6. Landfill Biogas Wellfield, Conveyance, and Condensate Systems

6.a System Description

6.a.1 Wellfield and Conveyance Systems

The LFG wellfield system is comprised of a network of wells or collectors in the landfill, coupled with conveyance piping for the transport of LFG to a blower-flare facility, other treatment and disposal, and/or energy recovery equipment.

Vertical extraction wells are commonly installed into the interior landfill waste mass for LFG emission control and energy recovery, once the filling operations have been completed. They are also installed along the landfill perimeter for LFG migration control. See ***Exhibits 6-1a*** and ***6-1b***.

EXHIBIT 6-1a: VERTICAL LFG EXTRACTION WELLS

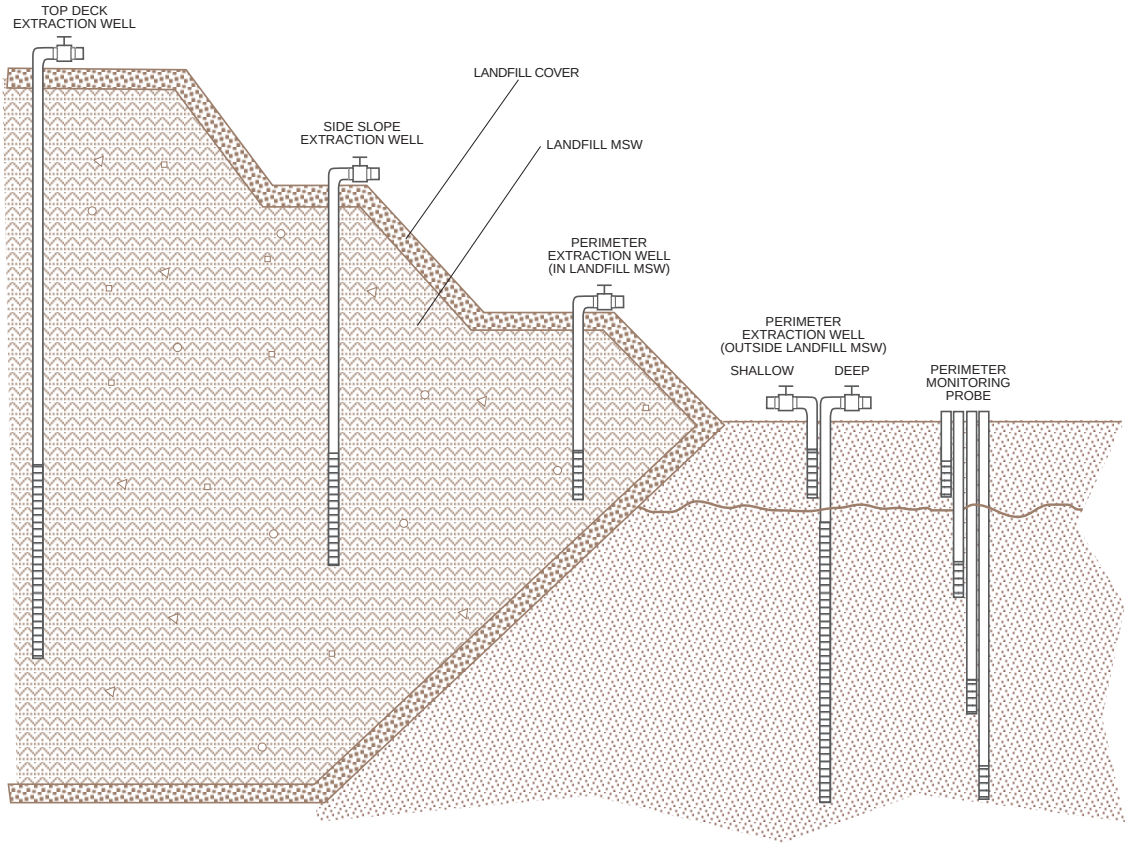
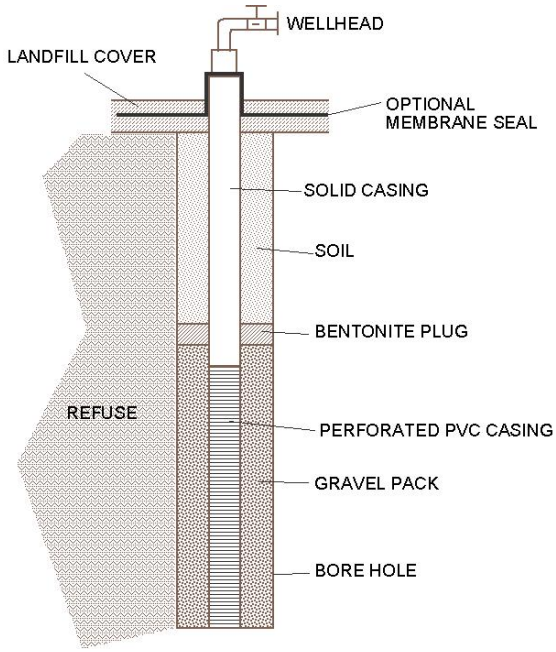


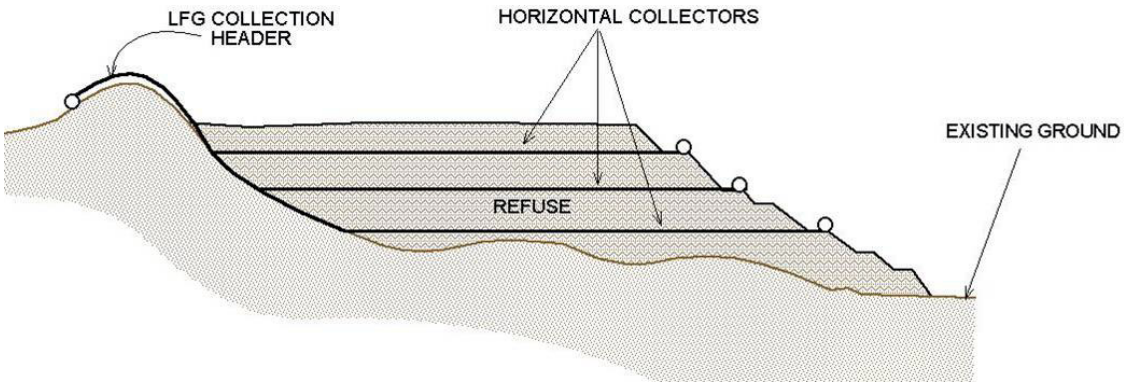
EXHIBIT 6-1b: VERTICAL LFG EXTRACTION WELL DETAIL



The installation of horizontal wells (e.g., trench collectors) serves as another efficient LFG collection method, particularly in landfills that are still being actively filled. See ***Exhibits 6-2a*** and ***62b***. Once a lift of waste has been placed and compacted in the landfill, perforated collection pipes are installed and another layer of waste is placed on top. This allows for LFG collection directly below an active fill area.

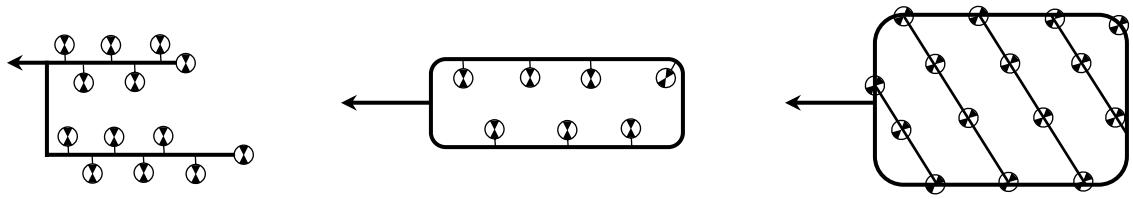
EXHIBIT 6-2a: HORIZONTAL LFG EXTRACTION WELL

EXHIBIT 6-2B: HORIZONTAL COLLECTORS DIAGRAM



A piping network is constructed to connect the LFG collection wellfield to the blower and flare facilities. The main pipe used to transport LFG from the wellfield to the processing facilities is known as a header. Lateral pipes connect landfill wells and trenches to the header(s). Subheader pipes connect the lateral pipes. There are different header piping configurations including: matrix, branch, and looped arrangements. See ***Exhibit 6-3***. A primary objective when designing the collection header piping configuration is to achieve effective LFG drainage.

EXHIBIT 6-3: LFG HEADER ROUTING CONFIGURATIONS

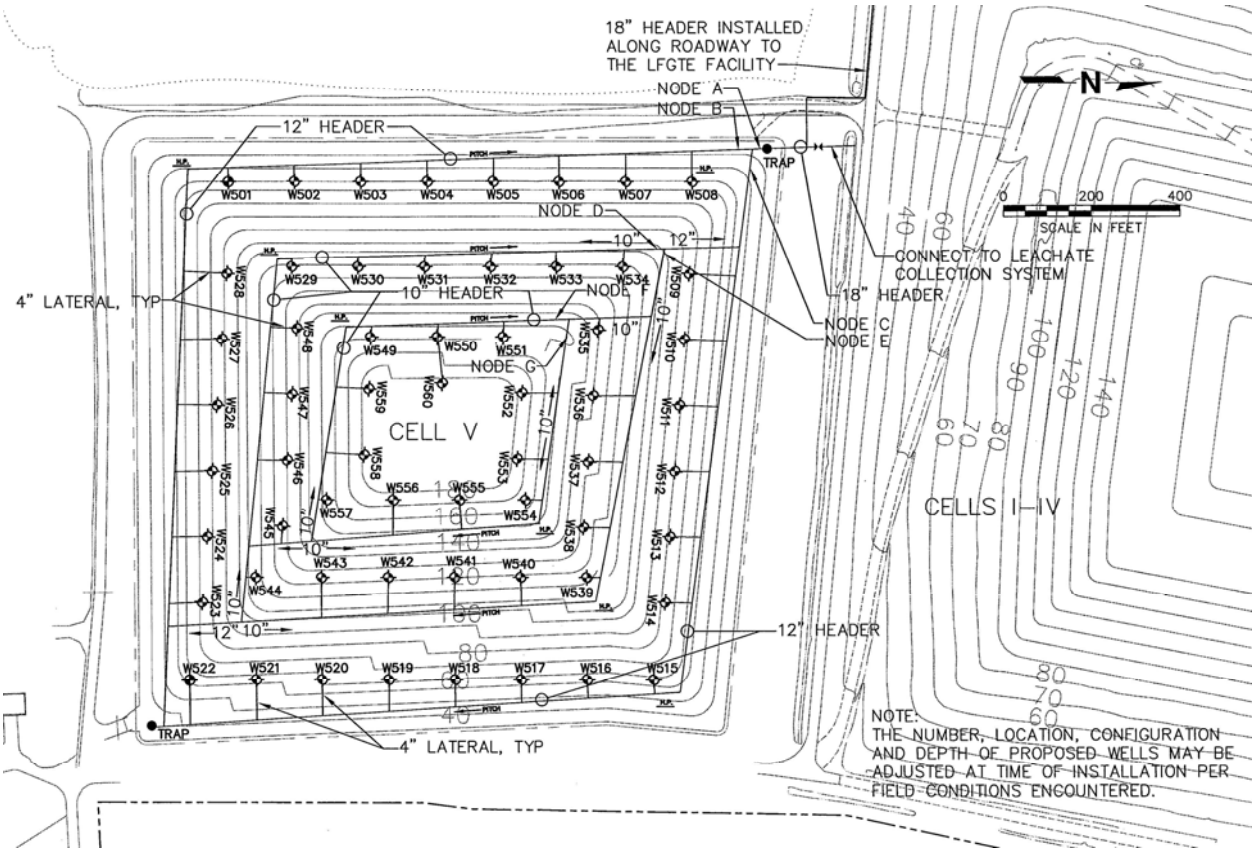


Branch **Loop** **Matrix**

Before LFG from the wellfield reaches the blower and flare systems, it typically passes by an inlet block valve which serves as the primary wellfield LFG flow throttle. During maintenance activities, the throttle may also be used to isolate the blower and flare facilities from the wellfield.

Next, the LFG typically passes through a liquid knockout vessel (i.e., mist eliminator) installed in a piping segment which removes the flowing liquid and particulate from the gas. The liquid may be collected in sumps or drained back into the landfill. A big advantage associated with inline knockouts is that they can be used in LFG piping where there is little or no slope. ***Exhibit 6-4*** shows a typical LFG wellfield and conveyance systems layout.

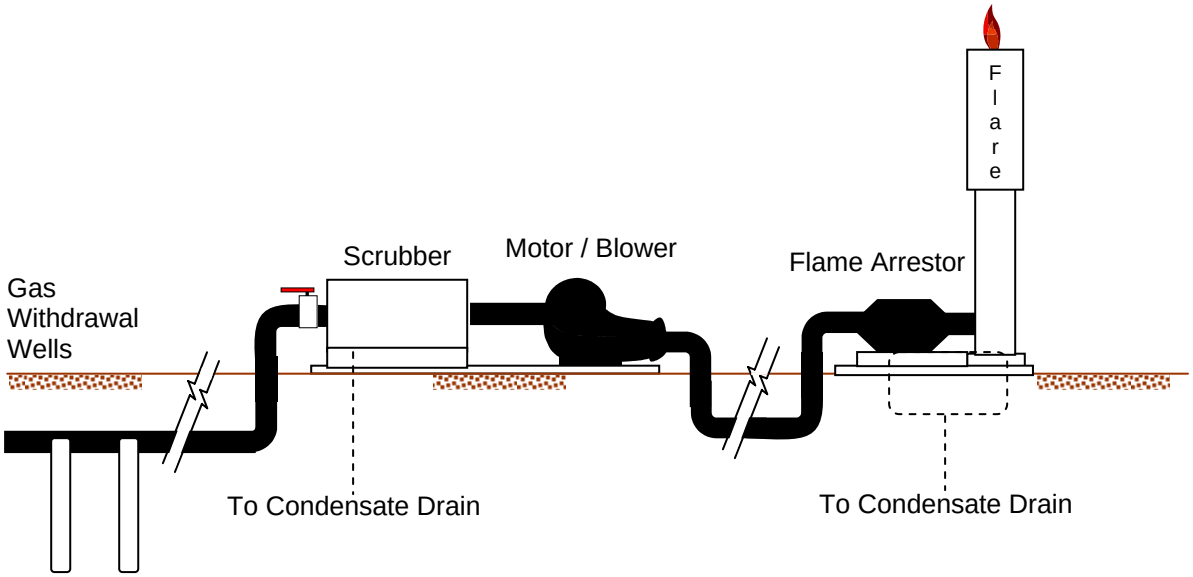
EXHIBIT 6.4: TYPICAL LFG WELLFIELD AND CONVEYANCE SYSTEMS



6.a.2 Condensate System

The LFG condensate system is responsible for removing water that condenses in the system as a result of gas cooling as it passes through the header piping and processing equipment. The condensate system uses traps, sumps, and knockouts, specifically located in the collection system, blower, and flare facilities, to collect and remove water. Such liquid gets in the way of LFG flow and must be properly managed, either through treatment and disposal back in the landfill or elsewhere. Typical LFG condensate system locations are shown in ***Exhibit 6-5***.

EXHIBIT 6.5: TYPICAL LFG CONDENSATE SYSTEM LOCATIONS



6.b Typical Components

6.b.1 Wellfield and Conveyance Systems

The primary components of the wellfield and conveyance systems include:

- Horizontal and/or vertical extraction wells (collectors)
- Well monitoring ports and flow control assembly for the extracted gas
- Piping for the LFG collection and conveyance
- Block valve
- Liquid knockout vessel
- Surface collectors
- Cover cap for the landfill.

LFG conveyance systems are typically made up of one or more of the following plastic materials: polyvinyl chloride (PVC), high density polyethylene (HDPE), and/or

fiberglass-reinforced plastic (FRP) pipe. Such pipe may be placed either under ground or above ground.

6.b.2 Condensate System

The primary components of the condensate system include:

- Condensate water traps
- Sumps
- Drain lines
- Oil and water separator
- Pumps
- Treatment equipment
- Air compressor
- Storage tank

6.c Data measurements

6.c.1 Wellfield and Conveyance Systems

Collecting data from the LFG wellfield on a consistent basis is important. This will enable operators to best achieve the goal of a balanced system. Monitoring frequency for the gas wellfield depends upon field conditions and requirements, but should at least be performed monthly. Landfills with energy recovery, ground water protection concerns, etc., should be monitored more frequently.

Further, it may be necessary to adjust the wellfield to ensure that the gas collection system is in an approximate ‘steady state’ of operation. This will help to minimize the amount of air that enters the landfill through the landfill cover and other means. Balancing the wellfield is accomplished by stabilizing the quality and rate of the LFG extracted.

It is important to note that the adjustment of one well can impact the performance of other wells at the landfill site. It is suggested that adjustment readings be started at the

furthest location from the blower and flare facilities and then worked toward these facilities. In this situation, it makes sense to record all of the data before making any adjustments.

The typical data measurement categories associated with wellfields include:

- Measurement person's name
- Time and date measurements taken
- Carbon dioxide concentration (as a basis for well adjustment)
- Oxygen concentration (as a basis for well adjustment)
- Methane concentration (as a basis for well adjustment)
- Balance gas (nitrogen) concentration (as a basis for well adjustment)
- Ambient temperature
- Wellhead gas temperature (an indicator of anaerobic conditions)
- Gas velocity
- Wellhead gas flow rate before and after adjustment (key parameter)
- Wellhead vacuum before and after adjustment (to calculate and determine flow)
- Wellhead adjustment valve position (to note degree it is open or closed)
- Carbon monoxide concentration (if problem suspected)
- Hydrogen sulfide reading (if problem suspected - potentially lethal)
- Maintenance observations.

While there are many wellfield adjustment criteria, methane quality and flow rate are the primary ones. These are indicators of the landfill's general anaerobic state and the impact of air intrusion on this condition. Still, a combination of criteria should be used to determine the appropriate wellfield adjustment. Key criteria, not previously emphasized, include:

- LFG control and collection system objectives

- Whether landfill conditions favor the generation of methane
- Landfill cover and construction factors (e.g., porosity, depth, leachate control, etc.)
- LFG gas well construction factors
- Proximity of side slopes to well
- Climatic, geographical, seasonal, geological, atmospheric (barometric) and other conditions

Of special note is the impact atmospheric pressure has on the behavior of LFG and system operation. Atmospheric air is driven into the landfill when this pressure exceeds the landfill pressure (i.e., indicated by negative landfill probe gage pressures). LFG is forced out of the landfill when the landfill pressure exceeds the atmospheric pressure. It therefore makes sense to monitor for LFG migration during periods when there is falling atmospheric pressure (i.e., early to mid-afternoon).

6.c.2 Condensate System

When conducting condensate data measurements, personnel should bear in mind that is very odorous and must be managed to avoid spillage.

A primary data measurement associated with condensate relates to blockage. Blockages typically result from differential settlement in the horizontal collectors, at buried road crossings, and along the LFG collection headers. By monitoring system vacuum pressure at various access ports in the system blockages can be isolated (i.e., pressure drop between access ports is a good indication of blockage).

6.d Operations and Maintenance

6.d.1 Wellfield and Conveyance Systems

From an operations standpoint, LFG extraction wells usually consist of perforated or overlapping pipe casing placed in the solid waste. A permeable material, such as gravel, is then typically backfilled over the solid waste, and an impermeable material is placed over the gravel to prevent air infiltration. Suction is then applied to each well and trench using a blower and the LFG is extracted and transported to the processing facility.

Landfill managers should always strive to achieve a smooth, consistent wellfield operation that promotes effective LFG recovery and control. Readings may be taken, relating to line vacuum, gas flow and quality, at key points along the main gas collection header and lateral branches. By doing so, leaking sections, poor performance, and pressure drops can be identified.

Normal operating activities associated with the wellfield and conveyance piping includes:

- Monitoring and adjusting LFG extraction wells;
- Inspecting landfill surface for indications that gas venting or air intrusion is taking place (e.g., settlement, openings, etc.);
- Looking at wellfields and conveyance piping for any needed adjustments and maintenance;
- Making sure monitoring instrumentation is operating properly; and
- Keeping thorough and accurate records and logs and scheduling appropriate maintenance services.

In terms of system maintenance, air leaks are a main concern. These may occur in the system as a result of settlement damage, conveyance piping expansion and contraction, system aging, and other factors. By comparing oxygen readings from the wellhead to access point readings, and looking for increasing concentrations, leaks can be detected and isolated. Major vacuum loss is another indicator of leaking air within the system. Such leaks are best repaired by replacing the damaged equipment. It is recommended that oxygen not be greater than 3 to 4 percent by volume of LFG in the collection piping.

Other maintenance activities associated with the wellfield and conveyance systems include:

- Repairing or replacing system components (e.g., wellheads, condensate traps, valves, etc.)
- Reinstalling probes (due to loss, damage, etc.)
- Repairing and adjusting piping supports and anchors
- Re-sloping and re-leveling piping support earth berms

- Removing sludge or particulate from the liquid knockout vessel (visually inspect annually)
- Making adjustments to the landfill surface (e.g., cover and cap maintenance).

Proper selection of the type of conveyance system pipe material is also important from an operations and maintenance standpoint. In choosing which pipe material(s) is most appropriate for a given LFG system, the following factors should be considered:

- Strength (a function of pipe thickness, type, and how installed)
- Chemical resistance (to varying mixtures found in the landfill)
- Weather resistance (minimized through proper storage and installation)
- Stress cracking (due to solvent, environmental, oxidative, and thermal conditions)

Ultimately, how long a pipe material lasts will depend upon the service conditions and the durability of the material.

It is also advisable to check the wellfield and collection systems for unusual conditions and maintenance needs. Unusual conditions would include: cracks and fissures, subsurface fires, liquid ponding, major settlement, etc. It should also be noted that the operation of extraction wells at temperatures greater than 145 degrees F or 63 degrees C may result in the weakening and possible collapse of thermoplastic well casings.

When repairs are being made to the LFG collection system it is often necessary to shutdown the blower and flare facilities as well. Such repairs should be coordinated with other shutdown procedures to minimize the down time of the overall LFG system.

6.d.2 Condensate System

It is typical to collect condensate from drain points in the main LFG collection header, the blower facility, and the flair facility. The condensate is actually captured and drained from the collection system using traps. These traps vary in design but all rely on a loop seal to maintain a liquid head pressure and overcome any countervailing force. ***Exhibit 6-6*** illustrates typical condensate trap.

EXHIBIT 6-6: LFG CONDENSATE TRAP

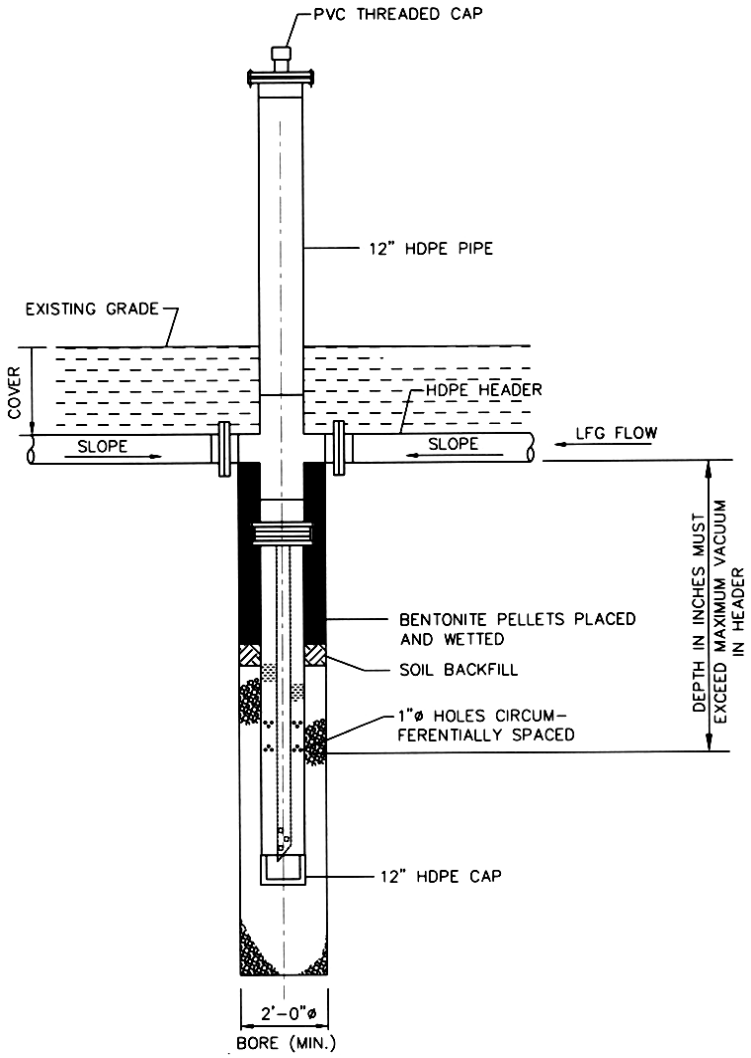


EXHIBIT 6-7: LFG CONDENSATE TRAP CONFIGURATIONS

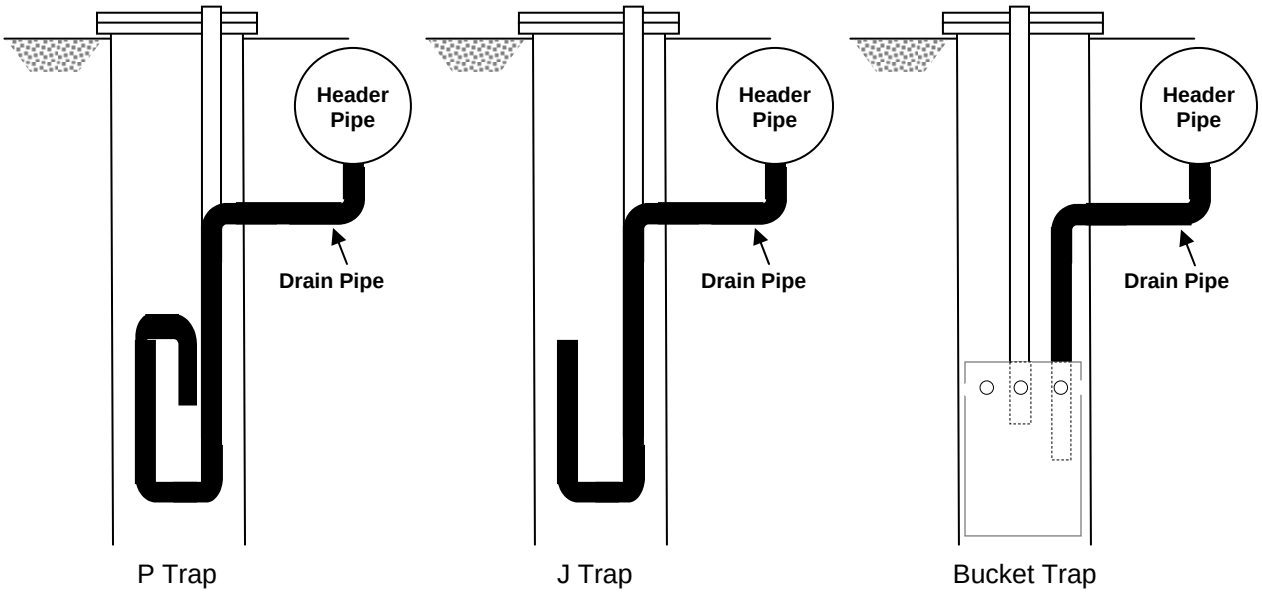


Exhibit 6-7 specifically shows "J," "P," and "bucket" style traps. J and P traps protect against liquid loss by being fitted with a sealing check valve to maintain a vacuum and seal the system. Bucket traps overflow either into a gravel pack and are directed into the landfill, or into a sump or container for transport off-site. Sumps can be automatically or manually pumped or drained.

Once collected, condensate is often stored in a single tank for later treatment and disposal. Such treatment and disposal can be done in a number of ways. Depending upon the level of contaminants in the condensate, treatment may simply involve the separation of oil from water or the adjustment of liquid pH, or it may involve a more complex process. Condensate often consists of a water based phase (i.e., aqueous), and an organic solvent and oil based phase (i.e., hydrocarbon).

Treatment and disposal options for LFG condensate include:

- Biological treatment
- Physical and chemical treatment
- Ultra-violet (advanced oxidation potential) and ozone treatment
- Combustion destruction (incinerator or flare)
- Waster reclamation discharge (for irrigation)

- Leachate management system discharge
- Hydrocarbon phase recycling
- Treatment, storage, and disposal as hazardous
- Sanitary sewer disposal
- Publically-owned treatment works disposal

Treatment and disposal techniques for condensate vary, depending upon the contaminants present, compliance requirements, and available treatment options.

The primary maintenance activities associated with the condensate handling includes:

- System components replacement or repair (e.g. condensate traps, sumps, pipe fittings, etc.)
- Correcting condensate blockages

6.e Health and safety

6.e.1 Wellfield and Conveyance Systems

When drilling and constructing a gas extraction well, the following types of safety procedures should be followed:

- One person who is fully trained in safety procedures and the use of safety equipment should be present at all times
- Fire extinguishers should be on location and there should be no smoking within 15 meters of a boring
- Personnel working near the well edge should be tethered to a parachute-type harness and safety line tied to an immobilized structure
- Workers near the drilling operation must bear in mind the less stable nature of solid waste buried in a landfill and the potential for side wall failure

- Drill operators should bear in mind potential contact with hazardous materials (e.g., chemical drums, asbestos, biomedical waste, radioactive waste, military munitions, etc.), especially if drilling in older landfills
- The well hole should be covered and all pipes should be capped at the end of the work day
- An exhaust hood should be used, if possible, to reduce exposures to LFG vapors

In addition, landfill personnel should be prepared for potentially lethal concentrations of hydrogen sulfide that could be present. Should high levels be detected, the use of supplied air or self-contained breathing apparatus may be required. In addition, operators should also periodically monitor for the presence of high levels of residual nitrogen since this could indicate conditions that could spark a landfill fire. Carbon dioxide concentrations can be used to determine residual nitrogen.

When performing landfill excavations, trenching and pipe installation, the following additional types of safety procedures should be followed:

- The atmosphere should be tested in excavations deeper than three feet before personnel are allowed to enter the space. Depending upon the test results, the appropriate respirator device should be used
- Workers should wear protective gloves and clothing to protect against direct exposure to the excavated waste
- Electrical motors should be non-sparking or explosion proof and construction equipment should have a vertical exhaust at least five feet above landfill grade
- Soil should be stockpiled near the excavation to smother any combustion that might occur
- Welding should not be permitted in or near the work area, unless it is verified on a continuous basis that methane and other combustible gases are not present
- As pipes are assembled, valves should be closed to prevent LFG migration through the system
- Gluing, bonding, or solvent pipe cleaning should be performed outside the trench to the fullest extent possible

- Common trench precautions should be taken. For example, no one should enter a trench deeper than about one meter unless precautions have been made to prevent cave-in (e.g., bracing, shoring).

6.e.2 Condensate System

Personnel should always avoid skin contact with condensate water because it may be biologically active and contain trace chemicals. When handling condensate, protective gloves and the appropriate splash protection should always be used. Also, VOCs may be released from LFG condensate and vapors emitted from storage tanks may be flammable. Such vapors need to be properly managed.