SECTION 6: WATER

6.1 INTRODUCTION

John Barnett and Associates (JBA) has retained SLR Consulting Limited (SLR) to undertake an hydrogeological and hydrological impact assessment for the continued restoration of a former gravel quarry at Blackhall, Co. Kildare using inert wastes.

This section details the local hydrology and hydrogeology of the application site and surrounding area (up to 4km radius around the site boundary) and identifies potential geological, hydrogeological and hydrological impacts associated with the proposed development.

Unmitigated impacts assuming that no mitigation is in place for the initial assessment are considered, before discussing appropriate mitigation measures and reassessing potential impacts. The assessment is based on a detailed baseline description of the local geological, hydrological and hydrogeological regimes.

6.1.1 Background

The existing inert waste facility site at Blackhall is located within a former sand and gravel quarry and operates in accordance with a waste permit issued by Kildare County Council. This assessment is completed in support of a Waste Licence Application for the site which requires submission of an Environmental Impact Statement. This chapter presents an assessment of the environmental impact of the restoration of the site by inert wastes on the hydrogeological and hydrological environment. Further information on the waste types and proposed schedule of works is detailed in Chapter 2.

6.1.2 Scope of Work

This chapter identifies the local hydrogeological and hydrological environment based on available information in the vicinity of the site. A qualitative assessment has been undertaken of the potential impacts on this environment arising from continued backfilling of the sand and gravel quarry using inert fill. The assessment considers the proposed phasing of the infilling, the waste types and any proposals for water management at the site. The methodology of the assessment is described in detail in Section 6.3.1.

6.1.3 Sources of Information

The following sources of information have been consulted in order to investigate the hydrogeology and hydrology of the area surrounding the application site:

- The Environmental Protection Agency for Ireland website (www.epa.ie) for maps and environmental information;
- Geological Survey of Ireland website (www.gsi.ie);
- Geology of Kildare-Wicklow, Sheet 16, 1:100,000 scale, Geological Survey of Ireland, 1995;
- Groundwater Protection Schemes, Department of the Environment and Local Government, Environmental Protection Agency, and Geological Survey of Ireland, 1999, and Appendix Groundwater Protection Response for Landfills; and
- Tables for the Hydraulic Design of Pipes and Sewers, 5th Edition, Hydraulics Research, Wallingford, 1990.

6.1.4 Contributors

The report has been compiled by SLR Consulting Limited in consultation with John Barnett and Associates.

6.2 RECEIVING ENVIRONMENT

6.2.1 Available Information : Geology and Soils

Soils and Subsoils
The Environmental Protection Agency (EPA) website publishes soils and subsoils maps created by the Spatial Analysis Unit, Teagasc in collaboration with the Geological Survey of Ireland and Forest Service. These maps indicate that the majority of the site is underlain by shallow well drained mineral soils, which are part of the Renzinas / Lithosols Great Soil Group. The north-east corner of the site in underlain by shallow poorly drained mineral soils which are part of the Surface Water Gleys (shallow) and Groundwater Gleys (shallow) Great Soil Groups. An area to the west of the site comprises deep well drained mineral soils which are part of the Grey Brown Podzolics / Brown Earths (medium-high base status) Great Soil Group. All soils in this area are derived from mainly calcareous parent material.

The entire site is shown as being underlain by subsoils (Quaternary drift deposits) which comprise glaciofluvial sand and gravels derived from Carboniferous Limestones. The sands and gravels are laterally extensive across this area and are reported by the Geological Survey of Ireland to be commonly more than 20m thick, reaching thicknesses in excess of 70m in the Blessington area to the south–east of the site. To the west of the site, beneath the Grey Brown Podzolics are Tills, which are also considered to be derived from Carboniferous Limestones. An extract of the subsoils map is presented as Figure 6.1.

Solid Geology
The superficial deposits under the entire site and surrounding area are underlain by bedrock of the Carrighill Formation. The published geological map of the area shows that the Carrighill Formation forms part of the Killcullen Group and is Silurian in age. The Carrighill Formation comprises calcareous fine grained greywacke siltstone and shales. An extract of the geological map is shown as Figure 6.2.

Local Geology
Three perimeter groundwater monitoring boreholes (PBH1a, PBH2a and PBH3) were installed across the application site in December 2007. The boreholes were drilled using rotary techniques, and therefore only general descriptions of the deposits encountered were obtained. The boreholes generally encountered an upper sand layer overlying clay overlying gravel which was overlying further sand deposits. The boreholes were drilled to a depth of between 19.5m (PBH1a) and 20.5m (PBH2a and PBH3) with monitoring standpipes installed so that the response zones were sealed within the saturated gravel and lower sand deposits. The materials encountered during drilling have been described as follows:

- MADE GROUND (sandy gravelly clay);
- Fine to medium to coarse brown to red brown to grey SAND;
- Brown slightly sandy slightly gravelly CLAY; and
- Grey slightly sandy medium to coarse GRAVEL with some cobbles.

The clay bands were recorded at a thickness of 1.6m and 3.1m. Well construction records are presented in Appendix 6.1

6.2.2 Available Information : Hydrogeology

Aquifer Characteristics and Groundwater Vulnerability
The published geological memoir which accompanies the geological map reports that the aquifer strata (i.e. sands and gravels) which cover a significant part of this region of Ireland can be developed to provide reasonably large water supplies from either springs or boreholes. Well yields in most of the remaining aquitard rocks (i.e. bedrock) are generally only sufficient for domestic or farm supplies and range from 20m^3/d -50m^3/d except along faults where they may be in excess of 200m^3/d.

The published geological memoir states that the bedrock hydrogeology in this region of Ireland is dominated by secondary fissure permeability and specifically that the Carrighill Formation is considered to be an aquitard. The bulk permeability of the Carrighill Formation is low and groundwater storage and movement is constrained to the upper weathered horizons of this unit and fractures / faults.

The Quaternary strata play an important role in the groundwater flow regime of this region. The sands and gravels allow a high level of recharge, provides additional storage to the underlying bedrock aquifers and, where sufficiently thick, can be an aquifer in their own right. Well yields for the Quaternary deposits are between 100m^3/d and 3000m^3/d.

Aquifer maps published on the EPA website indicates that the site is located on a locally important sand and gravel aquifer which is extensive to the south, north and west of the site boundary. An extract from the aquifer map is provided on Figure 6.3.

The EPA website indicates that the groundwater in the superficial sand and gravel aquifer in the vicinity of the application site achieved an Environmental Objective Score of 2a in 2005, which means that groundwater is expected to reach good status as per the EU Water Framework Directive in 2015. Groundwater to the north-west of the site associated with bedrock beneath the Naas Urban area achieved a lower Environmental Objective Score of 1b and is considered to be at risk of failing to meet the water framework objectives.

Groundwater vulnerability maps published on the EPA website indicate that the site is located in an area with High Groundwater Vulnerability status. An extract of the Groundwater Vulnerability map is presented as Figure 6.4. The groundwater vulnerability reflects the near surface presence of groundwater and potential for rapid groundwater movement in the superficial deposits.

Groundwater in the superficial sand and gravel aquifer has been intercepted by the former quarry workings and is evidenced by a spring in the quarry floor below the electricity pylon in the north-eastern corner of the site. The level and extent of the groundwater pond across the quarry floor in the northern part of the site varies seasonally. The closed depression in the south-western corner of the site also intercepts the groundwater table at its base, giving rise to a pond feature (see Figure 6.5).

Recharge Mechanisms
The published geological memoir reports that the rainfall in the area is around 1000mm/year. Potential recharge to the aquifers ranges from 325mm/yr to 550 mm/yr depending on the elevation and location. The bulk of this recharge occurs between late October and early March.

Groundwater Levels and Flow
The published geological memoir reports that in this region of Ireland, groundwater is generally within 10m of the surface with an annual fluctuation of less than 5m, except for the more elevated parts of the sand and gravel aquifers.

During the site investigation completed in December 2007, several groundwater strikes were recorded in each borehole during drilling. A summary of water strikes is presented in Table 6.1 below :

Borehole Name	Water Strike (mbgl)	Water Strike (approx. mOD)	Deposits recorded at water strike
PBH1a	13.0	144.5	Saturated grey brown sandy medium to coarse GRAVEL
PBH2a	12.6 (minor strike)	156.15	Grey slightly sandy medium to coarse GRAVEL with some cobbles
	16.0	152.75	
PBH3	17.7	142.8	Grey slightly sandy medium to coarse GRAVEL with some cobbles
	18.3	142.2	

Table 6.1. Groundwater Strikes Recorded during Drilling

Water levels were also collected approximately one week after drilling had ceased; groundwater was recorded at the following rest levels:

PBH1a – 143.5mOD (14mbgl)
PBH2a – 154.47mOD (14.28mbgl)
PBH3 – 143.65mOD (16.85mbgl)

Further to this is it is also reported that the water level in Well 1 in the south-western part of the site is approximately 19mbgl and is therefore approximately 134maOD, however it is unclear as to when this information was collected in relation to the levels reported in the newly installed boreholes. It is considered likely that this level is artificially depressed by pumping, as it is used for domestic water supply and wheel washing at the site. It is also assumed that pumping may be intermittent and therefore this water level has not been included in the construction of groundwater contours across the site.

Groundwater contours based on the rest levels recorded in the new boreholes and levels surveyed from the spring and ponds have been used to determine groundwater flow contours, which are presented on Figure 6.5. This shows that the indicative groundwater flow direction is across the site towards the north-west.

It is considered that any groundwater movement in the upper weathered horizons of the Carrighill Formation will be in hydraulic continuity with the overlying sand and gravel unit.

Groundwater Abstractions, Use and Quality

There are two existing groundwater wells (Well1 and Well 2) near to the site boundary. Well 1 is located on the south-western site boundary, near to the site access road and it is understood that this well is pumped. Well 2 is located just north of the northern site boundary. The well is located adjacent to a number of properties, and it is understood that it supplies drinking water to these properties. It is understood that this well is also pumped. No further records of groundwater abstractions in the vicinity of the application site were obtained.

Groundwater quality samples were obtained from Well 2 in April and October 2007 and from the new monitoring boreholes (PBH1a to PBH3) and Well 1 in January 2008. In addition samples of the groundwater at surface water monitoring points SW1 and SW2 were obtained in April and October 2007. All samples were sent to an independent accredited laboratory for analysis. A summary of reported water quality is presented overleaf as Table 6.2. As mentioned above, the surface water ponds are considered to be in continuity with groundwater, and are therefore compared to the water quality recorded in the groundwater monitoring wells.

It should be noted that mercury, cadmium, arsenic, lead and ammoniacal-N were not detected above the laboratory detection limits in any of the samples from any of the groundwater sampling points. The groundwater quality is considered to be very good, concentrations of all contaminants (except for manganese in PBH3) are much lower than the EU Drinking Water Standards. Additional List I analysis for Diesel and Petrol Range Organics, Mineral Oils, Benzene, Toluene, Ethylbenzene and Total Xylene, was carried out on the samples obtained in January 2008. The analysis shows that none of these List I substances were detected in groundwater.

The analysis also indicates that there is no disparity between groundwater quality recorded in upgradient or downgradient locations, which suggests that there is currently no adverse impact on groundwater quality attributable to either historical or ongoing site operations.

Parameters	Groundwater Sampling Locations						
	SW1 (upgradient)	SW2 (downgradient)	GW1 (upgradient)	PBH1a (downgradient)	PBH2a (upgradient)	PBH3 (downgradient)	Well 1 (midgradient)
Sodium (mg/l)	7.5 to 23.5	7 to 7.5	14.5 to 15	9.5	8.5	9.0	11.0
Potassium (mg/l)	0.6 to 3.5	0.5 to 0.9	1.0 to 1.3	1.2	0.6	1.4	1.0
Dissolved Calcium (mg/l)	<0.12 to 133.4	78.27 to 79.38	130.8 to 122.6	79.86	72.56	154.1	87.6
Dissolved Copper (ug/l)	<1	<1	<1 to 4	<1	<1	2	2
Dissolved Iron (ug/l)	2 to 30	19 to 30	39 to 20	<2	<2	<2	<2
Dissolved Lead (ug/l)	<1	<1	<1	<1	<1	<1	<1
Dissolved Magnesium (mg/l)	<0.1 to 12.1	8.46 to 8.85	29.1 to 33.8	11.7	7.63	17.46	15.89
Dissolved Manganese (ug/l)	<1 to 1	<1	<1	15	9	89	<1
Dissolved Nickel (ug/l)	<1 to 4	<1 to <1	<1 to 1	1	1	3	<1
Dissolved Zinc (ug/l)	<1 to 9	<1 to 9	<1 to 18	<5	<1	7	<1
Chloride (mg/l)	14 to 52	13 to 14	22 to 26	16	14	18	12
Ammoniacal-N (mg/l)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sulphate (mg/l)	11 to 69	11	11	20	9	15	8
Conductivity (mS/cm)	0.514 to 0.71	0.450 to 0.468	0.73 to 0.735	0.515	0.45	0.605	0.567
pH (units)	7.41 to 7.86	8.01 to 8.03	7.68 to 7.77	7.56	7.5	7.5	7.41
Total Alkalinity (mg/l)	220 to 270	178 to 260	300 to 320	220	200	170	290

Table 6.2 Summary of Groundwater Quality

Groundwater Protection

Groundwater in Ireland is protected by European Community and national legislation. The Geological Survey of Ireland (GSI) in conjunction with the Department of Environment and Local Government (DoELG) and the EPA have developed a methodology for the preparation of groundwater protection schemes to assist the statutory authorities and others to meet their responsibility to protect groundwater (DoELG / EPA / GSI, 1999). This methodology incorporates land surface zoning and groundwater protection responses.

The DoELG / EPA / GSI has developed a scheme (Groundwater Protection Response Matrix for Landfills) to assessing potential landfill sites on the basis of groundwater vulnerability and aquifer status. However, it should be noted that this scheme has largely been developed for new non-hazardous landfills and is therefore not an appropriate tool for assessment of established inert recovery facilities such as that at Blackhall.

Notwithstanding this, review of the Groundwater Vulnerability Map (Figure 6.4) and the Aquifer Map (Figure 6.3) in accordance with the DoELG / EPA / GSI methodology indicates that the Blackhall site is located within an area of High Vulnerability and a Locally Important Sand/Gravel Aquifer. These classifications have been compared against the matrix for non hazardous landfills; which indicates that the site setting falls within a response category of R3[1], which is described as being 'Not generally acceptable (for non-hazardous landfills), unless it can be shown that :

- The groundwater in the aquifer is confined; or
- There will be no significant impact on the groundwater; and
- It is not practicable to find a site in a lower risk area'.

The available soil and groundwater data from the application site indicates that the inert soil recovery / site restoration works undertaken to date have not had any detrimental impact on the local water environment. Assuming that activities at the site continues to be managed as heretofore, it is considered reasonable to assume that established operations can continue without any significant adverse impact on groundwater quality. Given that site restoration / recovery activities (such as those envisaged for this site) can only be undertaken where previous activities have created void space in the landscape, the additional requirement to identify other sites in lower risk areas does not apply. In any event, the backfilling of existing groundwater ponds and provision of inert soil cover (predominantly cohesive till) will provide an enhanced degree of protection, over and above that which exists at present.

Given the limited risk to groundwater associated with the placement and compaction of inert soil and stones compared to those presented by non-hazardous landfills, it is considered that the site setting is appropriate for an inert recovery facility. It is also reiterated that the DoELG / EPA / GSI groundwater protection methodology has not been developed for existing inert landfills or recovery facilities. Further to this, the significance of the impact of the development on groundwater is fully explored in Section 6.3.

6.2.3 Available Information : Hydrology

Local Hydrology and Surface Water Quality

The nearest watercourse to the site is the River Morell, which is a tributary of the River Liffey, and located within the Eastern Liffey River Basin District. The River Morell runs parallel to the minor road to the south and west of the site. Ordnance Survey mapping indicates that this watercourse is fed by waters emerging at springs at the base of the NE-SW trending ridge running to the south-west of the application site. One of these wells, known locally as Brides Well, occurs at the base of Slieve Roe in the townland of Newtown Great to the south-east of the application site. In 2005 the River Morell achieved an Environmental Objective status of 1a, in relation to the Water Framework Directive, indicating it is at risk of failing to meet good status in 2015. No water quality data is available for the River Morell.

Surface Water Flows and Discharge Consents

The EPA website indicates that there are no hydrometric stations within 5km of the site, and therefore no flow statistics are available for the watercourses close to the site. There is currently no information on discharge consents in the vicinity of the site.

Flooding
The Office of Public Works website (www.floodmaps.ie) indicates that there are no records of historic flooding recorded in the vicinity of the site, and therefore the proposed development is not considered to be at risk of flooding. Surface water run-off and discharges at site will be managed so that they do not increase the risk of flooding in the vicinity of the proposed development area. The proposed restoration profile allows water to be shed to the north-west of the site where it can infiltrate into the permeable sand and gravel aquifer.

6.2.4 Field Surveys

A site visit was undertaken by a senior SLR hydrogeologist on the 22nd January 2008. The following observations were noted:

- the majority of the site in the east and north east of the site, which has only been partially restored with a low permeability material, was wet underfoot.;
- the overflow of water from the wheelwash facility discharges into the pond located in low lying ground in the south-western corner of the site. Reeds are associated with the influx of water from the wheelwash facility (Plate 6.1);
- the base of the pond in the south-west of the site appeared to comprise sands and gravels and is therefore considered to be in continuity with groundwater;
- a ditch which collects surface water runoff from high ground in the north-west of the site was dry and was not contributing to the water in the pond in the west of the site (Plate 6.2);
- a groundwater spring was noted in the north-eastern corner of the site in a low-lying artificially formed valley. The spring water was collected in sump and directed into a concrete pipe which discharged into a pond in the north of the site (Plate 6.3);
- due to heavy rainfall prior to the site visit the spring was overflowing in the area of the sump, this was considered to be unusual and attributable to the high rainfall;
- the discharge from the concrete pipe into the pond was not pipe full;
- the pond in the north of the site is extensive, but shallow, and is within a lower lying area. The base of the pond was observed to be of sand and gravel and it is therefore considered that it is in continuity with groundwater (Plates 6.4 and 6.5);
- it was observed that a further discharge pipe entered the pond, but no flow could be observed (Plate 6.6).

Photographs of the features of note at the site are presented as plates at the end of this chapter and the viewpoint location and directions are indicated on Figure 6.5.

6.2.5 Limitations

The assessment is based on visual observations from site visits, available published information, and discussions on site and is a qualitative assessment.

6.3 IMPACT OF THE REMEDIATION WORKS

6.3.1 Evaluation Methodology

The impact of the proposed development (as detailed in Chapter 2) are assessed in this section. The methodology applied in the assessment is a qualitative risk assessment methodology in which the probably of an impact occurring and the magnitude of the impact, if it were to occur, are considered. This approach provides a mechanism for identifying the areas where mitigation measures are required, and for identifying mitigation measures appropriate to the risk presented by the development. This approach allows effort to be focused on reducing risk where the greatest benefit may result. The assessment of risk is outlined below in Table 6.3.

Probability of Occurrence	Magnitude of Potential Impacts			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near Zero
Low	Medium	Low	Low	Near Zero
Negligible	Low	Near Zero	Near Zero	Near Zero

Table 6.3 : Matrix Used to Assess Potential Impacts

The magnitude of potential impacts in relation to geology, hydrogeology and hydrology are detailed in Table 6.4 below:

Magnitude	Potential Impact
Negligible	No impact or alteration to existing important geological environs or important soil settings (i.e. valuable agricultural land) No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; No alteration to groundwater recharge or flow mechanisms; and No pollution or change in water chemistry to either groundwater or surface water.
Mild	Some loss of important soils or peat, but which has no long term impact Minor or slight changes to the watercourse, hydrology or hydrodynamics; Changes to site resulting in slight increase in runoff well within the drainage system capacity; Minor changes to erosion and sedimentation patterns; and Minor changes to the water chemistry.
Moderate	Slope failure or instability which may cause foundation problems, loss of extensive areas of important soils or peat, damage to important geological structures / features Some fundamental changes to watercourse, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff within system capacity; Moderate changes to erosion and sedimentation patterns; and Moderate changes to the water chemistry of surface runoff and groundwater.
Severe	Slope failure or instability which results in loss of life, permanent degredation and total loss of peat environment across the entire development site, loss of important geological structure/feature. Wholesale changes to watercourse channel, route, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff with flood potential and also significant changes to erosion and sedimentation patterns; and Major changes to the water chemistry or hydro-ecology.

Table 6.4 : Magnitude of Potential Geological, Hydrological and Hydrogeological Impacts

In addition to the nature and significance the potential impacts will be assessed in terms of their duration, whether they are direct or indirect impacts, and also if the impact will be cumulative.

The following sections identify the potential impacts of the proposed development on the geological, hydrogeological and hydrological environments. It also assesses the likelihood of occurrence of each identified impact in accordance with Tables 6.3 and 6.4. It should be noted that the impacts are initially assessed with no mitigation or design measures incorporated to reduce the risk.

6.3.2 Potential Impacts on Geology

Given the geological setting of the proposed development, (i.e. a former sand and gravel quarry) and the type of the proposed development (i.e. backfilling the quarry with inert wastes, specifically inert soil and stones and recovered secondary aggregate), it is considered that there is a negligible potential impact on the geological environment associated with developing the site as no further sand and gravel will be removed. The area of the site is small compared to the local and regional extent of the superficial sand and gravel unit.

6.3.3 Potential Impacts on Groundwater

Given the hydrogeological setting, it is considered that the proposed development has the potential to impact on groundwater in terms of both the groundwater quality and the groundwater flow regime. These are considered separately below.

Groundwater Quality
During the development and operation of the site there is a risk of groundwater pollution from the following potential sources:

- accidental spillage of fuels and lubricants by construction plant placing the inert fill and other operational procedures;
- increase in suspended solids and potential for contaminated runoff entering groundwater during development of the site; and
- rogue loads of contaminated material being deposited at the site.

It should be noted that Well 2 in the east of the site and Well 1 in the south-west of the site are used as private water supplies and therefore indicate that the locally important sand and gravel aquifer is used as a potable water supply. However, Well 2 is located up hydraulic gradient of the site, and therefore would not be impacted by the proposed development, whereas proposed land restoration with inert fill up hydraulic gradient of Well 1 is minimal. Current restoration with inert fill has been shown to have no impact on the groundwater quality or yield down hydraulic gradient of the site.

It is considered that without mitigation the probability of occurrence of spillage of fuels, lubricants and other potentially contaminative liquids is 'medium' due to the area of the site and number of vehicles that will be using the site and the magnitude of impact is 'moderate'. Therefore the overall risk to groundwater, without mitigation, is '*medium*'.

It is considered that without mitigation the probability of occurrence of an increase in suspended solids and potential for contaminated runoff entering groundwater during operation of the facility is 'medium' to 'high' due to the time frame over which this may occur and the potential for direct tipping of inert fill high in silt content into groundwater. The magnitude of impact is 'moderate' and therefore the overall risk is '*medium*' to '*high*'.

Without mitigation the probability of occurrence of a rogue load which may have the potential to contaminate groundwater at the site is 'medium' and the magnitude of impact is 'mild' to 'moderate' depending on where the rogue load is deposited. The overall risk is considered to be '*low*' to '*medium*'.

Groundwater Flow
Without mitigation, or consideration of operational procedures, infilling the site with low permeability inert fill material, particularly below the groundwater table and in the area of the groundwater spring, has the potential to create a low permeability zone which could hinder regional groundwater flow. This could alter the groundwater flow pattern around the site, leading to higher groundwater levels upstream of the site and lower levels downstream of the site. This in turn may affect groundwater abstractions and private water supplies downstream of the site. Without mitigation the probability of occurrence is 'high' and the magnitude of impact '*moderate*'.

Although, without mitigation the magnitude of impact is assessed as moderate, it is noted that (a) the regional permeability of the superficial sand and gravel aquifer is high which will maintain regional groundwater flow direction, and (b) runoff shed from the proposed restoration landform will infiltrate to form groundwater recharge on the downstream site boundary which will maintain aquifer recharge. The overall impact is therefore considered to be '*high*'.

6.3.4 Potential Impacts on Surface Water

Given the site setting, it is considered that the potential impact of backfilling the former quarry with inert fill will have a negligible effect on surface water in the area for the following reasons:

- there are no surface water features within the site boundary (all water features on site are considered to be representative of groundwater);
- the River Morell is not considered to be in continuity with groundwater, and therefore does not receive any baseflow from groundwater, so that any alterations to the recharge of the aquifer will not have an effect on the surface water flow in the river; and
- runoff from the completed landform will be discharged to ground within the site boundary.

6.3.5 Summary of Potential Impacts

A summary of potential impacts *without mitigation* is presented in Table 6.5 below :

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Groundwater Quality					
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes
Release of suspended solids	Local, Long Term, Direct	Medium to High	Moderate	Medium to High	Yes
Rogue load of contaminated material	Local, Short Term, Direct	Medium	Mild to Moderate	Low to Medium	Yes
Groundwater Flow/Recharge to Aquifer					
Impermeable barrier to groundwater flow	Local, Long Term, Direct	High	Moderate	High	Yes
Reduction in recharge to aquifer	Local, Long Term and Direct	High	Moderate	High	Yes

Note: it is considered that the potential impacts on the geological environment and surface water from the development is negligible and is therefore not detailed in this table.

Table 6.5 Summary of Unmitigated Risk and Magnitude of Potential Impacts at Blackhall

Review of Table 6.5 indicates that if no mitigation measures are incorporated within the design and backfilling operation for the former sand and gravel quarry, there is potential for the site to cause detrimental and direct impacts to the superficial aquifer by locally polluting groundwater and creating a low permeability zone to groundwater flow. The impacts are all local, but range from short-term to long-term. It is considered that if the identified potential impacts on either groundwater quality or groundwater flow were all to occur there would be a cumulative effect, which would increase the significance of the impact. It is therefore recommended that the mitigation measures outlined in the following section are incorporated to reduce the potential impact.

6.3.6 Do Nothing Scenario

Were the proposed backfilling of the application site not to proceed as envisaged, it is unlikely that a portion of the land at least could ever be put to productive use and that it would remain as a scar on the landscape. A minor risk of groundwater contamination will exist for as long as the groundwater ponds are present. Ongoing vigilance will be required to ensure no potential contaminating activities occur on or in the vicinity of the groundwater ponds.

6.4 MITIGATION MEASURES

Proposed mitigation measures required to reduce the potential impacts to acceptable levels are identified in this section. These measures either reduce the likelihood of an event occurring, or reduce the magnitude of the consequences if the event does occur. It should be noted that several of the mitigation measures proposed would have a positive effect on more than one potential impact.

6.4.1 Proposed Mitigation Measures

In order to mitigate against the risk of pollution to groundwater occurring during operation of the site the following management measures would be included:

- wherever possible a traffic management system would be put in place to reduce the potential conflicts between vehicles, thereby reducing the risk of a collision;
- a site speed limit would be enforced to further reduce the likelihood and significance of collisions;
- all plant would be regularly maintained and inspected daily for leaks of fuels, lubricating oil or other contaminating liquids/liquors;
- refuelling of vehicles would either be undertaken in a surfaced compound area from a fuel tank(s) that is bunded or be undertaken off-site to minimise the risk of uncontrolled release of polluting liquids/liquors;
- maintenance of plant and machinery would be undertaken within a site compound area or off-site, as appropriate, to minimise the risk of uncontrolled release of polluting liquids;
- spill kits would be made available on-site to stop the migration of spillages, should they occur;
- only granular wastes should be deposited into low areas below and immediately above the groundwater table to prevent the influx of suspended solids into groundwater; and
- waste loads should be inspected and tested to confirm they are inert prior to deposition at site.

These measures would reduce the potential impact of

(I) spillage of fuels and lubricants from '*medium*' to '*low*',
(II) an increase in suspended solids from '*medium to hig*h' to '*low'* and
(III) contamination from rogue loads from '*low to medium*' to '*near zero*'.

In order to mitigate against the risk of creating a low permeability zone to groundwater flow, thereby potentially locally altering the groundwater flow regime and the reduction of recharge to the sand and gravel aquifer the following design and management measures would be included:

- only granular and high permeability wastes would be deposited in low lying areas or within the areas where groundwater is ponding;
- the spring discharge is collected and discharged back into the in-situ sand and gravel aquifer

The engineering works associated with the spring discharge are proposed to comprise the following:

- granular fill of 40mm single sized granular material will be placed with a thickness of 600mm above the existing 300mm concrete pipe and will be separated from the inert waste by means of a geotextile protector;
- a new 300mm concrete pipe will be connected to the existing pipe and will be placed within a trench in the in-situ sand and gravels deposits. The pipe will have a granular surround of 40mm. This will in turn be separated from the in-situ soils by a geotextile separator;
- the join will form a 90 degree bend encased in a concrete thrust block with 400mm gravel surround and a geotextile separator to prevent leakage in or out;
- the new drainage trench and concrete pipe will be directed to a soakaway (10m by 10m) to discharge directly into insitu sand and gravel deposits;

- the soakaway will be partially constructed within the in-situ sands and gravels and will extend below the groundwater level. The base of the soakaway will be laid with 100mm single sized granular material or similar approved grading. The geotextile separator which is placed below the concrete pipe will continue and will be placed in the soakaway above the 100mm single sized granular material and below the 40mm single size granular material which forms most of the soakaway.
- the concrete pipe will allow discharge of the spring water into this granular material and above the groundwater table in the soakaway.

These proposed engineering measures are presented as Figure 6.6.

It is further envisaged that the remainder of the existing groundwater pond will be backfilled above seasonal groundwater level maxima using recovered secondary aggregates in order to minimise erosion or downward percolation of fines from backfilled cohesive soils into the groundwater aquifer.

The hydrogeological performance of the proposed spring collection and discharge infrastructure is assessed in Appendix 6.2.

6.4.2 Residual Impacts

A summary of the proposed mitigation methods, together with the predicted effects and residual impacts is presented in Table 6.6 overleaf.

Examination of Table 6.6 confirms that there are no significant residual impacts with respect to groundwater provided the appropriate mitigation measures are undertaken. It is therefore considered that the siting of an inert recovery facility in this location is acceptable and it has been shown that there will be no significant impact on groundwater.

6.5 INTERACTIONS

It is considered that there are no interactions at site between groundwater and surface water, as the local river, the River Morell, is perched and is therefore not in continuity with groundwater at the application site. It should also be noted that the River Morell receives baseflow from springs at the base of a NE-SW trending ridge to the south west of the site. As the groundwater at site flows towards the north-west, it can be confirmed that there will be no interaction between groundwater at the application site and surface water in the River Morell.

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?	Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Magnitude of Impact
Groundwater Quality									
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes	Traffic systems, maintenance, bunding and spill kits	Low	Moderate	Low
Release of suspended solids	Local, Long Term, Direct	Medium to High	Moderate	Medium to High	Yes	Minimisation, management, and waste deposition measures	Low	Moderate	Low
Rogue load of contaminated material	Local, Short Term, Direct	Medium	Mild to Moderate	Low to Medium	Yes	Inspection and testing of waste loads	Negligible	Low to Medium	Near Zero
Groundwater Flow / Recharge to Aquifer									
Impermeable barrier to groundwater flow	Local, Long Term, Direct	High	Moderate	High	Yes	Waste placement measures	Low to Near Zero	Moderate	Low to Near Zero
Reduction in recharge to aquifer	Local, Long Term and Direct	High	Moderate	High	Yes	Soakaway and engineering measures	Negligible	Moderate	Near Zero

Table 6.6 Summary of Mitigation and Residual Impacts at Blackhall

PLATES

PLATE 6.1 Reed Growth at Edge of SW Groundwater Pond

PLATE 6.2 Dry Surface Water Ditch leading to SW Groundwater Pond

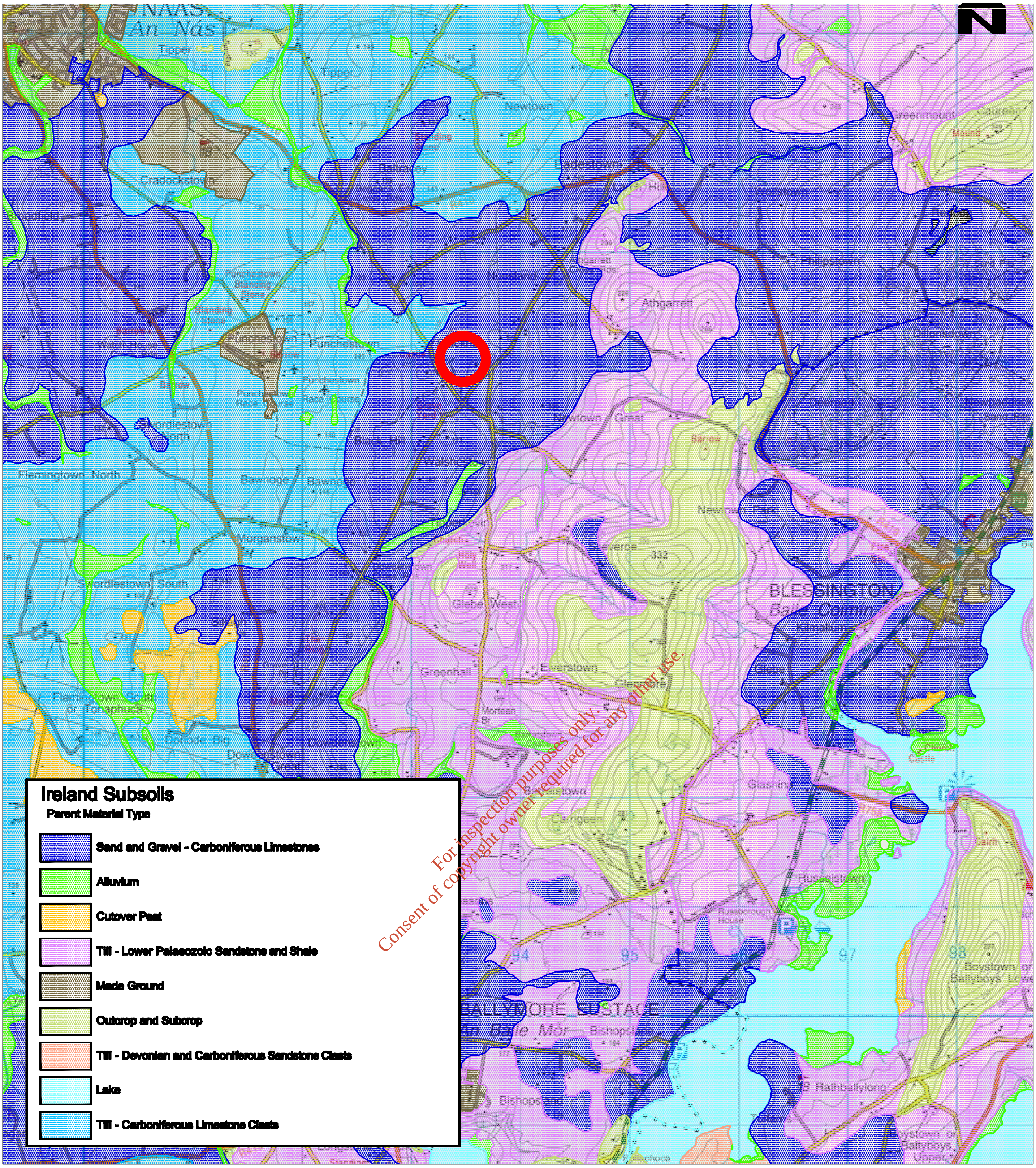
PLATE 6.3 Spring Emergence from Side of Existing Slope

PLATE 6.4 View of Northern Groundwater Pond looking N

PLATE 6.5 View of Northern Groundwater Pond and Discharge from Concrete Pipe

PLATE 6.6 View of Northern Groundwater Pond looking NW

FIGURES



Legend

Location of Site

Extract from 1:50,000 O.S. Discovery Series Map No 56

Scale: 1:50,000

0m 1000m 2000m 3000m

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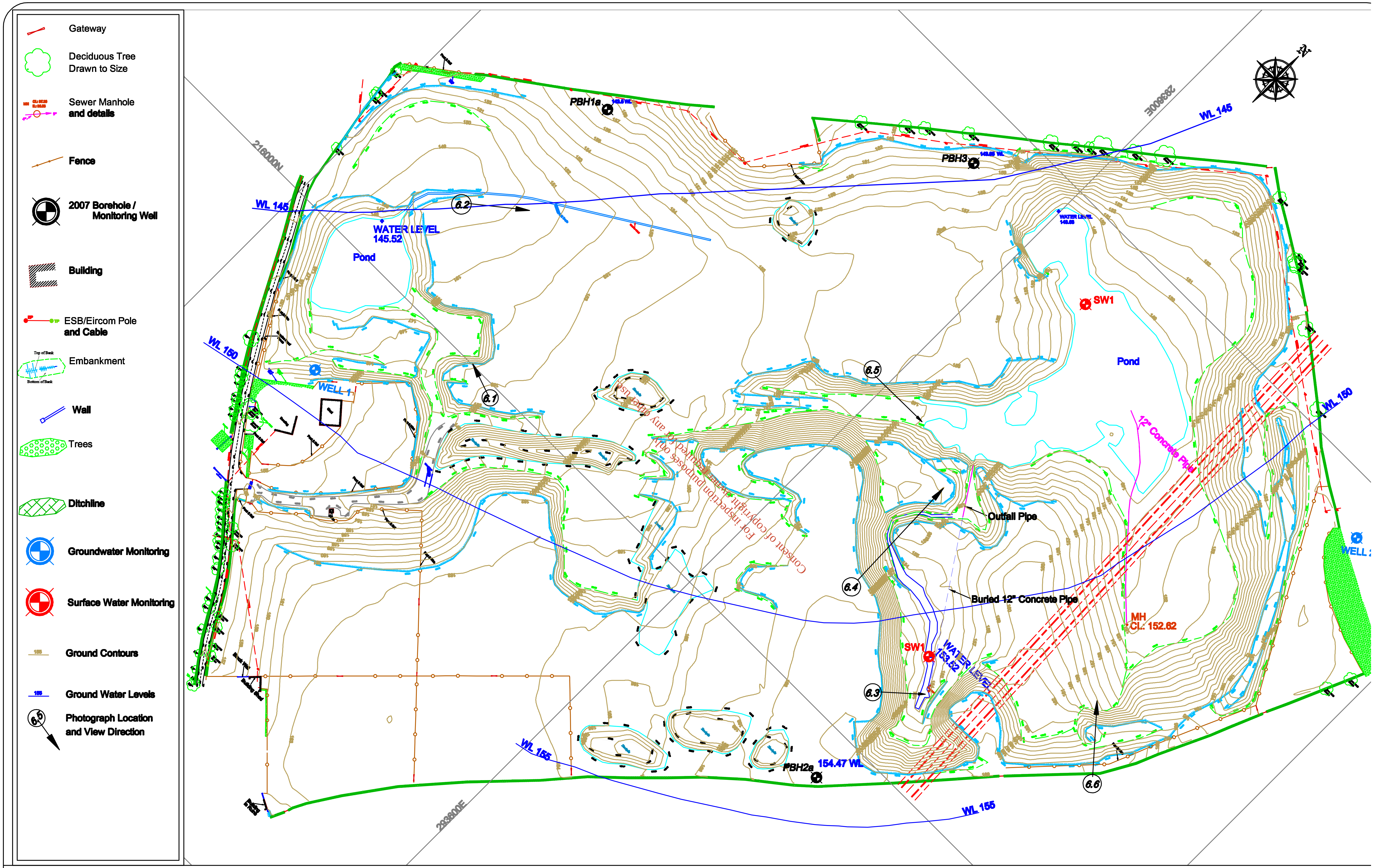
DUBLIN 14

Site: Blackhall, Punchestown, Naas, Co. Kildare		
Title: Subsoils Map		
Drawn: TP/PM	**Scale:** 1:50,000	**FIGURE 6.1**
Job. No: 3746	**Date:** March 2008	



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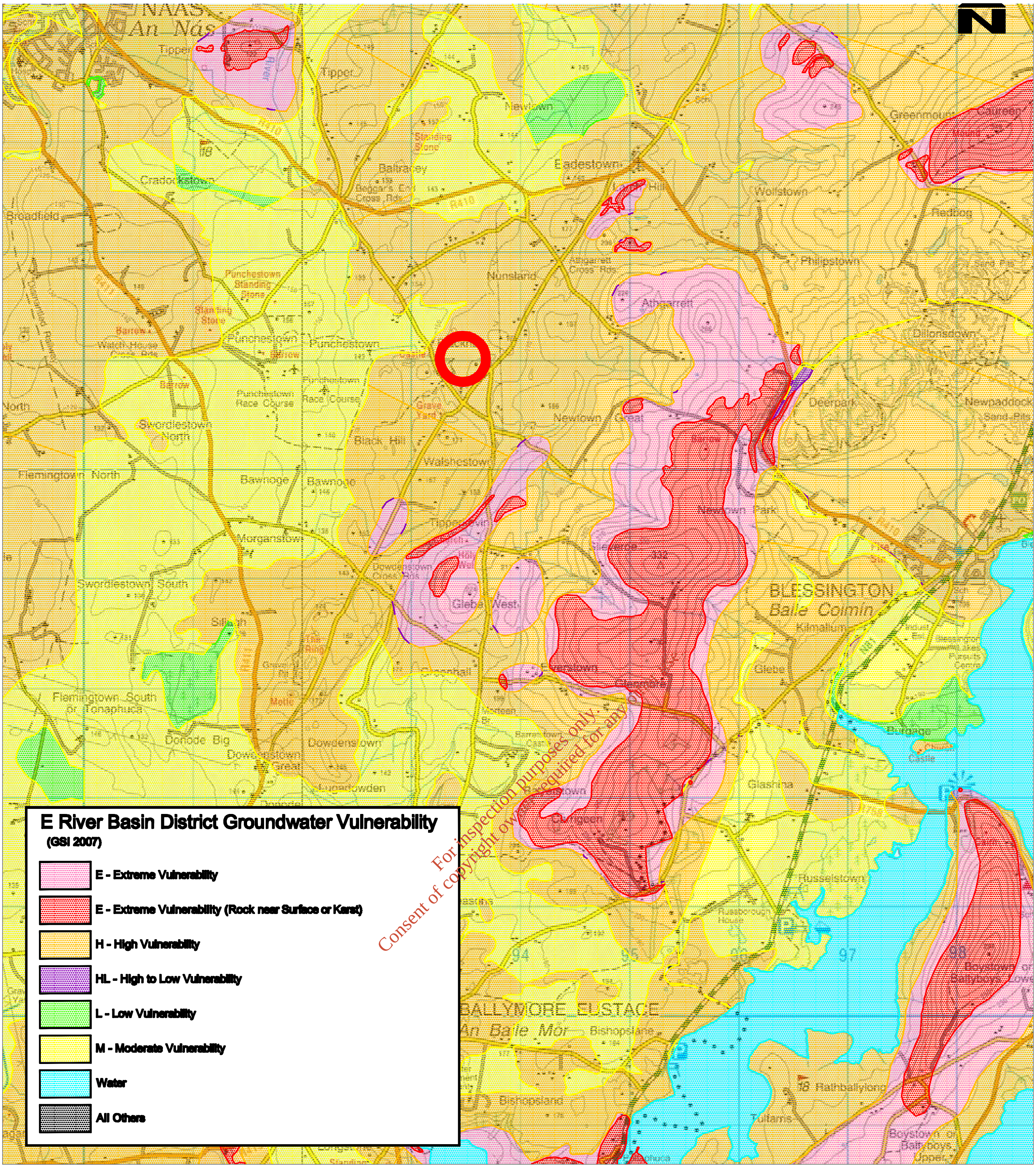
SURVEY INFORMATION PROVIDED BY ERKINA SURVEYS
REF: 0941-1 REV.0 DATED 22-8-07

Rev.	Date	By	Description
0	FEB 08	LMC	

Site: Blackhall, Punchestown, Naas, Co. Kildare
Project: Blackhall Site Restoration
Title: Local Hydrogeology and Hydrology
Drawn: SLR - BAK | Scale: 1:1250
Job. No: 405-636-0004 | Date: March 2008

FIGURE 6.5



Legend

Location of Site

Extract from 1:50,000 O.S. Discovery Series Map No 56

Scale: 1:50,000

0m 1000m 2000m 3000m

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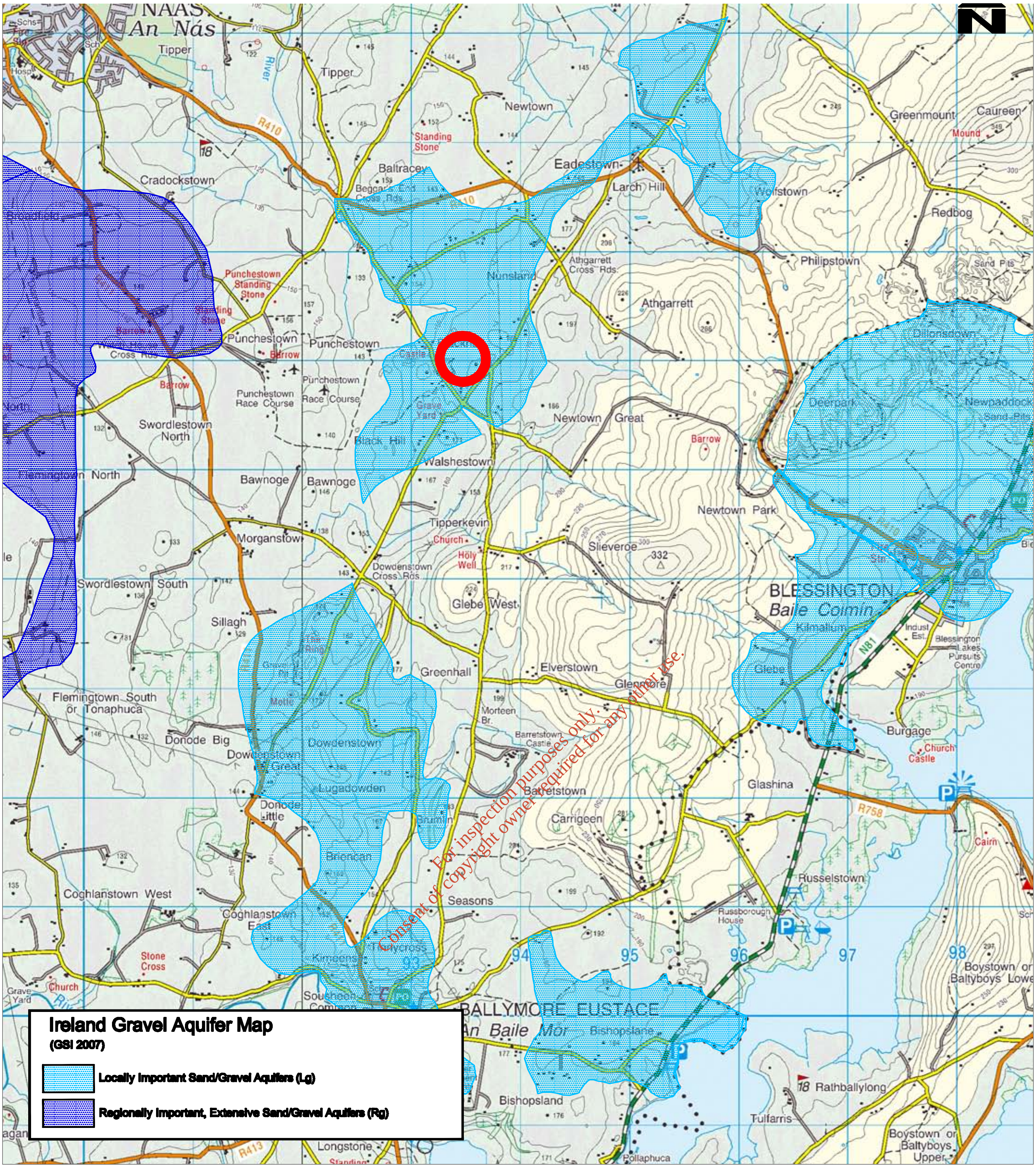
Site: Blackhall, Punchestown, Naas, Co. Kildare		
Title: Groundwater Vulnerability Map		
Drawn: TP/PM	**Scale:** 1:50,000	**FIGURE 6.4**
Job. No: 3746	**Date:** March 2008	



Legend

Location of Site

Extract from 1:50,000 O.S. Discovery Series Map No 56

Scale: 1:50,000

0m 1000m 2000m 3000m

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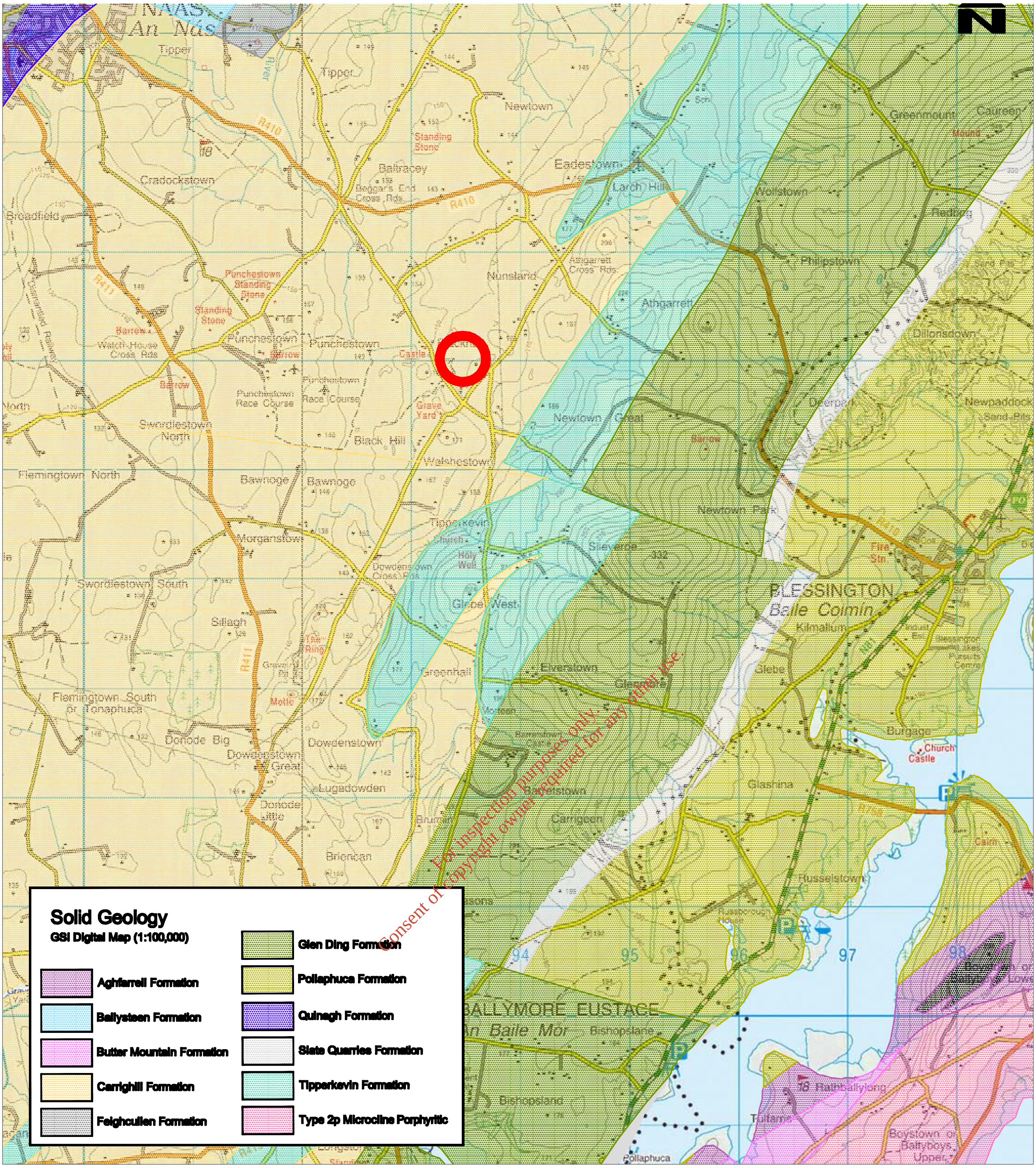
Site: Blackhall, Punchestown, Naas, Co. Kildare

Title: Gravel Aquifer Map

Drawn: TP/PM	**Scale: 1:50,000**	**FIGURE 6.3**
Job. No: 3746	**Date: March 2008**	



Legend

Location of Site

Extract from 1:50,000 O.S. Discovery Series Map No 56

Scale: 1:50,000

0m 1000m 2000m 3000m

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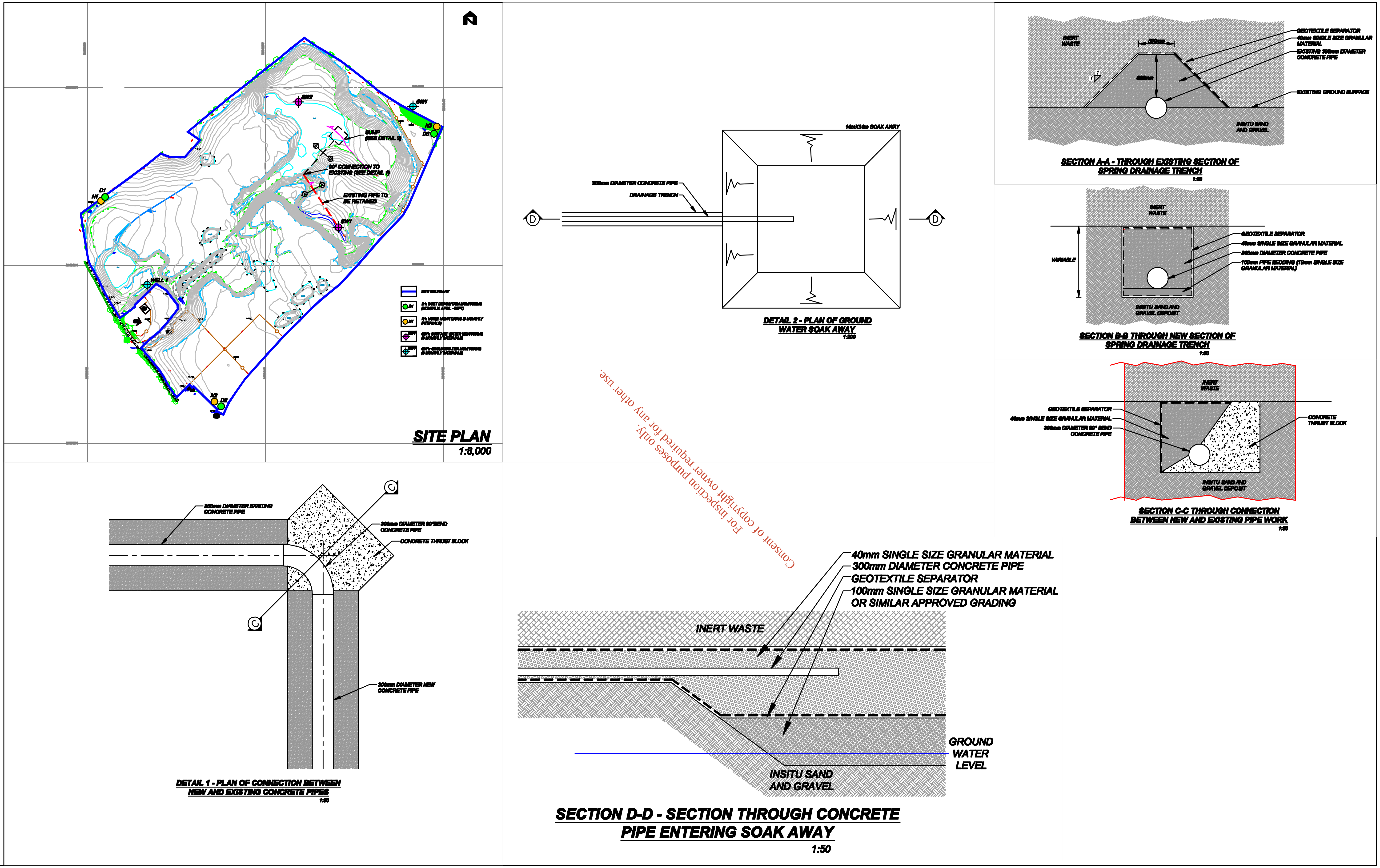
Site: Blackhall, Punchestown, Naas, Co. Kildare		
Title: Bedrock Geology Map		
Drawn: TP/PM	**Scale:** 1:50,000	**FIGURE 6.2**
Job. No: 3746	**Date:** March 2008	



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SURVEY INFORMATION PROVIDED BY ERKINA SURVEYS
REF: 0941-1 REV.0 DATED 22-8-07

Rev.	Date	By	Description
0	JAN 2008	SLR/JC	SECTIONS

Site:	Blackhall, Punchestown, Naas, Co. Kildare
Project:	Blackhall Site Restoration
Title:	Design of Proposed Discharge and Soakaway
Drawn: SLR/403SW	Scale: as shown
Job. No: JBA/3746	Date: March 2008

FIGURE E6.6

APPENDIX 6.1 ROTARY WELL CONSTRUCTION RECORDS

APPENDIX 6.2 HYDROGEOLOGICAL PERFORMANCE OF SPRING COLLECTION AND DISCHARGE INFRASTRUCTURE

HYDROGEOLOGICAL PERFORMANCE OF SPRING COLLECTION AND DISCHARGE INFRASTRUCTURE

Step 1a – Determination of a daily flow rate from the Spring

A daily flow rate from the spring can be calculated by considering the catchment area of the spring and multiplying this by the effective rainfall, by the following equation:

Catchment area (m^2) x effective rainfall (m/day) = flow rate (m^3/day)

The catchment area has been determined by considering the geological deposits, the groundwater flow direction and the topography around the site. This indicates that the catchment area is approximately 960,000m^2. The effective rainfall has been reported as ranging between 325mm/year and 550mm/yr, the maximum value of 550mm/yr or 1.51 $x10^{-3}$m/day has been used in the calculations, as a worst case.

The daily average flow rate from the spring is therefore calculated to be:

960,000 m^2 x 1.51 $x10^{-3}$ m/day = 1,550m^3 per day or 0.018m^3 per second

Step 1b – Determination of the current flow within the pipe

The daily flow rate from the spring can also be calculated by considering the current flow from the concrete pipe at site (note the site was observed during a period of heavy rainfall and therefore greater than average effective infiltration was occurring). This has been determined using the publication 'Tables for the Hydraulic Design of Pipes and Sewers, Fifth Edition, Hydraulics Research, Wallingford, 1990'. The pipe size (300mm), gradient (1 in 200) and roughness coefficient for concrete (0.15) have used in the calculations. The discharge water in the pipe was observed to be approximately a quarter of the pipe diameter full (i.e 75mm deep), and this has been incorporated into the calculations.

Reading from Table 5 (p.28) of the publication, the full bore discharge is 90.209l/s (i.e. 0.090m^3/s). Table 5 gives a coefficient for part-full pipes of 200. At a depth of 75mm the proportional depth is 75/200 = 0.375. Table 36(a) gives a proportional discharge of 0.3 (interpolating between adjacent columns), hence the discharge when the depth in the pipe is 75mm is 0.3 x 0.09m^3/s = 0.027m^3/s or 2,333m^3 per day. This is slightly greater than the average flow determined in Step 1a and considered reasonable given the heavy rainfall experienced prior to the site visit.

Step 2 – Determination Soakaway hydraulic performance

The ability of the soakaway to discharge the volumes determined in Step 1a and Step 1b is assessed in this step. This is determined by multiplying the permeability of the granular infill by the area of the soakaway. A range of permeabilities has been assessed.

Permeability of Gravel (m/s)	x	Area of Soakaway (m^2)	=	Discharge volume (m^3/s)
$1x10^{-3}$		100		0.1
$1x10^{-4}$		100		0.01
$1x10^{-5}$		100		0.001

The above calculations indicate that the permeability of the granular fill to be used in the base of the soakaway should be more than $1x10^{-4}$m/s.

In addition, the design of the soakaway will be sufficient to discharge the calculated volumes from the spring back into the surrounding in-situ deposits, without overtopping or ponding of the soakaway, as long as the in-situ deposits have a permeability of $1x10^{-4}$m/s or greater. If, at the construction stage, the in-situ deposits are found to have a permeability of $1x10^{-5}$m/s, then the design of the soakaway will need to be increased to 30m by 30m.

If the discharge pipe and soakaway are designed to the above standards then the recharge to the aquifer will remain unchanged from predevelopment rates and will not be impacted by infilling the site. These measures would reduce the potential impact of creating an impermeable barrier to groundwater flow from 'high' to 'low to near zero', and reduction in recharge to the aquifer from 'high' to 'near zero'.