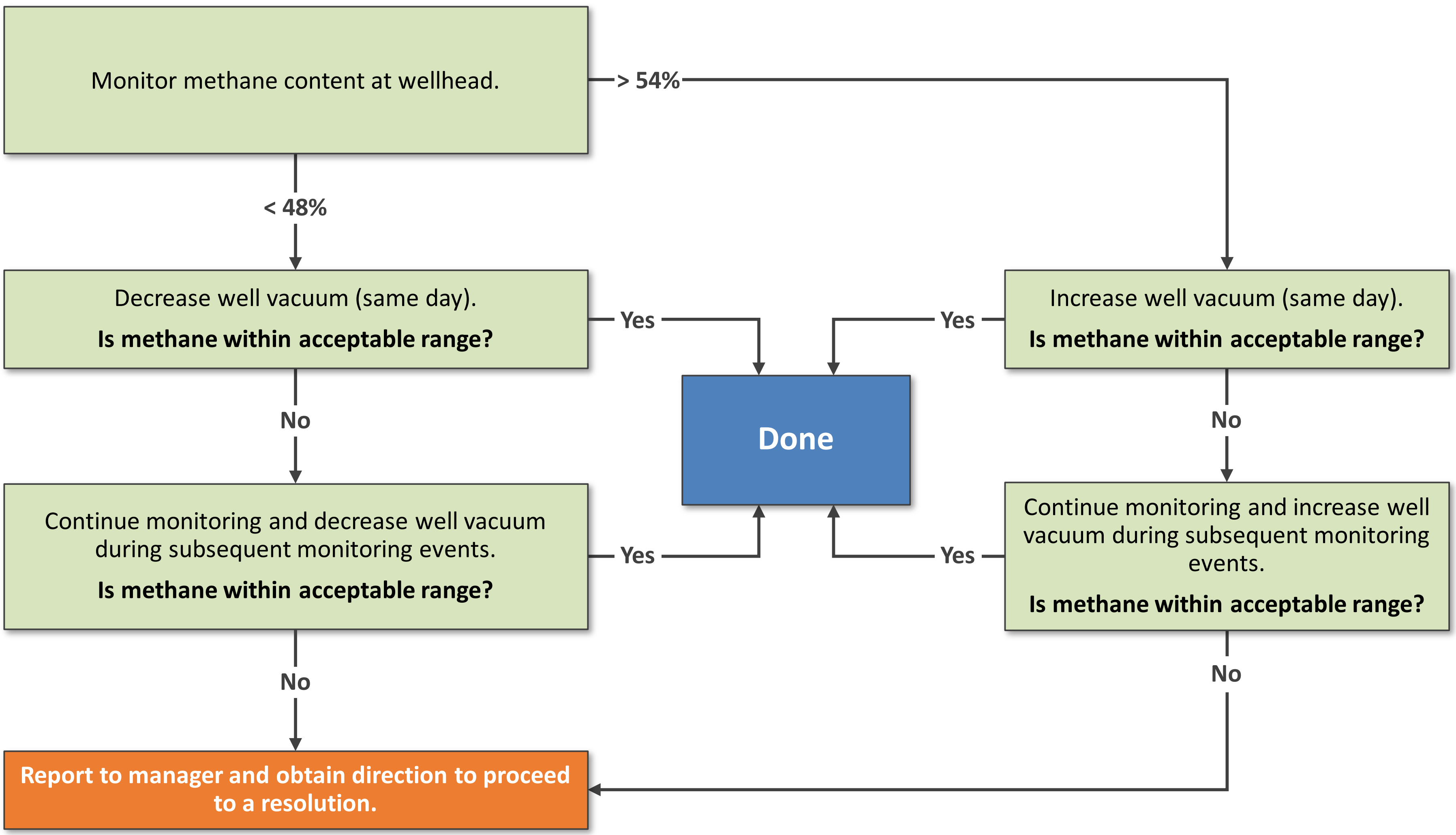

[a]High oxygen typically defined as: ≥ 2% for operational practice.

## High Temperature Monitoring Procedure[a]



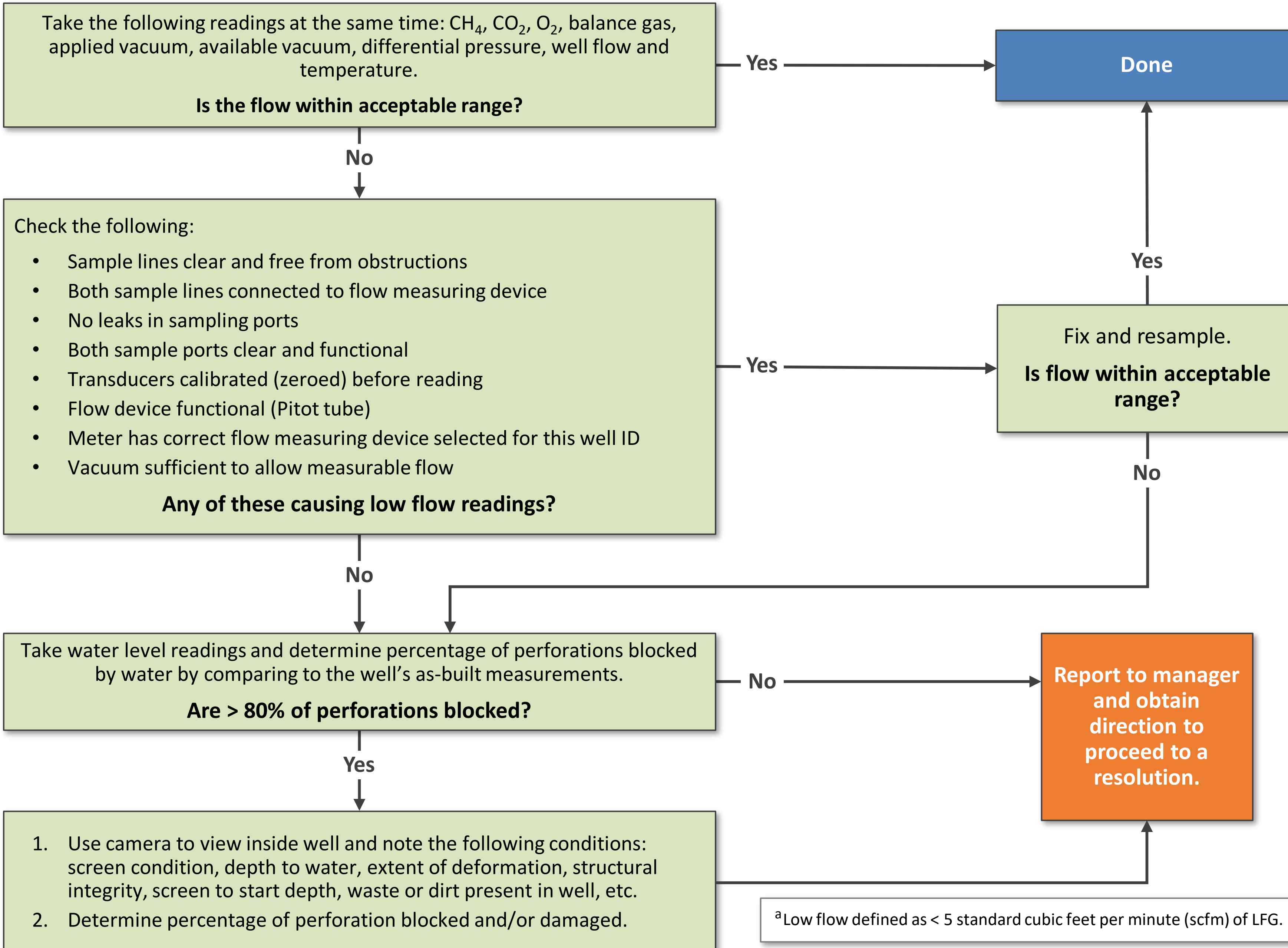

[a] High temperature includes ≥ 20% increase in temperature at a well that previously had stable temperature readings, or temperature higher than the established higher operating value at a well. If temperature exceeds 62.8˚C (145˚F), landfill must follow the enhanced monitoring requirements in the NESHAP for MSW landfills.

## Low/High Methane Monitoring Procedure[a]



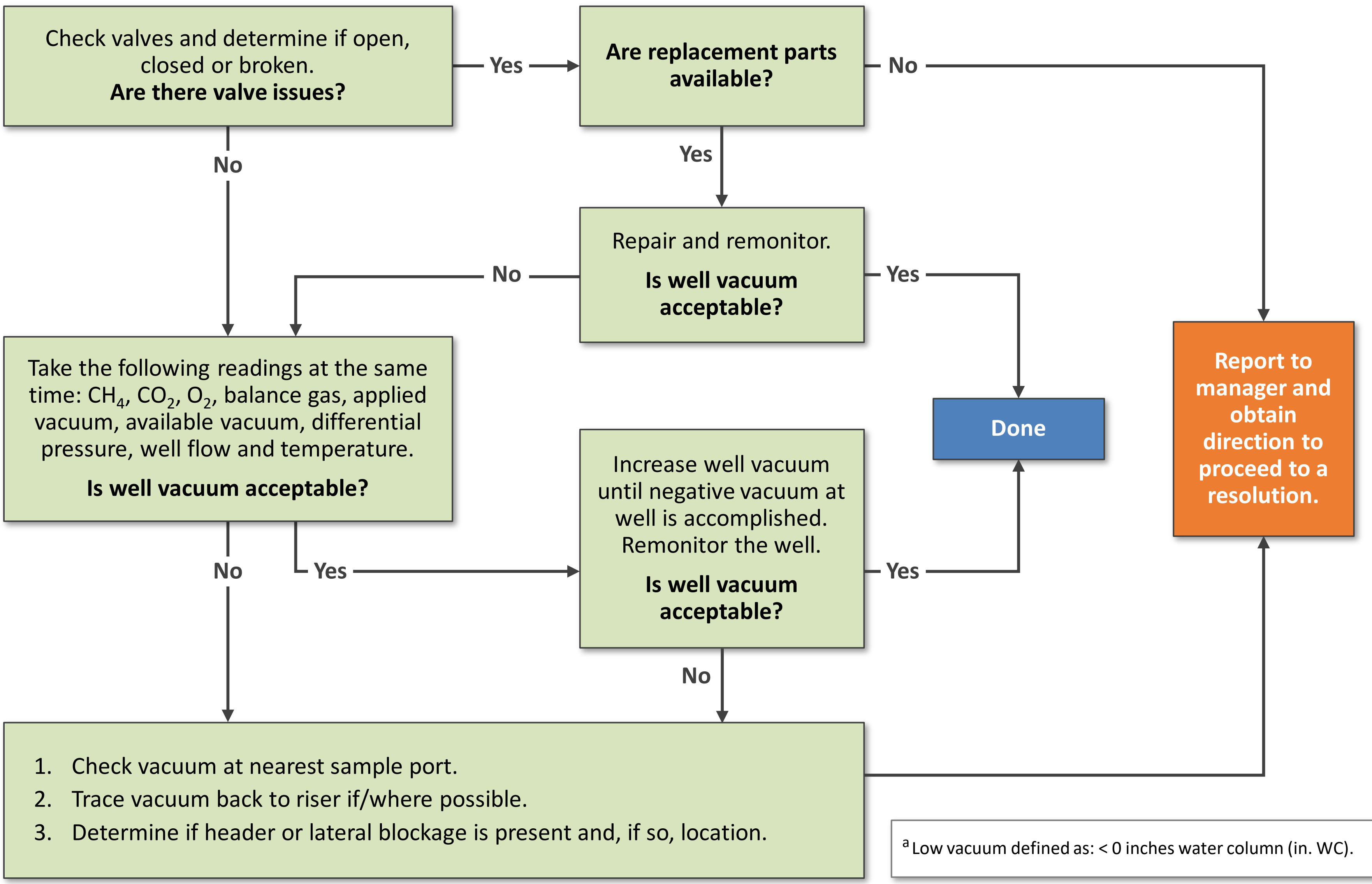

[a] Low methane defined as: < 48%; High methane defined as: > 54%.

**Low Flow Monitoring Procedure[a]**




[a] Low flow defined as < 5 standard cubic feet per minute (scfm) of LFG.

## Low Vacuum Monitoring Procedure[a]




[a] Low vacuum defined as: < 0 inches water column (in. WC).