Statement regarding the risk potential of the landfill in terms of gas and leachate emissions

Corranure Landfill
Cavan

For inspection purposes only.
Consent of copyright owner required for any other use.

(Project-No.: 96-10161100)

Client:

Oxigen Environmental Ltd
Merrywell Industrial Estate
Ballymount Road Lower
Dublin 22
Irland

Viersen, 09.04.2008

EPA Export 26-07-2013:01:34:21

CONTENTS

For inspection purposes only.
Consent of copyright owner required for any other use.

EPA Export 26-07-2013:01:34:21

1 REASON

The Cavan County Council has operated the landfill for household waste in Corranure in Cavan County since approximately 1960. The landfill has been approved by the Environmental Protection Agency (EPA – License: WL 0077-02). When Oxigen Environmental Ltd. took over the Corranure Landfill, a division of both the licenses and the responsibilities was also planned. While dividing the licenses the EPA raised the question of the allocation of the potential risks to the license holders. The following text aims to issue a statement regarding the potential risks arising from the leachate and landfill gas created by the landfill as well as the options for their allocation to the license holders.

2 LOCATION DESCRIPTION [1]

The Corranure Landfill is located in the townlands of Corranure and Lismagratty on the northern side of the Cavan to Cootehill road (R188). The facility is located in a rural setting, and there are several residences located within 250 metres of its boundary.

Consent of copyright owner required for any other use.
For inspection purposes only.

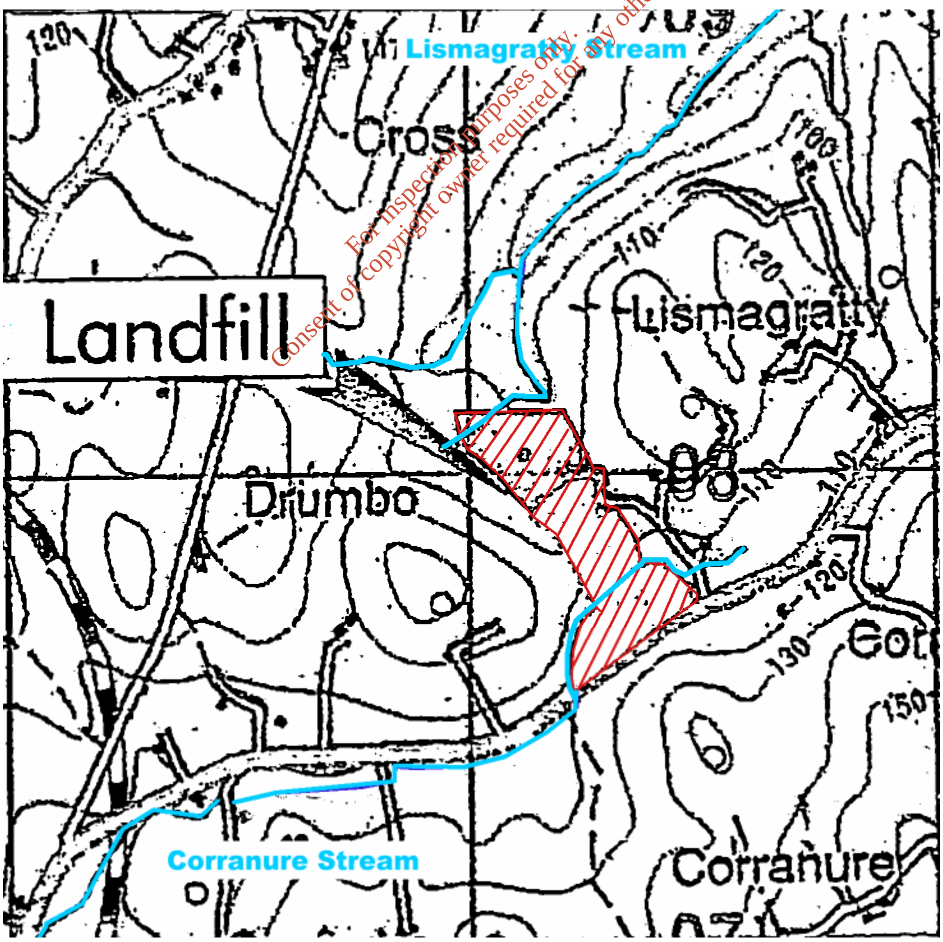

Fig. 1: Location Corranure Landfill

EPA Export 26-07-2013:01:34:21

The landfill is located in a valley. An elevation stretches to the north-east to a height of approximately 135 m. The terrain to the southwest reaches a height of approximately 130 m.

The original landfill is located at a height of approximately 108 m to the south and 90 m to the north. There is a visible peak in the middle of the location. The peak has a height of approximately 114 m. The Lismagratty Stream runs to the northwest of the landfill. The Corranure Stream runs to the southwest along the boundary of the landfill.

2.1 GEOLOGY

On the basis of the documentation provided [1] the surface layer in the landfill extension area consists of firm to stiff brown sandy, gravelled clay with boulders and cobbles (boulder clay). Sporadic layers of sand or gravel may also occur. As a result of the information gained from the exploration drilling carried out on location this glacial boulder clay layer possesses a thickness of 8 to 25 m. The geophysical explorations provide evidence for substantially higher thicknesses. On average the boulder clay possesses a thickness 10 to 15 m.

According to the geophysical explorations the boulder clay close to the surface (approx. 1 to 4 m below the surface) consists of a gravely clay distinguished by higher proportions of gravel and sand and includes the soil formation zone.

Below the boulder clay are middle Ordovician rock from the Coronea formation and the Red Island formation. These consist of fractured highly weathered shale, fractured jointed greywacke and broken fractured fine to medium grained sandstone.

For inspection purposes only.
Consent of copyright owner required for any other use.

2.2 HYDROLOGY

The boulder clay primarily consists of stiff impermeable clay. In accordance with the Geological Survey of Ireland (GSI) appraisal, it is to be assumed that no continuous loose sediment water bearing complex exists in the granular aquifer for these overburdens/beds. Existing groundwater is to be categorized as a restricted, perched, almost stagnant water table without lateral extension. The descriptions of the local water logging close to the surface and the sloughy areas emphasize the impermeability of the boulder clay. The 9 trial pits created in 2003 did not encounter any groundwater in the depths between 3.9 m to 6.7 m below the surface. Of the 6 trial pits bored down to the bedrock during this period of time only one discovered groundwater in a sandier bed of the boulder clay at a depth of 7 m. The head permeability tests performed in 2003 indicated an extremely low permeability for the boulder clay. Values from $2.8 \cdot 10^{-06}$ to $1.5 \cdot 10^{-09}$ m/s were determined, however the value $2.8 \cdot 10^{-06}$ represents an exception as a considerably sandier clay layer was tested. The average of all of the permeability values is $3.1 \cdot 10^{-07}$ m/s. The tests carried out in 1998 confirm these values. The results were between $1.98 \cdot 10^{-06}$ to $7.01 \cdot 10^{-08}$ m/s which provides an average

EPA Export 26-07-2013:01:34:21

of 9.81 • 10^{-07} m/s. As the results of the head permeability tests reflect more horizontal permeability it is reasonable to assume that the existing vertical permeability, which are decisive for an evaluation, are an additional magnitude lower. For an investigation with regard to the requirements for the land fill's sealing system we can assume a permeability of 1.0 • 10^{-08} to 1.0 • 10^{-09} m/s.

The bed rock belonging to the Coronea formation and the Red Island formation is to be categorized as a fractured aquifer as a result of the high level of tectonic stresses. The rocks encountered in the course of the drillings allow us to infer middle to low permeability. As a result of the packer tests a maximum permeability of 7.8 • 10^{-06} m/s was determined. The GSI assessment classifies both formations as "poor aquifer, generally unproductive except local zones (P1)". In accordance with the results of the groundwater level observation the bedrock contains confined groundwater.

The surface water arising as a result of rainfall forms in the low-thickness gravely clay layer close to the surface, which, according to the geophysical investigations, represents approximately the first 1 to 4 m of the boulder clay. The surface layers of the impermeable part of the boulder clay function as acquicludes along which the surface waters flow towards the receiving waters, Lismagratty Stream and the Corranure Stream, on the basis of the given topography.

For inspection purposes only.
Consent of copyright owner required for any other use.

2.3 CONCLUSIONS DRAWN FROM THE GEOLOGY AND HYDROLOGY

Taking into account the evaluated documentation one can determine that contamination of the bedrock aquifer from the landfill extensions and the remediate landfill can be ruled out as a result of the permeability and the high thickness of the top strata.

The 8 to 25 m thick top strata possess extremely low vertical permeability (1.0 • 10^{-08} to 1.0 • 10^{-09} m/s) and thus function as a groundwater aquiclude horizon upon which the surface water flows towards the receiving waters. The quality of this layer in terms of the requirements for a naturally occurring geological barrier in accordance with German guidelines and the Council Directive 1999/31/EC [2] are clearly exceeded in particular with regard to the thickness. If the Council Directive requires a minimum thickness of ≥ 1 m then here 10 times the value is achieved. The permeability clearly exceeds the requirements of the German guidelines however do not achieve the permeability of 1.0 • 10^{-09} m/s at a thickness of ≥ 1 m as demanded by the Directive. Taking into account the fact that the thickness of the boulder clay exceeds the requirements by a factor of 10 to 15 then the requirements are more than fulfilled from a compensatory perspective.

As the impermeability of the boulder clay prevents the permeation of possible leachate in the event of a failure, a contamination of the top strata is not to be expected. For example a dirt particle which permeates the boulder clay at an assumed vertical permeability of 1.0 • 10^{-08} m/s would require 30 years in order to negotiate a depth of 10 m and enter the bedrock

EPA Export 26-07-2013:01:34:21

groundwater aquifer (1.0 • 10^{-09} m/s equates to 300 years). However as, according to statements from the GSI, the movement of the groundwater in the top strata is extremely limited a risk situation can be ruled out here.

A possible hydrological risk is limited to the surface water on location, which feeds directly into the receiving waters from the gravely clay close to the surface. This possible risk must be avoided via appropriate technical measures. The design and position of monitoring facilities (position and expansion of the groundwater wells) must take into account this potential danger.

3 LEACHATE

The Corranure Landfill is divided into 5 cells in total. The Cell 0 (remediate landfill) is located in the south of the landfill. The low point of the terrain in Cell 0 is approximately 110 m in the northeast of Cell 0 [3]. Cell 0 has been recultivated and the surface sealed.

Cell 0 has been filled in since 1960. This cell does not possess a base seal. Nor has a leachate collection system been set up. In the years 2001-2003 a system consisting of leachate collection pipes and leachate interceptor drains was installed. This system can collect the infiltration water seeping out of Cell 0 and feed to the infiltration water storage. This leachate collection system was set up around Cell 0. This system collects and drains off the leachate from Cell 0 and the ground and surface water flowing in from outside. As such groundwater close to the surface flowing through the landfill body is not to be expected.

For inspection purposes only.
Consent of copyright owner required for any other use.

The recultivation of Cell 0 prevents rain water from penetrating into the landfill body. Leachate formation as a result of rainfall no longer occurs.

Cell 1 lies to the northwest of Cell 0 [4]. Cell 1 possesses a base seal system and leachate collection. The base seal system consists, as in the following cells, of a mineral water barrier stratum at least 1 m thick with a permeability of less than or equal to 1 x 10^{-9} m/s overlain with a 2 mm thick HDPE-Layer [5]. The leachate collection consists of collectors distributed around the base which end in a collection shaft and a drainage layer on the seal. The collection shaft lies to the west of the landfill area. The leachate is collected here and fed onward to a leachate storage tank via a pump. Cell 1 was established above Cell 0 and has now been sealed and the surface recultivated. The ground in the Cell 1 area lies at approximately 114 m to the west and 110 m to the east [6].

Cell 2 was attached directly to Cell 1 [7]. As with Cell 1, Cell 2 possesses a composite liner as well as leachate collection. The leachate is collected via the decline from east to west. The low point of the facility lies to the west of the landfill area. Cell 2 also lies on top of Cell 1 and has been sealed and recultivated on the surface since 2007. Sealing Cell 2 served to seal the surface of the entire filled landfill area (Cell 0, Cell 1 and Cell 2). Thus leachate only forms in

EPA Export 26-07-2013:01:34:21

these cells as a result of the water stored in the landfill body or through water arising from chemical processes.

Cell 3 has been filled in since 2007. Cell 3 lies to the west of Cell 2 [8]. The highest point of Cell 3 lies in the east of the facility adjoining Cell 2. The highest point has a height of approximately 117 m. The low point of the facility lies in the west of the landfill area. Here the grounds have a height of 107 m. Cell 3 possess a base seal and leachate collection in the west of the landfill section. Cell 3 lies above Cell 2 and an intermediate seal was inserted between Cell 3 and Cell 2.

Cell 4 is the direct expansion of Cell 3. However it has not been implemented yet. The low point of the planned Cell 4 lies in the north. Here the grounds have a height of 103 m.

3.1 LEACHATE RISK POTENTIAL

For inspection purposes only.
Consent of copyright owner required for any other use.

As is apparent in the explanations regarding the geology, contamination of the bedrock aquifer can be ruled out. . The impermeable boulder clay strata below the landfill prevent leachate from migrating into this aquifer. The groundwater close to the surface flows towards the landfill body. As a result of the terrain structure in the landfill the water flows towards the low points to the northwest and south. The groundwater reaches the surface at both of the terrain low points in the northwest and the south of the landfill and discharged via the Lismagratty Stream or the Corranure Stream.

A comprehensive leachate collection system has been installed in the Cell 0 area which prevents leachate from contaminating the groundwater close to the surface. Contamination can only occur in this area if the leachate collection system fails. This in turn can only occur if the collection no longer functions correctly or if the pumps transporting the collected leachate to the tanks fail.

Cells 1 to 3 posses a base seal. This base seal was constructed in accordance with the requirements from the licenses W0077-01 [5] and W0077-02 [9]. The requirements on the base seal systems from the licenses listed above comply with the specifications of the Council Directive1999/31/EC.Thus sealing systems were created in Cells 1 - 3 through which leakage and thus any risk can be almost entirely ruled out.

As the leachate in the cells 0 - 3 is transported out of the landfill body via pumps the only risk of groundwater contamination lies in the fact that a failure of the pumps could result in leachate building up in the landfill body and then overflowing from the facility grounds. As the surface of Cell 1 and 2 has now been sealed there is only a low level of leachate formation in these cells. Thus an overflow is only to be feared should the pumps fail for a long period of time.

EPA Export 26-07-2013:01:34:21

In Cell 3 the emplacement sections are open surfaces with infiltration water. Approximately 60- 80 % of the rainfall transforms into leachate, depending on the degree of evaporation. In this case large amounts of precipitation water transform into infiltration water after long periods of rainfall or heavy rain. The possibility of leachate overflow exists if combination of different events such as the failure of the power supply to the landfill as a result of a lightning strike during a thunderstorm in combination with heavy rainfall were to occur. However as the surface of the facility lies approximately 7 m below the surface of the terrain and thus provides a high leachate storage potential, there is little danger of leachate overflow.

3.2 REDUCING THE POTENTIAL RISK

In order to reduce the potential risk of contamination of groundwater close to the surface as much as possible a number of different aspects must be considered.

3.2.1 Power supply

Consent of copyright owner required for any other use.
For inspection purposes only.

In general it is essential to ensure that the power supply to the landfill is not interrupted for long periods of time. In the event of a power outage all of the pumps and control instruments such as fluid level monitors, etc. fail. In addition the leachate can no longer be pumped into the sewer system. The electricity supplier must provide contractual assurances or technical solutions (an external electricity generator) in order to guarantee that the power supply is restored within 12 hours at the latest. In the event of an emergency it must also be possible to drain off the leachate by means of a tanker. Failure of the electricity supply must be reported as a fault.

3.2.2 Leachate pumps

The leachate pumps in every cell must be installed along with redundant systems. This means that the function of the second pump must be guarantied at all times in order to take over the leachate removal in the event of failure of one of the leachate pumps. We recommend operating the pumps alternately under normal conditions so that the pumps do not remain inoperative for long periods of time and then do not function in the event of a failure. The failure of a pump must be displayed immediately in the landfill office and ideally forwarded directly to the landfill manager or the on-call staff member via SMS. This ensures that a pump failure is reported even during the weekend and appropriate measures can be initiated.
This redundant installation should be present in all of the leachate pump stations / leachate pump shafts.

EPA Export 26-07-2013:01:34:21

3.2.3 Fill level monitoring

The pumps are controlled automatically via fill level monitoring in the pump shafts. The leachate pumps start automatically as soon as a maximum leachate level (activation point) is reached within the cell. In addition a second fill level must be defined above the activation point. This Max-Max value defines with fill level within the individual cell at which an alarm is triggered. This alarm threshold informs the operating personnel that a pump fault has occurred, which was not previously reported or implies that the leachate pumping volume is less than the current leachate formation rate. The alarm provides the operating personnel with sufficient time to initiate the appropriate measures.

This fill level monitoring should also be implemented with redundancies.

3.2.4 Additional safeguards

In addition to the effective and secure leachate transport systems additional catchment systems can also be planned, which can prevent overflowing leachate from entering the nearby streams. As the low points of the facilities are known it is possible to determine the "theoretical" exit point of the leachate. A suitable catch drain or similar safeguards can be installed at these points.

For inspection purposes only.
Consent of copyright owner required for any other use.

3.3 MONITORING SYSTEM

3.3.1 Groundwater wells in the vicinity of the landfill

The creation of a series of groundwater monitoring wells is also planned. These wells should primarily be located directly on the landfill boundary. In addition to these wells a further 8 groundwater observation wells (GW 1 - 8) should be constructed in a large radius around the landfill [10] see fig. 2).

As previously determined, contamination of the bedrock as a result of the geological conditions can be ruled out. Therefore it is "only" important to monitor the groundwater close to the surface in order to protect the environment against leachate contamination.

As a result of the large thickness and the low permeability of the top strata below the landfill area the penetration of groundwater or leachate through this stratum is not expected. As such we recommend sinking the groundwater monitoring wells through the gravely clay close to the surface to approximately 1 m deep into the thick boulder clay in accordance with the results of the geophysical investigations. Sinking the shafts though this, on average 10 to 15 m thick stratum, is neither technically feasible nor of real interest with regard to the bedrock aquifer. Penetrating these strata would also serve to create a previously non-existent risk. As a result

EPA Export 26-07-2013:01:34:21

of these drillings groundwater close to the surface would be able to penetrate the bedrock aquifer. In the event of an accident contamination would thus be possible.

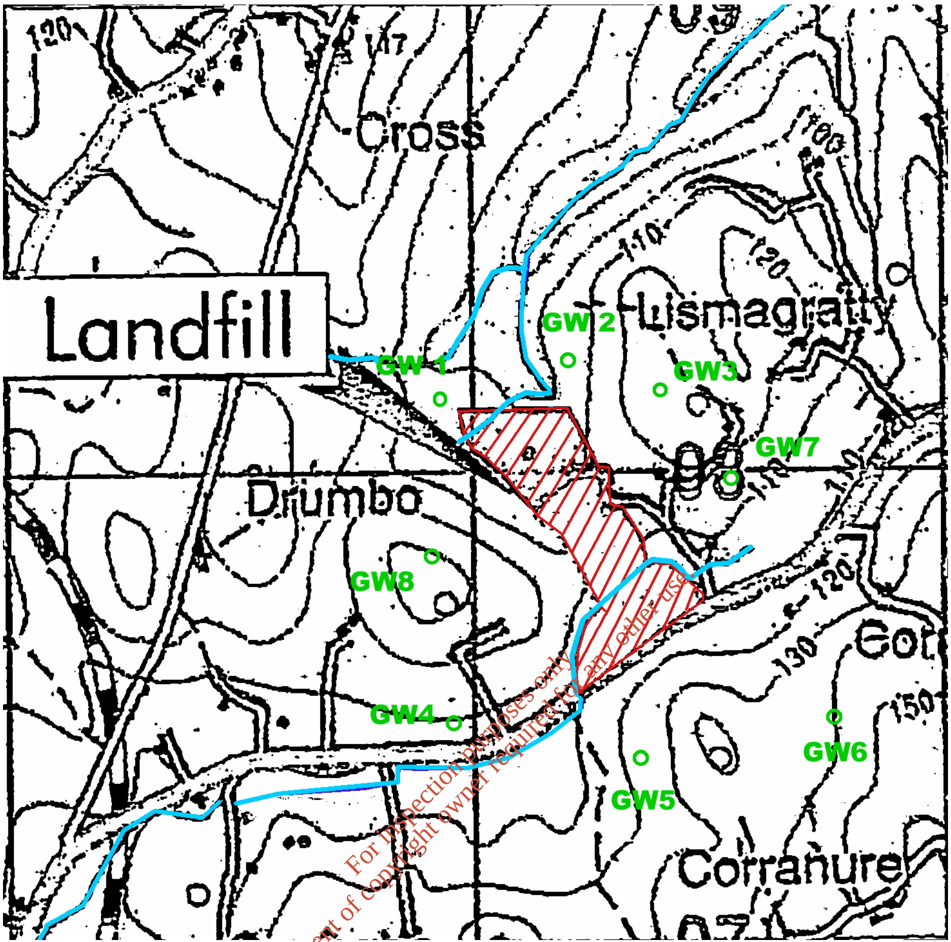

Fig. 2: planned location of groundwater monitoring wells

Consent of copyright owner required for any other use.
For inspection purposes only.

Installing 8 wells around the landfill and the receiving waters enables the analysis of the groundwater close to the surface. In this case penetrating the top strata is neither necessary nor sensible and should also not be carried out. The depth of the wells (GW 1 to 8) should be restricted to approximately 1 m into the impermeable boulder clay (total drilling depth of approximately 5 m below the surface).

By arranging the wells around the landfill these wells can contribute to a more detailed evaluation of the flow direction of the groundwater close to the surface. Unfortunately, during our investigations we were only able to imprecisely translate the exact location of the wells to the landfill and in relation to the elevation lines. More precise maps would definitely be of assistance.

Upon further examining the location of the wells we assume that the groundwater close to the surface generally flows perpendicular to the elevation lines.

EPA Export 26-07-2013:01:34:21

Wells GW 1 and GW 2

The wells GW1 and GW2 lie to the north of the landfill. The orientation of the elevation lines near the wells GW1 and GW2 allows us to conclude that the water found in the wells is not influenced by the landfill. However these wells are capable of determining interferences from higher areas which then enter the Lismagratty Stream directly before the Surface Water Monitoring Point B1 [11].

Well GW 3

The well GW 3 lies in almost exactly the same flow as the GW 2. As such it would be possible to position the well further the south-south-west. By moving this well it would be possible to analyze water flowing towards Cell 2 and Cell 3. Thus it would also be possible to determine any prior contamination of the groundwater close to the surface.

Wells GW 4 and GW 5

The wells GW 4 and GW 5 are arranged in a manner similar to GW 1 and GW 2 in order to record any possible prior contamination from the vicinity of the landfill in water flowing into the Corranure Stream upstream from the Surface Water Monitoring Point A3. The wells are not influenced by the landfill.

For inspection purposes only.
Consent of copyright owner required for any other use.

Wells GW 6, GW 7 and GW 8

These wells are arranged in such a way as to be able to register possible prior contamination from the surrounding area or the associated receiving water before the water reaches the landfill of the associated receiving water.

As a rule the wells should be meaningfully arranged in the vicinity of the landfill in such a way as to register the flow directions as well as any possible prior initial pollution / contamination of the groundwater. However the position of the wells should be examined using detailed maps and corrected where necessary. As a result of the conclusions regarding geology and hydrology it is important to bear in mind that, in general, the wells should not be positioned to far from the landfill and the receiving waters nor too high, from a topographical perspective in order to be able to monitor the largest possible catchment area. In our opinion this concerns the planned position of the wells GW 3, GW 6 and GW 8 in particular

3.3.2 Groundwater wells directly on the landfill boundary

Furthermore the creation of a gallery of monitoring wells around the actual landfill area is also planned. These wells lie within the landfill boundaries and should enclose almost the entire area. Up to approximately 30 wells are planned. The close network of wells enables detailed

EPA Export 26-07-2013:01:34:21

statements to be made regarding the flow directions within the landfill boundaries and in the nearby vicinity.

In this case the wells also only need to and should be sunk to approximately 1 m into the impermeable strata in order to evaluate possible groundwater contamination via leachate. In addition it is important to ensure that the depth of the wells is oriented on the depth of the existing landfill bases of the individual landfill sections. In this regard it is important to drill the well to 1 m below the low point of the landfill base in order to be able to register any possible contaminations. For example, at a gravely clay thickness of 2 m this would result in a necessary total depth of 3 m below the layer. If the base of the landfill lay at 5 m then the well would require a depth of 6 m.

Installing a monitoring system for the groundwater close to the surface which encloses the landfill serves to monitor the landfill in two respects. The enables monitoring of, firstly, the groundwater flowing into the landfill site and, secondly, the groundwater leaving the area towards the stream.

If, despite all of the safety mechanisms, an accident should occur then the damage can be determined and the position rapidly located using a detailed groundwater contour plan and a comprehensive monitoring system. This enables the allocation of a contamination to the individual Cells.

These monitoring measures can also register the contaminations of the groundwater close to the surface which flow from the vicinity of the landfill and thus represent a prior contamination of the groundwater for the landfill.

For inspection purposes only.
Consent of copyright owner required for any other use.

4 LANDFILL GAS

Landfill gas is created in the course of the biological conversion of organic components in the deposited waste. The formation of landfill gas creates an overpressure in the landfill body. As a result of this overpressure the landfill gas expands within the landfill body and migrates into the environment via the air paths or channels in the earth. The landfill gas primarily consists of methane and carbon dioxide. However landfill gas also contains aromatic substances and trace elements. Methane gas is combustible and creates an explosive mixture in concentrations between 5 - 15% volume. Carbon dioxide is a suffocating gas. Uncontrolled gas migrations can cause unpleasant odours or lead to major health risks.

If the landfill body has been equipped with a base seal and a surface seal than the landfill gas cannot migrate into the environment on its own. Here the landfill gas escapes via weaknesses or faulty sealing elements.

Weaknesses or faulty sealing elements primarily occur in the surface seal. The base seal is constructed at the beginning of the filling. After construction the base seal is protected by the

EPA Export 26-07-2013:01:34:21

drainage layer and the disposed waste. The surface seal is "damaged" by the installation of the vertical gas wells. This "damage" is compensated for via technical measures. This is where errors in creating a tight connection between the well and the seal can occur. The large number of wells increases the risk of faulty connections.
Furthermore settlement or plant growth can place additional strain on the surface sealing system which does not generally exist for the base seal.

4.1 LANDFILL GAS POTENTIAL RISKS

When investigating the landfill gas potential risks it is not important where the landfill gas forms. Migrations between the individual Cells as a result of leakage between the intermediate seals are of little importance to the following investigations. The critical aspect here is how and where the landfill gas is collected. Faults in the various collection and sealing systems cause the environmentally relevant migrations and can thus always be correctly allocated to a cell.

As already described, Cells 0, 1 and 2 are sealed on the surface. In the course of sealing the surface vertical gas wells were sunk in the cells. Cell 2 possesses an additional horizontal gas drainage pipe. These gas wells and horizontal pipes vent landfill gas from these cells. Cell 3, which is in use, is currently only vented via horizontal gas drainage pipes in the landfill body. The entire installed gas extraction system is operated as an active gas extraction system. An exhauster positioned before the flare creates negative pressure in the gas wells and the horizontal gas drainage pipes which then actively extracts the landfill gas from the landfill body.

Consent of copyright owner required for any other use. For inspection purposes only.

Separate and independent gas extraction systems have been set up in the individual cells. Approximately 21 gas wells have been bored in Cells 0 and 1 and connected to the exhauster via a main collecting pipe [12]. Approximately 13 gas wells along with 3 additional horizontal gas drainage pipes have been constructed in Cell 2. Cell 2 is also connected to the exhauster via a separate main collecting pipe. Together with an additional main collecting pipe the vertical venting from Cell forms the third independent collection system [13].

The vertical gas wells in the individual cells are connected with each other via HDPE pipes. The gas condensate which forms as a result of the cooling in the pipes during the gas extraction / transport is returned to the landfill at knock out points (KOP) or pumped into the leachate storage tank.

Cells 1 – 2 possess a continuous LLDPE seal. Cell 0 posses a capping with clay. In accordance with the directive the seal is affixed immediately after filling. Once the filling has been completed settlement occurs in the landfill body as a result of the decomposition of the organic contents. Settlements of up to 30% of the height of the refuse pile can occur. These irregular settlements place a high level of strain on the LLDPE layer, in particular along the seams. Furthermore the gas wells cannot adjust to the settlements in the landfill body. As a

EPA Export 26-07-2013:01:34:21

result the connections between the gas wells and the surface seals are subjected to additional strain.

A gas collection layer has been constructed beneath the surface seal. The vertical gas wells are integrated into the surface seal. The wells are connected with the gas collection layer. The cells are actively vented. This means that a negative pressure is generated for every gas well. This negative pressure ensures that landfill gas is immediately extracted from the landfill body. The gas collection layer channels landfill gases which are not directly collected by a gas well to the gas well where they are vented correctly.

The active gas extraction maintains a pressure balance within the entire landfill body. The overpressure generated by the gas production is absorbed by the negative pressure can gas can no longer escape from the landfill body. The surrounding air is also drawn in via any existing weaknesses and faulty connections as a result of the negative pressure.

4.1.1 Operating the active extraction system

There is little risk of landfill gas migrating into the environment when using a properly functioning and well maintained active gas extraction system. Even if, as in Cell 0, no base seal exists the active gas extraction can prevent a migration via earth channels.

Potential risks lie in the extraction system being incorrectly installed, maintained and set up. Operating an active extraction system means that the operating personnel's training with regard to the extraction system plays a decisive role in the extraction quality. Every gas well can be controlled separately. Valves can set the quantity of extracted gas in a gas well. By measuring the negative pressure and gas concentration it is possible to determine how high the gas production is and how far the gas valve can be opened. Regularly checking the negative pressure and the gas concentration of the individual gas wells enables a uniform ventilation of the landfill body.

For inspection purposes only. Consent of copyright owner required for any other use.

EPA Export 26-07-2013:01:34:21

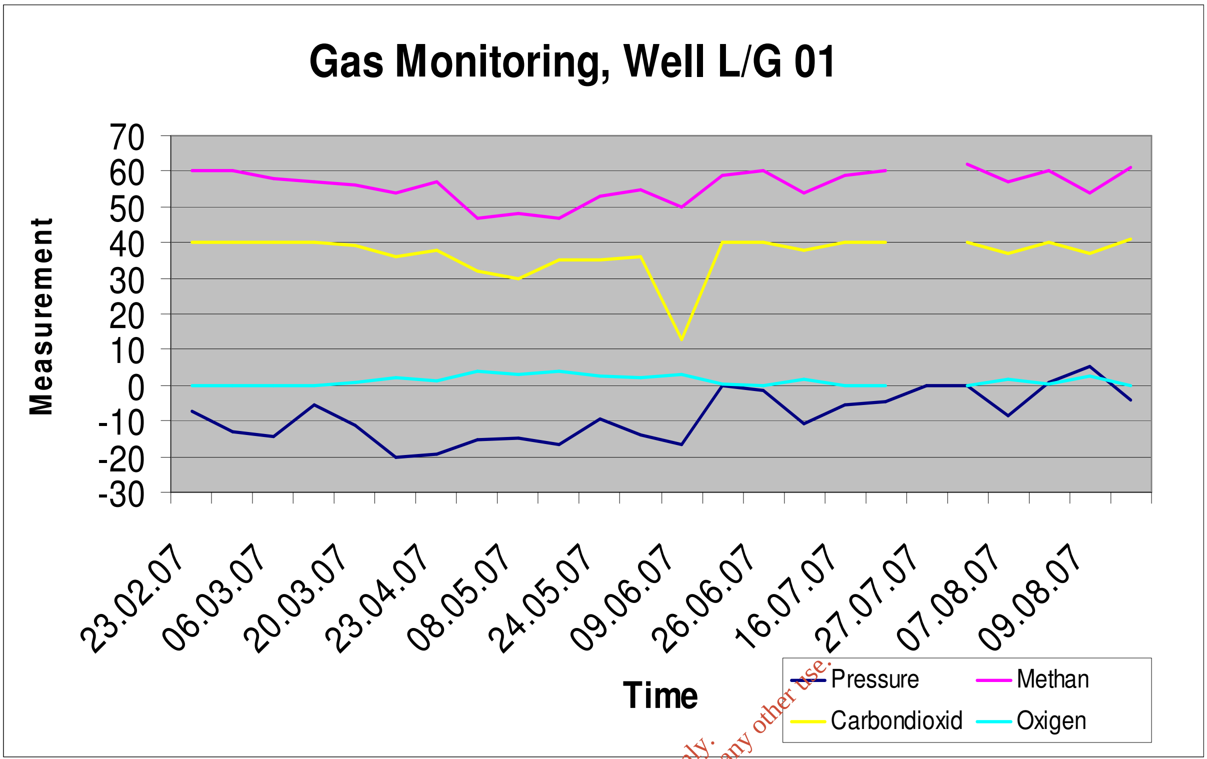

Fig. 3: Gas Monitoring, Well L/G 01 – period in 2007

Consent of copyright owner required for any other use.
For inspection purposes only.

Figure 3 displays the evaluation of the measurements of a gas well as the Corranure landfill in 2007. The negative pressure in this well fluctuates between approximately -20 to + 5 mbar. The methane production is approximately 60 % and carbon dioxide approximately 40 %. The gas production in the well area is good. As a negative pressure of -20 mbar the measures oxygen concentration increases and the methane concentration decreases. This indicates that at this level of negative pressure the well "over extracts" and draws in surrounding air. The negative pressure in the well should be maintained at a more stable level between -5 and -10 mbar.

EPA Export 26-07-2013:01:34:21

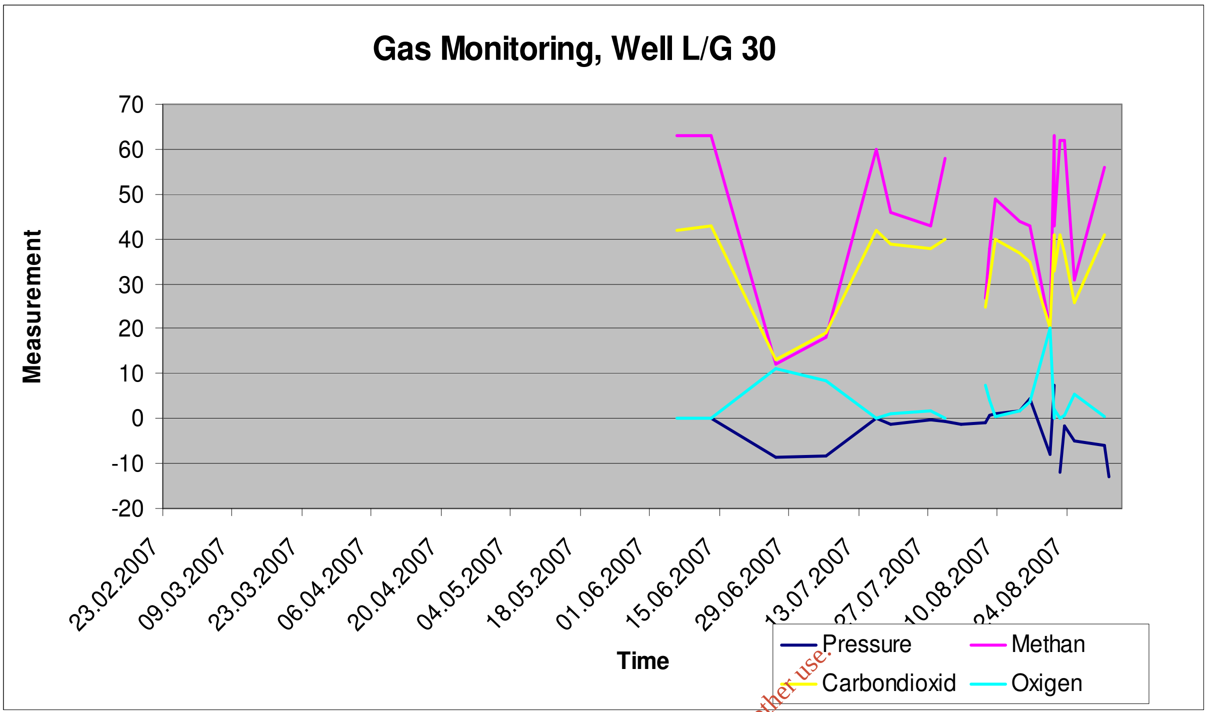

Fig. 4: Gas Monitoring, Well L/G 30 – period in 2007

Figure 4 displays a well in Cell 2 soon after construction the surface seal. At this point in time the sealing system had not yet been completely closed and there were problems with condensation drainage. The methane production is not yet stable and air still enters the landfill body.

As you can see the oxygen entry increases and the methane concentration decreases when the pressure is increased. Then no negative pressure is built up over a long period of time although the methane concentration lies at 50 -60 %. This could be a result of blocked pipes due to gas condensate. This image shows that the extraction was not or cannot be set up optimally for this well. This requires urgent improvement. The negative pressure should no exceed -5 mbar during the first few months until a stable methane production exists.

For inspection purposes only.
Consent of copyright owner required for any other use.

4.1.2 Gas condensate

When the landfill is extracted from the landfill body it possesses a temperature of approx. 30 °C. Transport via the buried pipelines cools the gas resulting in gas condensate formation. This condensate should be returned to the KOP's in the landfill. The KOP's are located at the low points of the pipes. Settlement in the landfill body can create undesired low points in the piping system. Gas condensate then collects in these low points and cannot be drained off. This results in blockages in the gas collection pipes. These blockages in turn lead to faults in the gas collection system and the failure of one or more gas wells. These faults can be

EPA Export 26-07-2013:01:34:21

rectified in the course of engineering measures where settlements are compensated for and new pipes laid.

4.1.3 Compressor and gas flare

The entire active gas extraction system depends on the function of the extractor positioned in front of the gas flare. This creates the necessary negative pressure on the suction side and transports the gas to the flare. Failure of the compressor as a result of a defect or power failure may result in the migration of landfill gas. The collected landfill gas is burnt using the flare. For a functioning system the flare completely burns the landfill gas. Failure of the flare disrupts the active gas extraction system and can thus lead to landfill gas migration.

4.1.4 Open areas in use

Cell 3 is currently in active use. A gas extraction system consisting of horizontally laid gas drainage pipes was been set up. This gas extraction system was connected to the extractor. When an area is in use the unpleasant odours cannot be prevented. The areas in use are kept small and the refuse surface is covered up with soil on a daily basis. Installing the horizontal gas extraction serves to drain off the gases formed in the lower layers of the refuse body. This method of operation reduces the emissions from the open areas to a minimum. As a result of the large surface area the concentrations of the landfill gas in the surrounding air are diluted, reducing the emissions.

For inspection purposes only.
Consent of copyright owner required for any other use.

4.1.5 Working at the landfill

Work needing to be carried out at the landfill which involves with the refuse body, e.g. laying horizontal gas extraction pipes, repairing pipes in the refuse body, drilling gas wells, results in increased emissions. These are inevitable however do not last long.

4.1.6 Shafts and buildings

Landfill gasses can collect at the low points of the landfill, in shafts and in building as a result of the lack of air movement. As such these areas are particularly at risk. The risks in these areas of the landfill can be controlled if the buildings are monitored via gas warning devices, for example. Special working instructions are to be created covering inspection of the landfill and work on the landfill or on the shafts.

EPA Export 26-07-2013:01:34:21

4.2 REDUCING THE POTENTIAL RISK

The existing potential risk is fundamentally dependant on the quality of the service at the landfill. Well-trained personnel with the appropriate experience can operate the gas extraction system in such a way that the emissions are reduced to a minimum. A high standard can be achieved by optimally adjusting the individual gas wells and regularly checking the gas collection pipes. During the daily inspection of the landfill attention is to be paid to the odour emissions and damage to the planting / vegetation which provides evidence of possible leakages or weaknesses. Weaknesses located in this manner must be corrected rapidly. These measures enable the rapid elimination of uncontrolled migration and reduce the potential risk to a minimum.

The individual gas extraction systems in the Cells 0 – 3 are designed in such a way that the occurring gas quantities can be disposed of. The number and location of the gas wells has been selected so as to be able to cover the entire area of the cell. In our experience it is reasonable to assume that an individual gas well has an effective radius of 15 to 18 meters at a reduce density of 0.8 – 0.9 t/m³. If, while operating the gas extraction system, it is determined that gas is not being extracted from individual areas then the installation of additional wells can improve the gas extraction and further reduce the potential risk

The open landfill areas are, in our experience, the largest source of emissions. Well planned refuse disposal (small disposal areas, rapidly covered on a daily basis) in combination with the installed horizontal gas drainage pipes results in a minimal level of odour emissions. Responsibly operating the open landfill area reduces all of the emissions to a minimum.

For inspection purposes only.
Consent of copyright owner required for any other use.

The compressor and the flare have been designed in such a way as to safely dispose of the gas quantity. The performance of the flare is to be adjusted to the current gas quantity in order to achieve thorough combustion and comply with the emissions limits specified by the licence.

In addition intensive contact with the EPA is necessary in order to be able to coordinate the necessary measures with the EPA before their implementation in the event of major or longer faults (e.g. the failure of the flare or a major leakage).

Overall the gas extraction system utilized at the landfill is comparable with the gas collection system planned and supported by WMT GmbH in Germany. The system consisting of horizontal gas drainage during usage and vertical gas wells upon closing a landfill section has proven itself for more than 20 years at these landfills. Only a low level of emissions occur which can generally be attributed to the weaknesses described above. One major difference between the current state of the gas extraction system employed at the Corranure Landfill and the systems constructed in Germany lies in the fact that the landfill is not immediately recultivated after filling. An intermediate coverage is first applied. This intermediate coverage generally consists of a 25 cm thick soil layer with differing permeabilities (depending on the existing license). This layer is left on the surface of the landfill for approximately 4 - 6 years in order to allow for the expected settlement. During this time the gas wells and the gas pipes on

EPA Export 26-07-2013:01:34:21

the surface are monitored intensively and adjusted to compensate for the settlement. The final sealing system is not added until after the settlement has ceased. Then the final wells are constructed and the pipes laid in the recultivation soil. Despite the temporarily laid gas pipe and the less tightly sealed surface during the initial years following filling only a low and generally negligible level of landfill gas migration usually occurs.

The decision to immediately apply the surface sealing system to the Corranure Landfill directly after filling it has the advantage of preventing gas emissions as a result of the thick LLDPE layer. However this sealing system is subjected to a higher level of strain as a result of the settlement, which may result in damage.

In general we have determined that, at the most, odour problems may occur if the gas extraction system is operated properly. The low level of emissions dilute the methane concentrations so strongly upon entering the surrounding air that any risk of explosion can generally be ruled out.

However the methane concentrations can increase in all of the gas transport systems as well as when working on the seal and gas extraction system. As such, special safety measures must be complied with then inspecting the shafts or when working at the landfill.

If work involving more intensive odours is necessary at the landfill the odour emissions can be reduced by the use of additional, local extractors which thus reduces the effects on the surroundings to a minimum for the duration of the measures.

For inspection purposes only.
Consent of copyright owner required for any other use.

4.3 MONITORING SYSTEM

As with the leachate a comprehensive monitoring system consisting of ground air gauges should be established. This system monitors the substratum in the landfill area. Similar to the leachate system the ground air gauges can regularly check the permeable strata for landfill gas. As such these wells should be constructed close to the surface in the groundwater- and surface water-free zones. The location of the ground air gauges should be oriented on the danger areas. Air gauges should be positioned close together when in the vicinity of buildings. They can be spaced further apart in open areas.

In addition to the daily inspections regular measurements using a Flame Ionization Detector (FID) are proposed. As the measurements from February this year show [14], an inspection of the landfill surfaces using a FID measurement is capable of registering gas emissions in the ppm (parts per million) range. This measurement can detect weaknesses before they cause major problems. As such the piping zones and gas wells in particular need to be inspected.

Gas can be safely extracted from the landfill by combining active gas extraction with "active" operation of the gas extraction system. Landfill gas occurring in the individual cells is collected and drained off by the separate collection systems.

EPA Export 26-07-2013:01:34:21

Inadequate gas extraction and the resulting migrations out of the landfill can be immediately attributed to the associated gas collection system and thus the Cell causing these emissions.

Utilizing an FID measurement (inspection) enables the discovery of additional emission points and the individual cell. These local emissions must then be rapidly eliminated through the appropriate construction and additional sealing measures.

Properly operating the active gas extraction rules out migrations via the ground. Setting up ground air gauges prevents landfill gas from escaping into the nearby surroundings despite all of the safety measures. If a ground air gauge detects methane concentrations then further migration can be prevented by extracting the ground air. Thus these possible, however highly improbable migrations remain restricted to within the facility. Thus any risk to the surroundings can be ruled out.

5 CONCLUSION

The landfill location possesses a naturally existing, high-quality geological barrier. This barrier prevents contaminating of the bedrock aquifer located below. The base seal and the surface sealing system in the Cells 1-3 comply with the specifications in the Council Directive 1999/31/EC and thus fulfil a high safety standard. Although Cell 0 does not possess a base seal a comprehensive leachate collection system has been set up. Overall the systems for collecting and disposing of leachate and landfill gas conform to a high technical standard which rules out any risks arising from leachate or landfill gas under controlled operation.

Consent of copyright owner required for any other use.
For inspection purposes only.

Possible accidents arising from technical failure can be prevented by installing the appropriate redundant systems. Additional safeguards provided by technical measures such as additional catch drains and the monitoring wells minimise the danger of possible contamination.

An alarm for the landfill managers and the on-call duty via SMS in the event of a fault in the leachate and gas systems enables the rapid recognition and similarly fast elimination of problems. The alarm and the intensive cooperation with the EPA enable the reduction of environmental influences to a minimum.

If an accident should occur despite all of the safety measures then the extremely tight network of control and monitoring points enable the rapid identification of the cell and the repair of the damaged area.

EPA Export 26-07-2013:01:34:21

6 DOCUMENTATION USED

[1] ENVIROMENTAL IMPACT STATEMENT for Corranure Landfill Extension, November 2003, Volume III, Technical Appendices

[2] Council Directive 1999/31/EC of 26. April 1999 on the landfill of waste

[3] Drawing E 02 -C – Remediation & Extension of Corranure Landfill – Site Plan

[4] Drawing E-04 – C – Remediation & Extension of Corranure Landfill – Proposed Detailed Cell Layout showing Leachate Collection System

[5] Corranure Landfill, Cootehill Road, Cavan, Co. Cavan, Waste Licence 77-1, 12/06/2001

[6] Drawing R-011 – C – Remediation & Extension of Corranure Landfill – Pavement Options Layout & Sections

[7] Drawing DG0002-01 C02 – Corranure Landfill, Phase 2 Extension – Leachate Collection & Pumping System

[8] Drawing DG 0020-01 – C01 - Corranure Landfill, Phase 2 Extension – Cell 3 Setting Out Details

[9] Corranure Landfill, Cootehill Road, Cavan, Co. Cavan, Waste Licence 77-1, 10/05/2005

[10] Drawing DE0751202-101-002 – Monitoring Wells – Proposed Borehole Locations

[11] Drawing DG 0007-01 – F01 – Corranure Landfill Licence Compliance – Location of Monitoring Points

[12] Drawing DG0014-01 – A01 – Corranure Landfill Licence Compliance – Gas Management System

[13] Drawing DG0010-01 – F01 - – Corranure Landfill Licence Compliance – Cell 3 Gas Management Plan

For inspection purposes only.
Consent of copyright owner required for any other use.

EPA Export 26-07-2013:01:34:21