OUTLINE LANDFILL GAS MANAGEMENT PLAN FOR ARDLEY

CONTROL MEASURES

Control Measures employed on the site can be broadly split into containment, collection and treatment.

CONTAINMENT

Cells will be constructed to comply with the standard set out by the Landfill Directive (with CQA) and incorporate the following design:

- a basal and sidewall liner comprising a 2mm HDPE geomembrane and 1m mineral liner with a maximum permeability of 1 x 10^{-9} m.s $^{-1}$; and
- a capping layer of 1mm thick very flexible polyethylene (CFPE synthetic liner overlain by protective layer and restoration soils.
- cell sizes to be minimised where possible to reduce potential for odour release.

COLLECTION

Collection systems shall use a manifold based approach to collect gas from the site. The general design philosophy and site specific elements are indicated below.

Design Philosophy

The Viridor design philosophy will be utilised on the site. The design philosophy has three primary objectives:

- To maximise the reliability of the gas collection system
- To reduce the incidence of failure of any part of a gas collection system
- To provide systems that are easily managed and balanced

Condensate

The gas is produced within a landfill site at temperatures of between 30 and 50° C and is in a saturated condition. Condensate is the liquid which is produced as this saturated gas cools from the temperature found within the site to the ambient temperatures experienced within the pipe work. These ambient temperatures vary considerably not just with meteorological conditions, but dependent upon the length and depth of pipe work.

Condensate production is inevitable and its removal by positive mechanical means is an essential part of the gas collection system. Passive condensate removal techniques such as dewatering legs and draining to gas wells will frequently lead to befouling and reduced porosity of the waste and to failure of the gas collection system in the worst conditions i.e. very wet winters. Passive condensate removal techniques have a limited role in managed gas collection systems designed for high reliability and low failure.

Settlement

Settlement occurs through the degradation and consolidation of waste. Waste is usually compacted by mechanical means when it is deposited in a landfill site. It will however settle further. The amount and rate at which it settles is affected by a number of factors. Settlement occurs:

- as a function of waste depth, rate of fill and time
- due to the breakdown of waste through degradation
- following the production and removal of gas
- and as a result of the removal of leachate through pumping.

The above factors give rise to general and differential settlement at differing rates particularly within the first ten years after land filling. Settlement is frequently underestimated.

Differential settlement causes low spots to form in the collection pipe work which then block with condensate. Condensate in pipes can cause wild pressure swings (called slugging).

Perimeter Gas Main

For preference a perimeter gas ring main is laid on either virgin ground or solid ground outside of the domestic waste to prevent differential settlement. In many laces it will be installed on the inert waste area. It is installed to permanent falls of typically 1:100 gradient with gas and condensate flow in the same direction. Where gas and condensate flow in opposite directions the fall shall be at least 1 in 50. Where the gas main has to be installed on waste the falls shall be 1 in 50 and 1 in 25 respectively to allow for some degree of differential settlement. Gas and condensate

drainage to pumped knockout pots must be included in this main. The gas main shall be black MDPE pipe.

The gas main shall be sized to take the predicted flows of gas from the site. It is expected that up to 3,200m3/hr of gas may be produced from the site. It is envisaged that a ring main shall be installed on the site, part of which shall utilise twin mains. The pipes should therefore be sized to take half of the expected flow under normal operating conditions but be capable of taking all the flow under non-routine operation.

Pressure loss calculations have been made for normal operating conditions and for a worst case. For the 315mm diameter SDR 17.6 pipes the maximum expected gas velocity within the gas main under normal operating conditions would be expected to be in the region of 3-4 m/s. The typical design criteria is to keep the gas velocity below 6 m/s to allow condensate to drain and to prevent excessive pressure losses. This leads to a maximum calculated pressure loss in the main to be in the region of 4 mbar under normal operating conditions.

Under conditions of failure on the gas main (i.e. if operating through one pipe rather than the complete dual ring main) the velocity may reach 6-7 m/s giving pressure losses up to 20 mbar. This is still within the available suction on the site therefore is acceptable for rare conditions of failure.

Pumped Knockout Pots

Pumped knockout pots must comprise a water sealed chamber from which condensate can be removed using automatic air pumps fed by their own dry compressed air circuit. This must be separate from any leachate pumping system. Condensate can be discharged into an on site soakaway (within the site containment) or a leachate collection system.

Condensate Pumping System

A condensate pumping system shall be installed to the knockout pots. This shall consist of compressed air driven pumps, a compressed air line, condensate drainage lines and a compressor. This system should be entirely independent of any leachate pumping systems on site to prevent loss of extraction when there is a requirement to isolate any leachate system.

Manifold System

Gas wells are to be connected individually onto a manifold. Manifolds are to be installed on the waste. They will be sited usually at a point of maximum gradient and within 30m of the edge of the site where possible. Manifolds are to include an outlet valve for secondary balancing and isolation purposes. Manifold chambers are to include surface water drains. Manifolds have the advantage of making gas balancing easier and quicker. Any problems with the gas mains and connecting pipes can be more quickly isolated and identified using manifold systems. If a problem forms due

to settlement of a connecting line, only one gas well will be affected rather than an entire area of the site.

Connecting Pipework

Each gas well is to be connected individually to a manifold and not directly to the gas main. The connecting pipework shall be small bore to ensure that a high velocity is maintained and that the system is capable of pulling through condensate and overcoming any small depressions which can be created by differential settlement. As the bulk of the site is relatively shallow and gas flows per well are expected to be relatively low 63mm pipe will generally be used.

Connecting pipework is to be laid to maximise falls from the well to the manifold. Under no circumstances are connecting pipes to be laid to give contra flow conditions i.e. condensate and gas flowing in different directions. Pipeline falls shall be 1 in 25 where possible.

Connecting pipes are to be joined at the manifold with inlet valves for primary balancing and isolation purposes.

Connecting pipe is to be black MDPE to SDR 17.6. This has been found to be resistant to condensate, easy and quick to install and flexible. Jointing shall be be electrofusion and butt fusion to give strong joints that will not fail (given correct installation). Above ground, where they can be easily inspected or replaced, mechanical joints may be used.

Gas Wells

These wells are to be constructed with a rigid or telescopic MDPE vertical liner to SDR 11 and will generally penetrate into the lower levels of the site. Vertical gas wells are to include facilities for dipping. They are to include flexible connections at the wellhead for relative movement in the vertical and horizontal plains. Such flexible connections are to be free to move within a chamber or above ground. Wells constructed with either a collapsible liner, or without a liner, or those which are not rigidly fixed to a liner are to be connected without a flexible connection.

Temporary Gas Collection Systems

Temporary gas systems shall comprise one of the following (selected as per the duty, length of time required, layout and specific task). Where possible parts of the permanent system shall be used to extract gas from temporary areas.

Selection of the type of temporary system will strongly depend upon the type of problem encountered, layout of the area to be extracted, length of time the system will be required and length of time that the area will be uncapped or left until surcharging. The table below summarises the selection of the correct temporary system to be used in a number of circumstances

Issue	Area	Timescale	Suggested Temporary System
Odour	Active cell	Still tipping	Horizontal Wells
Odour	Active or completed cell	To be surcharged or capped in <2 years	Push Wells
Odour	Active or completed cell	To be surcharged or capped in >2 years	Temporary Gas Wells
Shallow seated Migration	Active cell	Still tipping	Buried Push Wells
Shallow seated Migration	Active or completed cell	To be surcharged or capped in <2 years	Surface Push Wells
Shallow seated Migration	Active or completed cell	To be surcharged or capped in >2 years	Temporary Gas Wells
Migration at depth	Active or completed cell <20m deep	Any time period	Temporary Gas Wells
Migration at depth	Active or completed cell >20m deep	Any time period	Permanent Gas Wells

Horizontal Wells

In general, horizontal wells shall be installed in shallow waste areas, or in areas with active tipping. The advantage of horizontal wells is that they can be placed in active tipping areas and may be extracted from whilst tipping continues. This makes them ideal for odour control in the active cell.

If they become buried under many lifts of waste then they are subject to failure due to blockage or crushing and will need to be replaced with a new well at a shallower depth. This makes them of limited use in controlling migration from deep parts of the site. As they are installed only 1m below the surface they require at least one lift of waste on top to form a seal to prevent short circuiting of air into the well. This makes them of limited use in areas that are not going to receive further waste or be sealed in some way.

Push Wells

Push wells are gas wells created by driving a metal spike into the waste to create a void. This is then cased, gravelled and bentonited to create a shallow gas well. The maximum depth that can be achieved with this technique is approximately 6m.

Push wells may be installed in the active tipping area or in cells that that will surcharged in a relatively short period of time (1-2 years). If waste is to be left for a period greater than two years then gas wells should be installed instead. If they are installed in active areas then the connecting pipework and push wellhead must be buried to allow extraction whilst tipping continues. Usually push wells will be connected using a 63mm EF elbow as a wellhead.

Push wells will primarily be used in areas that are due to be surcharged but are causing odour issues. They can be installed on relatively close spacing (20-30m) so give greater coverage of an area than a traditional gas well. As they are sealed with bentonite they can be installed and extracted from without the requirement for additional lifts of waste (unlike horizontal wells). They may also be used to address shallow gas migration.

Since push wells are shallow they are not adequate to take gas migration from an area that is occurring at depth. If gas migration is occurring from depth then traditional gas wells will be installed. It is envisaged that push wells will have limited use at Ardley due to the depth of the site.

Gas Wells

Traditional gas wells may need to be installed as part of a temporary system. The gas wells may have the same specification as permanent gas wells or they may be drilled to smaller diameters and have smaller casing sizes if they are to be sacrificial, i.e. be buried.

Gas wells will be used for tackling gas migration that is occurring at depth from the site. Gas wells should also be installed in an area if it is to be left un-surcharged for a period of 2 or more years.

Permanent specification gas wells may be extended and be incorporated into the permanent gas collection system. Gas wells should be extended in 10 bar 160mm pipe (as per the original well) and joined using an EF coupler. Generally if gas wells need to be extended by more than 6, they shall be re-drilled rather than be incorporated into the permanent gas collection system.

Connecting pipe

Connecting pipe for temporary systems shall be installed in 63mm black MDPE as per the permanent connecting pipe work. It is important that connecting pipes on sacrificial systems buried in the waste are laid to falls of at least 1 in 25 to drain condensate away from the well (for preference) or back to the well if this cannot be achieved.

CQA

All work carried out to be incorporated into the permanent gas collection system, including temporary systems, will be carried out in accordance with the Construction Quality Assurance Plan. The Plan will be completed by the Contractor carrying out the works and all the necessary quality measures will be adhered to. Any works not meeting the quality measures indicated in the plan shall be rejected by the Engineer. Records shall be kept up-to-date on a daily basis for checking by the Engineer during installation. The Engineer shall review the CQA information on a weekly basis.

The Contractor will be required to produce three copies of a completion file containing all the relevant paperwork from the works. This shall include, but not be limited to, the following:

- Copy of Completed Tender Documents (including Pre-Tender Health and Safety Plan and CQA plan)
- Form of Agreement/Contract
- Details of any amendment to the original design
- Drilling Logs
- CQA information including: Dipped well depths, Butt fusion log sheets, electrofusion log sheets, failed joint log sheets, pressure test certificates for fabrications, gas systems and air main
- As built drawings
- A take over certificate (to be issued by the Engineer)
- Snag list
- Invoices and measure information
- Relevant instruction / maintenance manuals (e.g. for the air pumps)

The Contractor will be required to carry out a proper survey of the completed scheme. All pipeline routes, gas wells and other fabrications should be located and levelled. The survey shall be carried out to an accuracy approved by the Engineer and, shall be referenced to the OS grid and datum in accordance with Viridor's Survey, As Built and Drawing Specifications.

TREATMENT

Treatment Measures

Current treatment measures consist of a Hofstetter gas plant and flare and two landfill gas generators.

Flare

The gas flare is of an enclosed design. This permits a homogenous temperature distribution across the combustion chamber. The flare is lined with refractory material on the interior and the flare is contained within a self contained unit. The combustion air supply is controlled (using a signal from the thermocouple) so as to achieve a minimum of 1,000 °C, or less where a low temperature is required to meet the relevant emission standards, and 0.3 seconds retention time over a 10:1 turn down ratio. The design capacity of the flare is 3000Nm^3/hr of landfill gas (at 50% methane). An UV flame sensor detects when the flare is lit to prevent venting of un-burnt gases. A pilot line and slam shut valve controls the light sequence to ensure the flare lights in a safe and controlled manner. Flame arrestors are fitted to the flare line and pilot line.

Engines

The landfill gas generators on site are currently one CAT3516 generator which produces 1150 kW of electricity and one Cummins QSV91 generator which produces 1750 kW of electricity. The gas consumption of the two generators is 630 and 75 Nm^3/hr landfill gas at 50% methane.