JH Groundwater Ltd
Hydrogeological Solutions

HYDROGEOLOGICAL RISK ASSESSMENT. PROPOSED PIG UNIT EXTENSION - SLURRY STORAGE, RAVEN HILL FARM, KILHAM.

IAN PICK ASSOCIATES

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UK Company Registration Number: 08610467.
Registered Office: 23 Westfield Park, Redland, Bristol BS6 6LT
Tel: +44 (0) 7765 255 197
www.jhgroundwater.co.uk

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Author	Julian Hatherall BSc (Hons) MSc CGeol EurGeol FGS	Julian Hatherall BSc (Hons) MSc CGeol EurGeol FGS		
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1 Introduction

1.1 Background

JH Groundwater Limited (JHG) were commissioned by Ian Pick Associates (IPA) to undertake a Hydrogeological Risk Assessment (HRA) in support of a planning application for an extension to a Pig Unit at Raven Hill Farm which includes a slurry storage system. A previous report for the same farm was completed in June 2017. This was subsequently accepted by the Environment Agency

1.2 Objectives and Scope of Works

The principal objective of the HRA was to assess the risk of pollution to a groundwater abstraction at Kilham in support of a planning application. Where necessary, this document can be subsequently used to support an Environmental Permit application.

1.3 Requirements and Regulatory Background

The Environment Agency (EA) have requested a hydrogeological risk assessment for the development in relation to groundwater protection guidance given the high sensitivity of the location. As such they have requested evidence to demonstrate that the site is suitable for storage of slurry in an underground storage facility at the planning stage.

In guidance published by the Environment Agency (2018)[1], Section D requires justification for activities for "pollutant storage and transmission". The guidance covers both Hazardous and Non Hazardous activities.

Slurry/manure is classed as an animal by-product (specifically ABP2). The JAGDAG list for hazardous substances or non-hazardous pollutants for the purposes of the groundwater directive 2006/118/EC does not contain an entry for slurry.

In terms of waste classification, should slurry be removed from the site then waste code 02 01 06 for "animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site" is applicable. This classifies the waste as non-hazardous.

This tank will also collect foul wash down water when the fattening cycle within the unit is complete, a time of approximately 3 months. It is anticipated that the tanks will have approximately 3 months storage capacity but would be checked regularly and emptied as required. Slurry in the tank would then be removed for land spreading. Land spreading is an accepted way of dealing with ABP2 waste.

Position statement D2 of the EA guidance refers mainly to underground storage of hazardous substances inside and outside of SPZ1. However, reference if also made to general underground storage of Non-Hazardous substances.

[1] EA, 2017. The Environment Agency's approach to groundwater protection February 2018 Version 1.2. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/658135/LIT_7660.pdf. Accessed 10/05/19.

For the purpose of this assessment, slurry is considered to be a potential Non-Hazardous pollutant rather than Hazardous. As such the requirement of position statement D2, where applied to the management of Non-Hazardous substances to ensure that any discharges, are limited so as not to cause pollution rather than prevention of Hazardous substances being released to groundwater.

The EA have previously noted that, whilst smaller sites storing slurry with the same polluting potential may also be potentially located within SPZs, these have not been subject to an assessment due to their size.

It is important to note therefore that a large number of those facilities will have been of a similar design and that the design of the facilities, coupled with the absence of any known significant impacts is considered in the interpretation of risk.

The EA outline a need to consider the substances being stored, appropriate engineering standards and effective management. In addition the assessment should take account of the sensitivity of groundwater and the location with respect to SPZs. Proposals for underground storage of pollutants in principal and secondary aquifers are to be accompanied by a risk assessment appropriate to the volume and type of pollutants being stored and the hydrogeological situation.

The detail provided within this assessment is therefore considered to be appropriate for the level of risk and takes account of the requirements of position statement D2.

It is understood that the requirement for an assessment of this site has been triggered due to the development being large enough to require an Environmental Permit. As such an assessment of risk has been requested. The EA have noted that, whilst smaller sites storing slurry with the same polluting potential which may also be potentially located within SPZs, these have not been subject to an assessment due to their size.

It is important to note therefore that a large number of those facilities will have been of a similar design and that the design of the facilities and this, coupled with the absence of any known significant impacts is considered in the interpretation of risk.

2 Site Characterisation

Based on available data, a focused conceptual site model has been developed to inform the HRA. This is outlined below.

2.1 Site Summary

Site Address	Raven Hill Farm, Kilham, Driffield, YO25 4EG
National Grid Reference	Approximate centre of site: NGR TA 03798 66873
Area	Approximately 0.33 hectares
Site Location	A Site Location Plan is provided as Appendix 1.
Site Description	The site is an adjacent to an existing pig unit and is currently an arable field. A Site Layout Plan is provided in Appendix 1.
Surrounding Land Uses	The surrounding land uses is predominantly agricultural.

2.2 Terrain and topography

The site is located at approximately 107mAOD. The ground falls to the south and east but rises gently to the west.

2.3 Surface water

No surface water features, including springs, are shown on the 1:50 000 Scale Ordnance Survey mapping within 1km of site.

2.4 Geology

The geology beneath and adjacent to the site can be described in Table 3.1. There are no mapped superficial deposits.

Table 3.1: Geological strata

Period and Age / Unit		Strata	Geological Description (BGS)
Cretaceous	Upper Cretaceous	Flamborough Chalk Formation	White, well-bedded, flint-free chalk with common marl seams (typically about one per metre). Common stylolitic surfaces and pyrite nodules.

Despite the absence of superficial deposits, a number of local boreholes describe the presence of Chalk fragments and clay or weathered Chalk of up to 2.75m thickness.

2.5 Hydrogeology and Hydrology

2.5.1 Groundwater – general

A summary of the hydrogeology for the formations of interest is outlined in Table 3.2.

Table 3.2: Hydrogeological conditions

Period and Age / Unit		Strata	Hydrogeological Description
Cretaceous	Upper Cretaceous	Flamborough Chalk Formation	Classified by the EA as a Principal aquifer with High vulnerability. The formation has low primary porosity and flow will be predominantly in secondary fracture porosity.

2.5.2 Groundwater Levels and Flows

Groundwater levels are estimated from BGS, Hydrogeological mapping to be approximately 25mAOD. This represents an approximate unsaturated zone thickness of 82m. A borehole record for the (TA06NW33) at NGR 503570 466726 states a water strike at 86mbgl at a similar elevation to the proposed unit and therefore confirms the unsaturated zone.

2.5.3 Groundwater Abstractions and Catchment

The site is within a groundwater source protection zone (SPZ). Specifically this is an SPZ2. The source is understood to be "Borehole 1 and Borehole 2 – Chalk – Kilham", operated by Yorkshire Water as a Public Water Supply (PWS) borehole. The NGR is provided as 506000 464800 (TA060648), being accurate to within 100m. Data from 2014 suggests that the maximum licensed abstraction rate is 1818400m^3/a and 5455.2m^3/d.

The boreholes are located approximately 2.9km from the site.

Groundwater vulnerability is mapped to be that of a Principal (shown as Major) aquifer with high vulnerability.

The presence of private groundwater abstractions has not been considered as part of this risk assessment.

2.6 Controlled Waters Conceptual Model

Based on available data the following conceptual model has been developed:

- According to geological maps, in the vicinity of the Site, no superficial deposits overlie the Flamborough Chalk Formation.
- The slurry storage system is sealed and acts a very low permeability pathway.
- Groundwater is present in the Chalk at an estimated depth of approximately 82mbgl and is likely to be unconfined. There is a significant unsaturated zone.

- The unsaturated Chalk acts as a pathway to the saturated Chalk aquifer. Groundwater flow is towards the abstraction.

The Chalk therefore acts a pathway for contaminant transport to the abstraction boreholes at Kilham which, together with the Chalk aquifer as a whole are considered to be the primary receptors.

Should any contamination escape from the structure, Advection, Dispersion, Retardation and Decay processes will occur along the pathway to mitigate any impact of potential contamination. This is particularly important in the unsaturated zone.

3 Controlled Waters Risk Assessment

3.1 Introduction

This Hydrogeological Risk Assessment (HRA) considers a Source-Pathway-Receptor **(**SPR**)** approach to determine how pollution from slurry within the lagoon (the Source) could pass through the engineered containment and underlying geological strata (the Pathway(s)), and impact on the environment (the Receptor(s)).

The HRA has been undertaken in two main parts:

- Development of a conceptual model; and
- Risk screening.

A description of the conceptual model is presented in the preceding section.

3.2 Overview of Development Proposals

An outline of the current development proposals are shown in Appendices 1 and 2.

The proposed development must fully comply with the terms of The Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) (SSAFO) Regulations 2010 and as amended 2013.

The builders of the structure are AM Warkup, who are a leading constructor of agricultural buildings and facilities. They have been constructing robustly designed pig units across the UK, including Yorkshire since 1963. In that time they have constructed a significant number of units of this type using the construction techniques proposed. The use of the proposed techniques is to a maximum depth of 1.8mbgl. In discussions with AM Warkup, it is clear that the proposed design has been acceptable to regulators, that the design is robust and that no significant failures are understood to have occurred previously.

Consultation will be made with the EA regarding the design, and in line with the regulations the EA will be informed verbally or in writing at least 14 days before starting any construction work. The notification will include the type of structure, the proposed design and construction and once an agreed proposal has been constructed. The developer will send a completed WQE3 notification form before using the facility.

3.3 Technical Precautions

Certain technical precautions are incorporated within the design to provide protection to groundwater and surface waters resources. These are understood to be the same as the adjacent sheds. The details of this are below.

The slurry storage consists of a poured concrete base and waterproof rendered filled concrete block side walls which create an impermeable tank. The below ground structure will consist of 3 blocks plus the thickness of the 150mm base slab and will be approximately 840mm below ground level.

The tank is compartmentalised. When emptying is required slurry will be pumped out via a central channel into which the individual tanks sluice.

In terms of monitoring and maintenance the slurry levels can be observed through the pen floors. The pen floors being made up of pre-cast concrete slats with slotted holes for the slurry to drop through. Visual inspection can therefore be undertaken on a regular basis and significant changes in slurry levels identified in individual tank compartments throughout the building. Full inspection can be undertaken once the unit is empty and cleaned.

For the purpose of this assessment the storage system is referred to as a lagoon below.

3.4 Source, Pathway, Receptor

A source, pathway, receptor approach has been used in establishing the risk posed to controlled waters by the construction proposals.

3.4.1 Source

The contaminant source is slurry stored within the lagoon. This is considered to be a non-hazardous potential contaminant. Organic matter is degraded by oxidation reactions ultimately breaking down compounds into inorganic species such as ammonia, nitrate, and sulphate and cations such as sodium and potassium. Denitrification can lead to the development of nitrate. The source also contains a number of metals and microbiological contamination.

3.4.2 Pathway

Fugitive slurry has the potential to migrate through the base and sides of the slurry lagoon, although these are of low intrinsic permeability. Where present contamination can pass vertically through the unsaturated zone where attenuation, transformation and degradation of contaminants would occur. Leachate could then enter groundwater within the underlying Chalk aquifer migrating under the hydraulic gradient to the PWS borehole approximately 2.9km downgradient. Any leachate migrating through the Chalk will undergo degradation and significant dilution.

The overall potential risk posed by the proposed development must be considered in context. Research shows that agricultural slurry stores pose a low risk of contaminant migration and that this is especially low where construction is robust. To contextualise the current development some key points from research this field are outlined below.

Gooddy *et al* (2002)[2] discuss the fact that whilst the storage of livestock manure can present a serious potential risk of surface water pollution, there has not been the same concern about potential pollution to groundwater possibly because of the greater dilution and less immediate impact expected in groundwater systems (Gooddy et al., 2001)[3]. They go on to say that the majority of livestock slurry storage structures generally only pose a risk of water pollution because of structural or operator failure. Only in the case of

[2] Gooddy D. C., Clay J.W., & Bottrell S.H., 2002. 2002 Redox-driven changes in pore water chemistry in the unsaturated zone of the chalk aquifer beneath unlined cattle slurry lagoons. Applied Geochemistry, 17 (7). 903-921

[3] Gooddy, D.C, Hughes, A.G., Williams, A.T., Armstrong, A.C., Nicholson R.J., Williams, J.R., 2001. Field and modelling studies to assess the risk to UK groundwater from earth-based stores for livestock manure. Soil Use and Management 17, 128-137.

unlined earth-based slurry lagoons, which were unregulated before 1991, and field heaps of solid manure, is there risk that pollutants can leach to groundwater (Withers *et al*, 1998[4] and Gooddy 2002).

Research was carried out for MAFF between 1997 and 2000[5]. The objectives of that study were to establish whether farm waste slurry stores pose a significant threat to groundwater and to suggest ways in which the pollution risk could be minimised. Since all stores constructed after 1991 are required to have an impermeable base, field studies focussed on unlined stores, which were considered to pose the greater threat of contamination to groundwater.

In the case of the proposed development the base of the tank is engineered using what is essentially impermeable concrete and the sides of the tank are formed of concrete blockwork which will be sealed with waterproof render. This will be fundamentally more secure than unlined sites.

In the noted studies, where unlined stores had self-sealed with slurry precipitation, migration potential was considered to be low and a major finding of the project was that even unsealed but lined farm waste slurry stores do not pose an overall threat to groundwater quality.

MAFF also concluded that even for unlined facilities, farm waste stores represents a relatively small point source of contamination in the very large water body of a groundwater catchment. Where leakage did occurred from those stores the travel times are slow and there is significant dilution within the aquifer resulting in a minimal impact on abstractions.

Where a deep unsaturated zone exists, such as in the current proposed site, any potential risk to groundwater quality is further reduced. Travel times are slow in the unsaturated zone and direct hydraulic connectivity between the base of the lagoon and the water table is absent. Furthermore, at Chalk sites, geochemical reactions can often be buffered by the calcium carbonate based Chalk matrix.

For pathogens that might have relatively short lifespans in the subsurface, long travel times are of great significance because transit times from lagoon to the water table abstraction would be greatly increased.

An attempt at risk mapping which links the estimated number of slurry lagoons per unit area with the soil vulnerability analysis was also attempted as part of the MAFF study. They concluded that the Yorkshire Chalk does not appear to have a high risk of groundwater pollution. This was in part due to the absence of unlined facilities.

3.4.3 Receptors

The following are considered to represent the key potential receptors for any contamination migrating away from the proposed development.

1. Groundwater in the Chalk aquifer beneath and downgradient of the site; and

[4] Withers, P.J.A., McDonald, H.G., Smith, K.A., Chumbley, C.G., 1998. Behaviour and impact of cow slurry beneath a storage lagoon: I. Groundwater contamination 1975 – 1982. Water, Air and Soil Pollution 107, 35-49.

[5] MAFF, 2000. The impacts of farm waste stores on groundwater quality. Final Project Report. MAFF Research and Development, project code WA0517. http://randd.defra.gov.uk/Document.aspx?Document=WA0517_234_FRP.pdf Accessed 19/5/17.

2. The Borehole 1 and Borehole 2 – Chalk – Kilham PWS approximately 2.9km downgradient of the site;

3.4.4 Pollutant linkages

The primary potential source of contamination is considered to be the slurry within the lagoon which primarily contains elevated nutrients and is considered to be non-hazardous. The robust engineering of the lagoon means that the slurry is considered to pose a low risk of releasing fugitive leachate.

A groundwater receptor exists (the Chalk aquifer beneath the site) as does the PWS downgradient of the site.

The robust engineering and low permeability of the slurry lagoon, together with good management procedures, a substantial unsaturated zone and the distance between the development and the PWS abstraction boreholes, means that that the residual risk to controlled waters posed by the development is considered to be very low.

3.5 Risk Assessment

In assessing the risk posed to controlled waters, a tiered approach has been completed such that the degree of effort and complexity reflects the potential risk posed by the proposed operation.

This process comprises a risk screening which has been used to determine whether the development proposals represent, or potentially represent, a significant risk to groundwater and surface water resources and if further assessment is required.

Considerations made in the risk screening are summarised below:

- The development area lies within a Principal Aquifer and is within SPZ2 for a PWS operated by Yorkshire Water. The PWS is approximately 2.9km downgradient of the site
- There is a significant thickness of unsaturated zone, greater than 80m, beneath the development. The tank forms the base of the pig unit which is covered and therefore no rainfall infiltration will occur directly beneath the unit.
- It is anticipated that in the unlikely event of leakage from the lagoon, this would only be of a low volume. No catastrophic failure of the structure is anticipated based on knowledge of other installations.
- The base of the unit is formed of 150mm poured concrete and the walls are formed of filled breeze blocks which are completed with waterproof render to seal the tank. The unit is compartmentalised and these are connected to a central channel for removal of slurry by a system of sluices.
- Management practices within the operation will minimise the risk of structural or operator failure. There is compartmentalisation within the main tank further limiting risks of catastrophic failure. The slurry level can be observed through slotted slabs which form the floor of the building. Full periodic inspection of the lagoon will be made following removal of slurry and proactive risk management measures can be performed where necessary.
- Any above ground leakage will be visible and will be managed according to spill procedures in line with the Environmental Management Plan for the operation.

Based on published research, the conceptual hydrogeological understanding of the site, the robust engineering of the development, and the proposed management of the operation it is anticipated that the proposed development will pose a very low residual threat to the water environment.

It is concluded that further risk assessment is therefore not required.

Notwithstanding this, the assessment prevented here does not guarantee that release of contamination will not occur in the future but provides a perspective on the perceived risk taking account of the environmental setting and engineering proposals. Appropriate environmental management procedures should be developed to deal with any release of fugitive leachate in the unlikely event that this should occur.

Appendices

Appendix 1 – Location and Layout Plans

Appendix 2 - Design Drawings