APPENDIX 1

GROUNDWATER RISK ASSESSMENT

TOM O' BRIEN

ANNISTOWN, KILLEAGH, CO. CORK

APPLICATION FOR IPPC LICENCE

REG. NO. P0790-02

GROUNDWATER RISK ASSESSMENT

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CIVIL-WATER-ENVIRONMENTAL

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GES Limited

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IE Consulting / GES Ltd.
Innovation Centre
Green Road
Carlow

Client :-
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1 INTRODUCTION

IE Consulting/GES Ltd. were requested by NRGE Ltd. on behalf of Tom O' Brien to undertake a groundwater risk assessment at the pig unit in Annistown, Killeagh, Co. Cork.

Tom O' Brien applied for an Integrated Pollution Prevention and Control (IPPC) Licence on 27th November 2008 (P0790-02).

In response to the IPPC licence application, the Environmental Protection Agency (EPA) issued a request for the following information in a letter dated 1st May 2009:

"Please submit a comprehensive evaluation of the potential risk to groundwater posed by the Pig farm. This evaluation should include a hydrogeological evaluation, an assessment of the underlying aquifers classification and vulnerability, and should refer to the relevant source protection areas. This evaluation should also include any historical contamination of the groundwater on site".

2 OBJECTIVES OF ASSESSMENT

The objectives of the assessment were as follows:

- To characterise the existing environment, with particular regard to the existing hydrogeological setting and groundwater flow regime.
- To identify activities/items on site that may pose a potential risk to the groundwater.
- To estimate the risk that these activities may have on the existing groundwater quality and flow regime.

3 SCOPE OF WORKS

The scope of works proposed for the groundwater risk assessment is outlined as follows:

- An initial desk based study which included a review of the following:
  - Review of previous available reports and documents pertaining to the site;
  - Obtain existing hydrogeological data from the Geological Survey of Ireland (GSI);
  - Assessment of on-site activities and any risk to groundwater;
  - Assessment of existing on-site groundwater borehole and groundwater quality;
  - Assessment of hydrological regime of the adjacent Dower River (Aughnasassonagh River);
  - Assessment of existing private wells up-gradient and down-gradient of the site.
- A site visit was undertaken on 14th April 2010 to confirm the findings of the initial hydrogeological study, obtain a groundwater level measurement from the on-site borehole, identify site activities and structures that may pose a risk to groundwater beneath the site.
- Preparation of a groundwater risk assessment report including any recommendations for further works, if deemed necessary, based on the information collated as part of the desk

study and site visit, as well as recommendations for future groundwater assessment or monitoring works as may be required by the Environmental Protection Agency (EPA).

4 DATA SOURCES

The primary data sources for the desk study of this assessment were:

- Information submitted by Tom O' Brien as part of the IPPC licence application (P0790-01 and P0790-02);
- Information available on EPA website and in hard copy format in the EPA office in Iniscarra, Co. Cork on previous Dairygold Farms Ltd. IPPC licence applications (P0438-01 and P0438-02);
- Information available on Dairygold Farms Ltd. historical files;
- Previous GES Ltd. report concerning the site when operated by Dairygold Farms Ltd. entitled "Hydrogeological Assessment" (Report No. 99/19/01) pertaining to the spreadlands associated with the Annistown Pig Unit, Killeagh, Co. Cork;
- Geological Survey of Ireland (GSI) online webmapping;
- Geological Survey of Ireland Source Protection Plan for Dower Spring;
- Environmental Protection Agency (EPA);
- Ordnance Survey of Ireland (OSI);
- Met Eireann;
- Site walkover on 14th April 2010.

5 SITE INFORMATION

5.1 Site History

A summary of the site development history of the pig farm at Killeagh is presented in *Table 1* below.

Year	Activity
1965	East Cork Co-operative Pig Enterprises Ltd. was formed and 55 acres of agricultural land was purchased at Annistown, Co. Cork.
1965	Planning permission was obtained by East Cork Co-operative Pig Enterprises Ltd.
1975	Planning permission was granted for an extension of the pig unit for sow accommodation.
1982	Planning permission was obtained for the retention and relocation of existing pig fattening units and retention and modification of slurry holding tanks and out-buildings to a final capacity of 300 sows and 2500 fattening places.
1989	Mitchelstown Co-operative Agricultural Society Ltd. (predecessors of

Year	Activity
	Dairygold Co-operative Society Ltd) acquired the "engagements, undertakings and assets" of East Cork Co-operative Pig Enterprises Ltd.
1993	All pig farming operations of Dairygold were integrated into Dairygold Farms Ltd.
1998	Dairygold Farms Ltd. proposed to convert the pig unit from a 280 to a 600 sow-breeding unit, producing 13,200 weaners per annum.
2006	Tom O' Brien received planning permission to expand the pig unit from a 280 sown unit to comprise a 600 sow unit.

Table 1. Summary of Site History and Relevant Planning Applications

The initial pig farm unit was developed on a Greenfield site by East Cork Co-operative Pig Enterprises in 1965.

Planning permission was granted for an extension to the unit for sow accommodation in 1975. Planning permission was obtained for the retention and relocation of houses and slurry holding tanks for 300 sows in 1982.

Dairygold Farms Ltd. (formerly Mitchelstown Co-Operative Agricultural Society Ltd. acquired the pig unit in 1989. In 1998, Dairygold Farms Ltd. were granted planning permission by An Bord Pleanala for the extension of the unit to comprise a 600 sow integrated pig unit. Subsequently permission was sought to modify the plans and extend the unit.

In 1998, Dairygold Farms Ltd. applied to the Environmental Protection Agency (EPA) for an IPPC licence under the 6.2 Intensive Agriculture class of activities (Reg. No. P0438-01). This application and the subsequent IPPC licence application (Reg. No P0438-02) were withdrawn by Dairygold Farms Ltd.

The pit unit was purchased by Tom O' Brien in 2004 and planning permission was sought to expand the 280 integrated sow unit to comprise a 600 sow unit. In 2006, planning permission was granted by Cork County Council for the pig unit extension.

The expansion of the unit from a stocking rate from 280 to 600 sows is required to be licenced by the EPA. The current IPPC Licence Application (P0790-02) is for the existing 600 sow integrated pig unit on the site at Annistown, Killeagh, Co. Cork.

The site is being operated as a minimal disease unit in which access into the housing units is strictly controlled. As part of the unit expansion, the facility has been upgraded, particularly in terms of pig slurry collection and storage. The new pig housing units constructed to accommodate the additional numbers have been constructed above or partially below ground level. All new housing have leak detection systems and slurry is diverted via a newly constructed channel network to the on-site slurry pit in order to reduce the residence time of the slurry in the underground tanks. As part of the expansion it is proposed to replace the existing slurry pit with a lined slurry basin. It is estimated that in excess of 80% of the stock is housed in the newly constructed buildings.

5.2 Site Structures

An examination of historical aerial photographs (www.osi.ie) indicates that the footprint of the site area and the site building locations has not altered during the period 1995 to 2005. As a result of the extension to the integrated pig unit, the area within the site boundary has increased from 1.6 hectares (3.6 acres) to 3.86 hectares (9.5 hectares).

The location of the site in a regional context is presented in *Drawing No. IE565-001-A (Appendix A)*. The extent of the pre-extension site layout (1995-2004) compared to the existing and proposed layout is presented in *Drawing No. IE565-002-A (Appendix A)*.

A list of the pre- and post-expansion structures and the architectural drawings associated with these are presented in *Appendix B*. The sick bay, previously located in the south-eastern corner of the site has been removed and replaced by the dry sow housing unit.

This list of structures and associated drawings indicate that the depth of the underground tanks beneath the new buildings ranges between 0.61m and 1.2m below ground level. The depth of the slurry collection channels ranges between 1.525m and 1.83m below ground level. All new buildings are constructed with mass concrete. The depth of the storage tanks beneath the existing structures ranges between 0.6m to 1.3m below ground level. At the southern end of the site, the storage tanks are above ground.

5.3 Site Services

5.3.1 Fuel

An oil-fired boiler produces all heat used on the pig unit. A 150kVA standby generator fulfils the electrical demands of the unit during a power interruption. The fuel storage locations and the generator are shown on *Drawing No. IE565-002-A (Appendix A)*.

5.3.2 Water Supply

Water supply for the site is provided from the on-site well on the eastern edge of the site (*Drawing No. IE565-002-A and Drawing No. IE565-003-A, Appendix A*).

According to information obtain from NRGE Ltd. this well was installed by Dairygold Farms Ltd. No drilling log is available for this borehole and the depth of the borehole is unknown.

The wellhead of the on-site well is currently open, with the casing extending approximately 0.2-0.3m above ground level. The provision of a wellhead cover and a surface seal around the site well would prevent the entry of surface water, rodents and other surface contaminants into the site water supply.

Based on annual pig unit water requirements for the current wet feed system, it is estimated that the average annual water usage at the site is 7000m^3/yr. This equates to a daily water usage of approximately 20m^3/day. It is proposed to install a water meter on the well in order to monitor future water usage at the site.

Water from the well is stored in a 1,000 gallon (4.5m^3) storage tank adjacent to the well on the eastern side edge of the site. An additional 12,000 gallon (54m^3) storage is provided in 2No. large tanks on the western side of the site (*Drawing No. IE565-002-A, Appendix A*).

The available water quality information for this well is discussed in *Section 6.8.*

5.3.3 *Wastewater Effluent Disposal*

Based on a report by Murphy McCarthy Consulting Engineers, submitted to the EPA as part of the Dairygold Farm Ltd. IPPC licence application (P0438-01), the septic tank and soakaway in use at the site was constructed when the piggery was first development in 1965/1966 (*Appendix C*).

The approximate location of the septic tank and soakaway is presented in *Drawing No. IE565-002-A (Appendix A).* T tests carried out approximately 10m south of the soakaway indicated a "T" value of 5, which is indicative of a high permeability Sand/Gravel material. The depth at which the test was taken and the soil/subsoil composition was not recorded on the report.

There are currently 3-4No. employees at the site at any one time. The estimated maximum volume of effluent entering the septic tank is 0.5m^3/day. The composition/construction of the septic tank cannot be confirmed. The depth of the soakaway is unknown.

5.3.4 *Stormwater Runoff Disposal*

Currently roof water is collected and diverted to a soakaway at the southern end of the site. A stormwater monitoring point has been installed immediately upstream of the structure. A copy of the stormwater pipe layout submitted as part of the active IPPC licence application (P0790-02) is presented in *Appendix C.* The soakaway structure is 8-10m in radius and is 1.5-2.0m in depth. As part of the on-site monitoring regime, it has been proposed to sample the runoff for COD/BOD on a quarterly basis and visually inspect the monitoring point on a weekly basis.

Prior to the practice of on-site separation and disposal of roof runoff, surface water from the site was discharged via a land drain into the adjacent Dower River (Aughnasassonagh River). As part of the IPPC licence No. P0438-01, it was proposed to block this former drain to the stream and infill the trench. The approximate route of this drain to the adjacent river is shown on *Drawing No. IE565-003-A (Appendix A).* This drain was decommissioned by the previous site owners, Dairygold Farms Ltd.

5.3.5 *Pig Manure Collection and Recovery*

All slurry from the pig unit housing are collected in storage tanks under the slats in each of the pig housing units. The older slatted tanks are comprised of mass concrete, the base of which (pre 2005) are set below existing ground level to maximum depth of 1.3m. As mentioned previously, the base of the as-built structures are higher in elevation than the older units. At the southern end of the site, the storage tanks are above ground.

Mass concrete collection channels, ranging in depth between 1.525m and 1.83m below ground level, divert the effluent directly into the existing slurry pit from the newly constructed tanks.

An underground mass concrete channel network diverts slurry collected in the tanks beneath the older housing to the slurry pit. Sluice gates are used to control the release of slurry into the slurry pit. An overview of the proposed slurry collection system is presented in *Appendix C.*

Information from the Dairygold Farm Ltd. IPPC licence application (P0438-01) indicate that the older slurry tanks were inspected by Murphy McCarthy Consulting Engineers Ltd. in February 1996 and 13th December 1998 (*Appendix D*). However, although it was noted that tanks were "visible portion of the tanks appeared to be well constructed in mass concrete" the scope of the inspections were limited by the fact that the housing units were full. All new structures are constructed of mass concrete.

The slurry is currently collected in an open underground slurry pit, which comprises a surface area of 462m^2 and slopes from ground level to a maximum depth of approximately 2m below ground level at the centre of the pit. Slurry may be pumped in the above-ground slurry tank for storage. The capacity of this tank is 1538m^3. The stored slurry is pumped from the slurry pit into tractor tankers for recovery in accordance with the Nutrient Management Plan.

As part of the expansion of the pig unit, it is proposed to decommission the existing open slurry pit and install a covered engineered geomembrane-lined covered storage basin (*Appendix C*).

5.4 Operation Overview

The objective of the site operation is to serve as a fully integrated pig production unit in which pigs are produced and fattening to factory weight.

The numbers of various pig types and the associated pig manure production, as presented in the IPPC licence application, is shown in *Table 2* below.

Pig Type	Number of Stock	NEAT excreta Pig/week (litres)	Total litres/week	Total m^3/week
Farrowing Sow	180	100	18,000	18
Dry Sows	420	35	14,700	14.7
Boars	4	35	140	0.14
Gilts	160	35	5,600	5.6
Weaner	3600	13	46,800	46.8
Fattener	3600	30	108,000	108
Total Pig Manure (per week)			193,240	193
Total Pig Manure (per annum)			10,048,480	10,048
Extraneous water 6%			602909	603
Total annual production pig manure			10,651,389	10,651

Table 2. Pig Types and Associated Manure Production

The operation on-site can be divided into the following main stages or production:

- Farrowing;
- 1st Stage Weaning;
- 2nd Stage Weaning;
- Service Area;
- Dry Cow;

- Fattening;

The integrated pig production unit comprises the following components:

- Raw material and energy inputs;
- Disinfection/maintenance/disease prevention;
- Outputs
- Waste products
- Site infrastructure;
- Surface water drainage;
- Effluent drainage;
- Water supply;

As part of the groundwater risk assessment, the various possible contamination sources that may pose a risk to the groundwater beneath the site must be identified. A summary of the various components of these is presented in the following sections.

5.5 Raw Materials and Energy Inputs

5.5.1 Feed Stuffs

An automated "wet-feed" system is in operation at the site for all pig stock, apart from 1st stage weaners, which are fed directly with dry feed. The volume of feed given to the 1st stage weaners is less than 2% of the total feed volume on site.

Feed bins set in concrete hardstand at the western end of the site are filled directly from dry feed lorries. The feed is mixed with water in the wet feed mixing unit located in the feed and pump house.

Copper sulphate is added to the meal mixture of growing and finishing pigs. This is stored in the on-site dry store.

Additional pre-extension feed bins are set in concrete hardstand in the western side of the unit. The 25kg feed bags for the 1st stage weaners are stored in a large storage container in the western side of the site.

The liquid feed tanks are bunded and any outflow is diverted into the underground storage tanks. All pig slurry is collected in underground tanks and diverted via slurry collection channels to the existing slurry pit and above ground tank. This is then recovered in accordance with the Nutrient Management Plan.

The storage locations of these products are presented on *Drawing No. IE565-002-A* (*Appendix A*).

5.5.2 Site Fuel

The heating oil for the site is stored in 3No. oil tanks, which are set above ground on concrete blocks. The locations of these tanks are shown on *Drawing No. IE565-002-A (Appendix A)*.

The primary heating oil storage tank is located between the offices and the farrowing house in the western edge of the site. The tank is double-skinned with an in-built alarm. It is proposed to decommission the other tanks once the current fill is empty. The on-site heating oil tank will be bunded in accordance with the IPPC licence requirements.

5.5.3 *Veterinary Supplies/Supplements*

The facility is being operated as a minimal disease unit so that there is minimal use of antibiotics or vaccines on the site.

All antibiotics and vaccines, when required, for disease prevention, control and treatment, are stored in the refrigerator in the manager's office and in the dry store. When utilised on-site, the residues of these wastes in the slurry is minimal, particularly in consideration of the dilution effect of the slurry itself. Veterinary waste disposed of by the licenced contractor in accordance with the IPPC licence requirements.

5.5.4 *Pig Slurry*

Pig manure is analysed for the following parameters: dry matter, nitrate, phosphate ammonia. The pig slurry is comprised of the following major components: nitrate, phosphate, faecal coliforms, BOD and COD.

The slurry is collected directly beneath the pig housing units and diverted to below ground and above ground storage structures.

These are collected from on-site storage containers and recovered in accordance with the Nutrient Management Plan.

5.5.5 *Animal Carcasses*

Animal carcasses are produced as a result of incidental mortality of production. The carcasses are stored in a skip on a gravel area of the eastern side of the pig unit. The carcasses are collected on a fortnightly basis by a licenced contractor and brought to a licenced rendering plant for processing in accordance with IPPC licence requirements.

5.5.6 *Domestic Waste and Recycling*

Domestic waste and recyclable products from employees is stored in Cork County Council collection bins and collected by a licenced contractor and transported to an approved facility in accordance with the IPPC licence requirements.

5.6 *Contamination History and Spillages Events*

There are no records of historical contamination events on the site. Elevated nitrates detected in the site well during the period 16/5/1996 to 8/4/1998 was attributed in the IPPC licence application (P0439-01) to historical agricultural practices.

The water quality data for the site well is discussed in further detail in *Section 6.8*.

6 ENVIRONMENTAL SETTING

6.1 Topography

The pig unit is situated in the townland of Annistown, Killeagh, Co. Cork. The site, which comprises 3.86 Hectares, is shown its regional setting in *Drawing No. IE565-001-A (Appendix A)*.

The site is located at the northern extent of a generally low-lying area which extends southwards towards the coast. The average elevation of the land to east, west and south of the site is 20-30m OD. This low-lying coastal topography is characterised by generally east-west trending hills and valleys. Within the Midleton-Castlemartyr valley to the south, the topography can be described as knolly/hummocky. Immediately north of the site, the land rises into an upland region of north-west/south-east aligned ridges. In a local context, the land immediately north of the site rises to a peak elevation of 149m OD at Drominane (*Drawing No. IE565-001-A, Appendix A*).

Within the site boundary, natural pre-development ground level slopes rapidly from 46m OD to 40m OD in the north-eastern corner of the site boundary. From the north-eastern extent of the pig unit to the southern site boundary, the land slopes more gently from 40m OD to 34m OD.

6.2 Meteorology

The closest operational rainfall gauging station (at a similar elevation) is positioned at an elevation of 27m OD approximately 9km south of the site in the townland of Shanagarry North. The average annual rainfall (AAR) recorded at this gauging station, based on data between 1961-1990, is 990mm/yr. The mean annual potential evapotranspiration (PE) from the nearest synoptic station 36km south-west of the site at Cork Airport, is 513mm/yr (based on data between 1961-1990). The actual evaporation (AE), estimated as 0.90PE, is calculated to be 462mm/yr. Rainfall and evaporation data was obtained from Met Eireann (1996). Using these figures, the Effective Rainfall (E.R.) is taken to be approximately 528mm/year. Table 4 of S.I. No. 101 of 2009 refers to an average net rainfall of 37mm/week during the specified storage period.

6.3 Hydrology

In terms of river basin management planning, the site is located in the South Western River Basin District (SWRBD), within the surface water catchment of the Womanagh River, which is the primary regional surface water feature (*Drawing No. IE565-001-A, Appendix A*). The Dower River (also referred to as the Aughnasassonagh River), a minor tributary of the Womanagh River, originates in the hills north-west of the site. This river flows in a southerly direction approximately 60m west of the site boundary and continues its route southwards until it disappears underground into a swallow hole at Ballyvorisheen, approximately 1.8km downstream of the site. The Dower spring emerges approximately 2km south of the swallow hole. Tracer work undertaken on the Dower Spring has established a link between the sinking stream at Ballyvorisheen and the Dower Spring (*Drawing No. IE565-001-A, Appendix A*).

There are no natural surface water features within the site boundary. A drainage ditch previously used to discharge surface water runoff from the site into the adjacent watercourse (*Drawing No. IE565-003-A, Appendix A*) has been backfilled by the previous owner, Dairygold Farms Ltd. Currently all roof water from the site buildings is collected and diverted to the soakaway in the

southern end of the pig unit. Surface water falling on the hardstand area within the confines of the secured pig unit area is collected via an underground drainage system and diverted to the slurry pit at the south-eastern corner of the site. Along the perimeter of the secured pig unit, within the confines of the site boundary, precipitation is allowed to percolate to ground via a crushed stone ground cover.

6.4 *Geology*

Reference to the 1:100,000-scale map of the Geology of East Cork-Waterford) (Sheet 19) (Geological Survey of Ireland, 1995) indicates that the southeast of Cork is characterised by a series of elongated east-west valleys separated by intervening ridges, formed when the rocks were folded 290 million years ago during the Variscan Orogeny (*Sleeman, A.G. and McConnell, B., 1995*). The carboniferous limestones are restricted to the synclinal valley and flanked by the anticlinal ridges of the Devonian and early Carboniferous rocks (*GES Ltd. Report 99/18/01*).

The site is shown to be underlain by both the **Cuskinny Member** and the **Ballysteen Formation**, and possibly the **Gyleen Formation** (*Figure 1, Appendix E*). The Cuskinny member is described as flaser bedded sandstone and mudstone. The Ballysteen Formation is described as fossiliferous dark-grey muddy limestone. The Gyleen formation is described as sandstone with mudstone and silt.

Both the Cuskinny Member and the Ballysteen Formation were deposited during the Carboniferous period. The Cuskinny Member is described in the Generalised Bedrock Map (*Figure 2, Appendix E*) as Dinantian Mudstones and Sandstones of the Cork Group (DMSC). The Ballysteen Formation is referred to as Dinantian Lower Impure Limestones (DLIL). The Gyleen Formation was deposited during the Devonian period and forms part of the Devonian Old Red Sandstones (*Figure 2, Appendix E*).

The rocks have been folded into anticlines and synclines with approximate east-west axes by the Variscan Orogeny. The rock are broken by a system of steeply dipping cross faults running approximately NNW-SSE, roughly at right angles to the fold axes. (*GES Ltd. Report 99/18/01*).

The bedrock beneath the site and surrounding land youngs from north to south, which is reflective of the position of the site on the northern flank of a regional east-west trending syncline (*Figure 2, Appendix E*) (*GES Ltd. Report 99/18/01*).

An inferred regional north-west/south-east trending shear fault is mapped beneath the site along (or within) the eastern site boundary. The lateral extent and the depth of the faulted zone beneath the site cannot be determined without a site-specific investigation. The faulted contact between the sandstone and limestone formations beneath the site has the potential to act as a preferential conduit for groundwater flow in a southerly direction.

6.5 *Soils and Subsoils*

Reference to the General Soil Map of Ireland (1980) indicates that the soils in the area surrounding the site are described as Acid Brown Earths or Brown Podzolics.

The South Western River Basin District (SWRBD) Soil Map (Teagasc/EPA, 2006) indicates that a boundary between two soil types form at the location of the site. Deep poorly drained mineral soils (AminPD) are mapped as underlying most of the southern portion of the site, where as the northern part of the site is mapped as being underlain by deep well drained mineral soils (AminDW) (*Figure 3, Appendix E*).

The subsoil is described on the SWRBD Subsoil Map (Teagasc/EPA, 2006) indicates that the subsoil comprises Till derived from Devonian Sandstones (*Figure 4, Appendix E*). Limited fieldwork undertaken as part of the Groundwater Source Protection Plan for the Dower Spring (Geological Survey of Ireland, 2002) indicates that the Till is described as mainly Sandy Till, generally free-draining and of moderate permeability.

A soil profile of approximately 2.3m depth is exposed along the eastern edge of the site which indicates that, overall, the soil consists of sandy SILT/CLAY. Given the location of the soil profile on the site, it is likely that this profile represents the deep well drained mineral soils (AminDW) north of the site.

A horizontal layer of gravels, cobbles and boulders were noted at a depth of 1m below ground level. According a previous hydrogeological assessment of the spreadlands undertaken by GES Ltd. (Report No. 99/18/01, June 1999) on behalf of Dairygold Farms Ltd., at least 12m of clay soil was encountered at the site.

6.6 *Depth to Bedrock*

A review of the geotechnical borehole files from the GSI indicated that no geotechnical boreholes, which provide information on the depth at which bedrock is encountered, have been installed in the vicinity of the site.

The Dower Spring Source Protection Report (GSI, 2002) indicates that the depth to bedrock in the upland catchment of the Dower Spring, the setting of the pig unit, is generally between 3m and 10m below ground level with areas of shallower depth limited to the small, incised valleys of the streams that drain it.

The GSI webmapping well database was also consulted for depth-to-bedrock information in the vicinity of the site. No wells are recorded within a 500m radius of the site.

A depth to bedrock map was presented in a previous hydrogeological assessment report of the spreadlands undertaken by GES Ltd. (Report No. 99/18/01, June 1999) on behalf of Dairygold Farms Ltd. The depth-to-bedrock points are reproduced on *Drawing No. IE565-003-A (Appendix A)*. This information indicates that that the depth to bedrock is variable in the vicinity of the site.

A depth to bedrock of 29m was recorded west of the site, whereas the depth to bedrock south of the site was recorded at 39m below ground level. Depth to bedrock along the road leading south-west of the site was recorded at 12m below ground level (not presented on *Drawing No. IE565-003-A, Appendix A*). The thickness of soil/subsoil material is therefore variable over short distances and irregular in depth.

According to the information in the GES Ltd. report, excavations at the site of the pig unit record a thickness greater than 12m of clay overlying bedrock.

The 6 inch to 1 mile scale geology field maps held by the Geological Survey of Ireland (GSI) are available for the area in which the site is located. These show no information for the low-lying land immediately adjacent to the site. However, outcrops of red and green slates as well as purple sandstone were recorded north of the site. In addition, purplish green sandy shales were recorded along the road south of the hill north of the site (*Drawing No. IE565-003-A, Appendix A*).

6.7 Hydrogeology

6.7.1 Groundwater Body (GWB) Characteristics and Aquifer Classification

The approximate lithological boundary between the Dinantian mudstones and sandstones of the Cuskiny Member and the Dinantian lower impure limestones of the Ballysteen Formation, east and west of the mapped regional fault, also represents the boundary between the Ballinhassig groundwater body to the north and the Midleton groundwater body to the south. Groundwater flow direction is generally from the Ballinhassig groundwater body towards the Midleton groundwater body.

The Ballinhassig groundwater body is comprised of bedrock aquifers that are classified as **Ll**, locally important aquifers, moderately productive in local zones or **Pl**, poor aquifers which are generally unproductive except for local zones. The key characteristics of this groundwater body have been identified by the GSI as follows:

- Most groundwater flow occurs in the upper 15-20m of the aquifer, in the weathered zone and the interconnected fracture network beneath this;
- Groundwater flow gradients are likely to be in the range 0.01-0.04;
- Transmissivity in the aquifer is low, in the range of 2-10m^2/day, with median values towards the lower end of the range. Storativity values are thought to be low;
- The general low permeability characteristics of the aquifer and the high/steep slopes indicate that a high proportion of recharge will discharge rapidly to surface watercourses.
- Groundwater flow paths are expected to be relatively short, typically 30-300m;
- The bedrock units comprise non-carbonate rocks, with alkalinity ranges about 10-300mg/l (as $CaCO_3$) and conductivities ranging between 125-600µS/cm.

The Middleton groundwater body is comprised of bedrock aquifers that are classified as **Ll**, locally important aquifers, moderately productive in local zones or **Rkd**, regionally important karstified aquifer dominated by diffuse flow.

The Dinantian lower impure limestones underlying the site and the area south of the site form part of a narrow area around the margins of the body, which is classified as **Ll**. The characteristics of Ll section of the groundwater body have been identified by the GSI as follows:

- Most groundwater flow occurs in an upper weathered layer of a few metres and a zone of interconnected fissures often not extending more than 15m from the top of the rock,

although occasional deep inflows associated with major faults can be encountered. Impure limestone is less susceptible to karstification than pure limestones;

- Transmissivity in the aquifer is low, in the range 5-20m^2/day but may be higher where karstification has occurred. Storativity is low in the aquifer;
- The sandstone ridges to the north (Ballinhassig GWB) provide abundant runoff which recharges the limestone aquifer in the valley. A small volume of groundwater may cross as throughflow from the sandstone into the groundwater body. Diffuse recharge will occur over the entire GWB via rainfall percolation through the subsoil;
- Regional groundwater flow is towards the rivers draining the valley. Groundwater flow paths can be up to several kilometres long but may be significantly shorter where the water table is very close to the surface;
- The water table elevation is generally within 10m of the surface, except for more elevated parts of limestone aquifers, and the typical annual fluctuation of the water table ranges up to 6 or 7m;
- The groundwater is dominated by calcium and bicarbonate ions. Groundwater alkalinity is high, up to 400µS/cm and typical limestone conductivities are in the order of 500-700µS/cm;
- The major north-south trending shear faults are paralleled by a well-developed system of vertical north-south joints, commonly spaced at 0.5-2m intervals;

The key characteristics of the karstified bedrock south of the site are presented below:

- Transmissivities in the pure bedded limestones can range up to a few thousand m^2/day;
- Groundwater gradient are considered to be low, in the range 0.001-0.002.
- Groundwater flow paths can up to several kilometres long, with the groundwater flow direction towards the rivers draining the valleys.

The bedrock units underlying the pig unit are classified as a locally Important aquifer, which is moderately productive in local zones (*Figure 5, Appendix E*). The regionally Important karstified aquifer, representative of the Waulsortian Limestones, is mapped approximately 400m south of the site.

6.7.2 *Groundwater Levels, Flow Direction, and Gradient*

There is one water supply well on the site (E197375 N076505), as shown on *Drawing No. IE565-003-A (Appendix A)*. The site well is calculated to abstract approximately 20m^3/day in response to the water demand on site. In order to obtain a static groundwater level beneath the site, the pump was switched off at 6pm on the evening before a water level measurement was taken on 14th April 2010. The water level was recorded at 11.515m below the top of the steel casing at 08:53.

Two third party wells (TPW), referred to as TPW1 and TPW 2, had been identified previously as downgradient water quality monitoring points in the Dairygold Farm Ltd. IPPC licence application

(P0438-01). The approximate locations of third party wells in the vicinity of the site are shown on *Drawing No. IE565-003-A (Appendix A)*. It is considered that TPW2 is downgradient of the site. However, given the location of TPW1 in relation to the site, it is likely to be considered along gradient to the site.

Access was not obtained in order to record further static water levels in the vicinity of the site. It is considered that these wells will not be available as future groundwater monitoring points. The groundwater flow gradient beneath the site could not be determined in the absence of water level data.

A summary of previous available static water level monitoring data, for the site well and the closest third party monitoring wells, is presented in *Table 3* below.

Monitoring Point	15/5/96	3/6/96	26/6/96	15/4/10
Site Well	11.7	12.9	13.3	11.51
TPW 1	16.7	-	-	-

Table 3: Available Water Level Data For Site Well and TPW1

In the absence of water level data relative to Ordnance Datum (mOD), it is assumed that the groundwater flow direction is a subdued reflection of the topography. Therefore the groundwater beneath the site is assumed to flow in a southerly and south-westerly direction. On-site boreholes would need to be monitored in order to accurately determine the groundwater levels, gradients and flow direction beneath the site.

Given the groundwater table elevation relative to the elevation of the water in the Dower River, it is unlikely that the groundwater is moving towards the river along the section adjacent to the site.

It is proposed that a detailed survey (including flow and water level monitoring) of the existing site well be undertaken on order to delineate the zone of contribution (ZOC) to the well. The delineated ZOC to the well will inform an appropriate location for additional monitoring points.

These installations will enable site-specific information on depth to bedrock, subsoil and groundwater flow direction to be obtained. Furthermore, these boreholes will serve as monitoring points for the integrity of on-site structures.

6.7.3 *Groundwater Vulnerability*

Groundwater vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. Where the subsoil thickness is <3m, the vulnerability is rated as Extreme (the highest risk situation). Where the subsoil thickness is >3m, the vulnerability is rated as High, Moderate or Low (depending on the nature and thickness of the subsoil).

The South Western Interim Vulnerability Map for Cork, which was completed as part of GSI's Groundwater Protection Scheme, indicates groundwater beneath the site has been assigned an interim vulnerability rating of **High (H)** along the northern section of the site, whereas the vulnerability of the groundwater beneath the southern section of the site is classified as **Moderate**

(M) (*Figure 6, Appendix E*). These ratings are based on the assumption that the depth to bedrock beneath the site is greater than 3m.

6.7.4 *Dower Spring Source Protection Area*

The pig unit is located within the Outer Source Protection Area of the Dower Spring but within 400m of the Inner Source Protection Area *(Figure 7, Appendix E)*. The Dower Spring serves as a public water supply, the abstraction rate for which is approximately 4545m^3/day. The minimum discharge from the spring is recorded as 6,820m^3/day.

The location of the site within the source protection area of the spring means that groundwater moving beneath the site eventually emerges at the Dower Spring. The site is located within the source protection zone designated as SI/M.

The pig unit is referred to in the Dower Spring Source Protection Plan (GSI, 2002) as an activity with the potential to contaminate the water supply source. It is considered that the proposed new housing and slurry storage structures will serve to reduce any potential impact of the unit on the public water supply. The existing new housing structures are built partially or entirely above ground level. In addition, each of the new housing units has an individual leak detection system, which will be visually inspected monthly and a record of these inspections maintained on-site in accordance with IPPC licence requirements. These measures undertaken serve to reduce the risk that the facility poses to the water supply source.

6.8 *Groundwater Quality*

6.8.1 *Regional Data*

As part of the Water Framework Directive (WFD) initial characterisation work, all groundwater bodies in the country were assigned a score based on the likelihood of the groundwater quality achieving good status by 2015. The **Ballinhassig and Midleton** groundwater bodies were assigned a score of **1a** indicating that the **water body is at risk of achieving good status in 2015**.

Water quality data from the Dower Spring Groundwater Protection Report (GSI, 2002) indicates that nitrate levels in the spring, particularly since 1992, have been noted and considered to indicate significant contamination of the spring. The nitrate range, based on 30 samples, was reported as 12-37.5mg/l. Also, levels of ammonia, E. Coli and Total Coliforms have been found to be periodically unsatisfactory, possibly attributable to runoff following heavy rainfall events.

6.8.2 *Site Groundwater Quality Information*

The analysis results of a groundwater sample taken from the site well on 14th April 2010 is presented in *Table 4* below. The Certificate of Analysis is presented in *Appendix F*. The results were compared with the limits and threshold values set out in the following legislation and guidelines:

- European Communities (Drinking Water)(No. 2) Regulations 2007 (S.I. No. 278 of 2007).
- Environmental Protection Agency Interim Guideline Value (EPA IGV) for Groundwater (EPA, 2003).

- European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010).

Parameter	Site Well	EPA IGV	Drinking Water Regs 2007	EC (Environmental Objectives) Ground Water Regs 2010
pH	6.93	> =6.5 <=9.5	> =6.5 <=9.5	-
Alkalinity (mg/l as $CaCO_3$)	129	-	-	-
Electrical Conductivity (µS/cm)	419	1000	2500	800-1875
Nitrate (mg/l NO_3)	38.9	25	50	37.5
Nitrite (mg/l NO_2)	0.066	0.1	0.5	0.375
MRP (mg/l P)	0.06	-	-	0.035
Ammonium (mg/l NH_4)	<0.02	0.15	0.3	0.065 – 0.175
Calcium (mg/l)	36	200	-	-
Magnesium (mg/l)	18	50	-	-
Manganese (mg/l)	0.012	0.05	0.05	-
Iron (mg/l)	<0.03	0.2	0.2	-
Potassium (mg/l)	2.24	5	-	-
Sodium (mg/l)	15	150	200	150
Sulphate (mg/l)	16	200	250	187.5
Chloride (mg/l)	24	30	250	24-187.5
Total Phosphorous (mg/l P)	0.23			-
Total Petroleum Hydrocarbons (mg/l)	<0.01			
Total Coliforms (cfu/100ml)	<1			
Faecal Coliforms (cfu/100ml)	<1	0	0	-
Enterococci (cfu/100ml)	<1	0	0	-

Table 4. Water Quality Data on Site Well on 14th April 2010

The bacteriological quality of the water sample was found to be good. The nitrate concentration of 38.9mg/l was found to be elevated relative to the Groundwater Threshold Value of 37.5mg/l (S.I. No. 9 of 2010). The phosphate concentration at 0.06mg/l was also elevated compared to the groundwater threshold value of 0.035mg/l.

Generally, sources of elevated nitrates and phosphates, apart from pig slurry, are from agricultural activities such as tillage and animal grazing. There were no available upgradient and downgradient water quality monitoring points against which to compare the results. Therefore, the proposed site well survey and monitoring outlined in Section 6.7.2 would provide a framework to assess the integrity of all tanks and pipeline systems on-site.

A summary of all available sampling results for the site well, obtained from previous IPPC Licence applications and planning applications for the site, is presented in *Table 5*. The available Certificates of Analyses are presented in *Appendix F*.

Parameter	Date								
	16/5/96	3/6/96	26/6/96	16/1/97	6/4/98	30/5/01	20/9/05	21/3/07	21/9/07
pH	6.5	-	6.5				-	-	-
Nitrate (mg/l NO_3)	24.6	17.5	21.5	10.2	22.8	70	39.4	18	54.5
Ammonium (mg/l NH_4)						<0.13	0.09	0	<0.013
COD (mg/l)	5.4	9	3			<10	-	-	-
Total Phosphorous (mg/l P)	0.14		0.05				-		-
Total Coliforms (MPN/100ml)						6	29	0	0
Faecal Coliforms (MPN/100ml)						0	0	0	0

Table 5. Available Historical Monitoring Data

Samples were taken from the nearest third party wells and the site well on 26th June 1996. This information is presented in *Table 6* below.

Parameter	Site Well	TPW 1	TPW 2
pH	6.5	6.5	6.5
Nitrate (mg/l NO_3)	21.5	10.1	11.9
COD (mg/l)	3	<1	<1
Total Phosphorous (mg/l P)	0.05	0.04	0.04

Table 6. Groundwater Monitoring Data on Site Well and Third Party Wells on 26th June 1996

The results above indicate that, historically, the nitrate concentrations in the samples taken from the site well have been elevated. The concentration in the sample taken in September 2005 approximates to the concentration taken in April 2010.

The samples taken on 26th June 1996 indicates also that the nitrate levels in the site well were elevated relative to the concentrations in the closest along gradient and downgradient. The phosphate levels were shown to be relatively consistent in the three wells.

7 GROUNDWATER RISK ASSESMENT AND POTENTIAL CONTAMINATION SOURCES

The concepts of Risk, Risk Assessment and Risk Management have become important tools in the area of environmental protection. The philosophical basis and language of risk is useful in that it provides a logical framework for considering the impact of potentially polluting activities on the environment.

This framework enables a more rigorous systematic approach to decision making. In reality it is putting a recognised framework to what is done intuitively, but by being systematic. In addition, it

is an aid in conceptualising the potential impact of the discharge of effluent on the wider environment.

A **hazard (source)** presents a risk when it is likely to affect something of value (the **target/receptor**), which in this case is groundwater and/or surface water, which in turn may impact on humans. It is the probability of the hazard occurring and its consequences that is the basis of Risk Assessment.

The conventional Source-Pathway-Receptor model for environmental management can be applied to identify potential sources, receptors and pathways, and hence potential pollutant linkages relating to the site.

For a particular contaminant to present a risk to receptors, three components must be present:

Source	An entity or action that releases contaminants into the environment
Pathway	A mechanism by which receptors can become exposed to contaminants
Receptors	The human or ecological component at risk of experiencing an adverse response following exposure to a contaminant

The qualitative risk assessment presented in *Table 7* below is based on the hydrogeological information collected to date in relation to the site, and incorporated into previous sections of this report.

Source	Pathway	Receptor	Risk	Mitigation
Antibiotics Vaccines for disease Prevention	Crack/joint in building hardstanding. Residues in effluent slurry.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	Very low risk in raw form. Very low risk for residues in effluent slurry given the low quantities used and the dilution effect with slurry.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring
Cleaning products/ Disinfectants.	Crack/joint in hardstanding area. Underground storage tanks. Underground slurry collection system. Underground slurry pit.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	Low to moderate risk only if integrity of underground pipe network and in underground sumps breached or compromised.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring
Pig effluent slurry: Nitrate. Phosphate. Faecal Coliforms. BOD. COD.	Crack/joint in hardstanding area. Underground storage tanks. Underground slurry collection system. Underground slurry pit.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	High risk only if Integrity of underground pipe network and in underground storage tanks and slurry pit are breached or compromised.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring

Source	Pathway	Receptor	Risk	Mitigation
Domestic Effluent	Cracks in septic tank chamber. Direct percolation into subsoils from soakaway.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	Moderate to High risk only if depth of soakaway and permeability is such that the effluent is not treated sufficiently before reaching the water table.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring
Heating Oil	Crack/joint in hardstanding area. Seepage through hardcore area.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	High risk only if spillage occurs on ground during refuelling.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring
Animal Carcasses	Seepage through hardcore area.	Groundwater beneath the site. Site water supply. Source Protection Area of Dower Spring.	Low risk only if storage container does not leak and if stored on concrete hardstand.	Provision of tank and pipeline assessment proposal to the EPA based on groundwater monitoring

Table 7. Qualitative Risk Assessment

The primary method to reduce the potential risk that a source would have on a receptor is to remove the pathway to the receptor. The measures already implemented at the site to reduce the risk to potential receptors are:

- Leak detection system in new underground tanks and slurry collection system;

The following measures, proposed as part of the expansion of the pig unit, will also reduce the risk to groundwater of the site activities:

- Bunding of site fuel storage tank;
- Installation of slurry basin lined with a geotextile membrane.

8 CONCLUSIONS AND RECOMMENDATIONS

The quality of the groundwater beneath the site and the risk of contamination of groundwater and surface water are primarily dependent on the integrity of the following infrastructure:

- Underground pipework;
- Slurry storage tank beneath the slatted houses;
- Existing slurry pit;
- Soakaway for domestic effluent.

The following measures, some of which are already partially installed, which were proposed as part of the expansion of the pig unit, will reduce the risk to groundwater from site activities. These measures include:

- Leak detection system in new underground tanks and slurry collection system;
- Installation of slurry basin lined with a geotextile membrane;
- Bunding of site fuel storage tanks.

In order to address and monitor all site structures, both old and new, the following monitoring programme is proposed:

- Undertake a detailed survey of the existing site well, which will include the installation of a flow meter and water level monitoring;
- Delineate the Zone of Contribution to the site well in order to determine the proportion of the site structures that are contained with the ZOC or capture zone to the site well.
- The delineated ZOC to the site well will inform the most appropriate locations for additional monitoring wells.
- An additional downgradient monitoring well may be required if it is determined that the capture zone of the site well does not extend beneath the entire facility. A minimum total of 3No. groundwater monitoring points are required to determine the groundwater flow direction.
- Site-specific information regarding the depth to bedrock, subsoil permeability and composition will be obtained from the installation of on-site monitoring points.

The provision of a wellhead cover and a surface seal around the site well would prevent the entry of surface water, rodents and other surface contaminants into the site water supply.

The suite of parameters for which the groundwater from the site well and other monitoring points is tested will be extended to include for baseline analysis:

- Major cations and anions;

- Indicator parameters for the presence of contaminants from on-site activities that are not already included in the major cations and anions.

It is recommended that the site well tested annually for the suite of parameters set out in the Drinking Water Regulations 2007 (S.I. 278 of 2007) or for a set of parameters to be approved by the EPA.

9 REFERENCES

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