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**HYDROLOGICAL RISK ASSESSMENT, PROPOSED
EXPLORATION BOREHOLE (SM12), KNAGGY
HOUSE, NORTH YORKSHIRE**

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HYDROLOGICAL RISK ASSESSMENT, PROPOSED EXPLORATION BOREHOLE SITE (SM12), KNAGGY HOUSE, NORTH YORKSHIRE

1 INTRODUCTION

The purpose of this hydrological risk assessment is to provide the UK regulator for Controlled Waters in England, the Environment Agency, with sufficient information to support a planning application to construct a borehole for the purpose of searching for minerals. Following advice received from the Environment Agency (Ref. 1), Form WR-9, the Oil and Gas UK Guidelines for the Suspension & Abandonment of Wells (Ref. 2) and other relevant Environment Agency guidance (Ref. 3) have been used in the preparation of this document.

Basic information on the geological units and hydrogeology of the Cleveland Basin has been summarised in Ref. 4 for use in this document.

2 BASIC DETAILS

2.1 GRID REFERENCE

The National Grid Reference (NGR) for the proposed borehole is **489247 505877**. The general location of the proposed borehole drilling site is shown in Figure 1 at 1:2,500 scale which includes an insert at 1:25,000 scale. The precise location of the drilling platform in relation to the drill site is currently not known. This will be decided by the company undertaking the drilling contract.

2.2 INDICATED DEPTH

The indicated maximum depth for the proposed borehole (terminating within the Fordon Evaporites sequence), based on the borehole prognosis (Table 1), is approximately **1,655 metres**.

2.3 MINE WORKINGS

There are no former or current mine workings (coal, jet, ironstone etc.) anticipated at this location.

2.4 GROUNDWATER ABSTRACTIONS

There are no domestic drinking water groundwater abstractions within 250 m of the proposed drilling site. Environment Agency records indicate the nearest registered groundwater abstraction is approximately 3 km northwest of the site, to the southeast of Ruswarp. Local Authority records indicate the nearest recorded utilised private water supply is located at the Moorside Supply South (serving Moorside Farm, Moorside House and Thornhill) at NGR 488753, 505094, approximately 850 m SW of the proposed site and at approximately 190 mAOD. These records also indicate that the Low Moor caravan site at NGR 489460 503944 has a water supply borehole based on EA and field observations as being located at NGR 489570, 503620, approximately 1.90 km S of the proposed borehole site, and that Newton House has a private water supply at NGR 488880 504006, approximately 1.88 km SW of the

proposed borehole site. There is also a known spring abstraction for potable drinking water at Soulsgrave Farm, approximately 1.75 km from the proposed drill site.

2.5 ANTICIPATED GEOLOGICAL SEQUENCE

The anticipated geological sequence to be encountered by the proposed borehole, based on available geological information, is given in the borehole prognosis in Table 1.

2.5.1 NEAR-SURFACE GEOLOGY

The 1:10,560 and 1:1:50,000 scale geological maps (Figures 2 and 3) indicate the near-surface geology on site comprises the Moor Grit Sandstone, underlain by the grey limestone of the Scarborough Formation, both of which are part of the Ravenscar Group (Table 1).

There are no geological borehole logs in close proximity to the site available from the BGS GeoIndex database. FWSC have undertaken a number of preliminary site investigations of the Knaggy House Site. Trial pit logs confirm the presence of between 0.21 and 0.28 m of topsoil across the site, underlain generally by between 0.82 m and 2.05 m of clay. In some trial pits a layer of sand, weathered bedrock, was identified beneath the clay, generally between 0.2 and 0.8 m thick. Bedrock has been identified as sandstone, forming a roughly horizontal, often weathered rockhead surface at depths ranging from 1.70 to 3.10 mbgl.

2.5.2 GEOLOGICAL BOREHOLE DATA

Available geological borehole logs from the BGS GeoIndex database, proximal to the proposed borehole location, are as follows:-

BOREHOLE NAME	REF NO.	DEPTH (m)	EASTING	NORTHING
Sneaton Low Moor Caravan site	NZ80SE6	73.2	489570	503620
RTZ 3	NZ90NW4	1269.8	491805	506684
YP5	NZ80NE9	1285.95	489566	506853

The nearest available Water Well data from the BGS GeoIndex archive are:-

BOREHOLE NAME	REF NO.	DEPTH (m)	EASTING	NORTHING
Sneaton Low Moor caravan site	NZ80/7	73.2	489570	503620

The borehole log for NZ80/7, which is located approximately 1,900 m south from the proposed site, includes hydrogeological and pumping test data from the Scarborough Formation (Secondary A aquifer unit in this area). Water was struck at 68.6 m bgl, towards the base of a 6.7 m thick grey weak sandstone unit which is most likely part of the Scarborough Formation, and rose to a rest water level of 56.1 m bgl. During pumping, at a rate of 720 gallons per hour, the groundwater level fell to 59.7 m bgl, and recovered, on completion of

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pumping tests, to the original rest water level within two minutes. A record of the groundwater quality is also given, indicating a pH of 6.8, low levels of trace metals, 0.1 mg/l iron, 0.1 mg/l manganese, 30 mg/l chloride, 206 mg/l CaCO₃ alkalinity, 0.04 mg/l free ammonia and <1 coliform bacteria per 100 mls.

In addition, York Potash has access to borehole records for the SM7/7A/7B exploration borehole which was located approximately 1.2 km northeast of the proposed borehole site (Ref. 10).

2.6 ANTICIPATED AQUIFER UNITS

An assessment of the anticipated aquifer units to be intercepted by the proposed borehole has been determined from the geological profile summarised in Table 1.

2.6.1 PRINCIPAL/MAJOR AQUIFERS

There are two Principal/Major aquifers, as identified by the Environment Agency, which will be intercepted by the proposed borehole at depths below 800 m (Table 1). These are as follows:-

- Sherwood Sandstone Group;
- Brotherton Formation (Upper Magnesian Limestone).

2.6.2 SECONDARY A/MINOR AQUIFERS

There are a number of Secondary A aquifers anticipated to be intercepted within the upper 250 m (Table 1) by the proposed borehole as follows:-

- Moor Grit Member;
- Scarborough Formation;
- Cloughton Formation;
- Eller Beck Formation;
- Saltwick Formation (may/may not be present at this location);
- Dogger Formation;
- Blea Wyke Sandstone Formation (if present);
- Cleveland Ironstone Formation;
- Staithes Sandstone Formation.

2.6.3 SECONDARY B/NON-AQUIFERS

There are a number of Secondary B aquifers anticipated to be intercepted by the proposed borehole as follows:-

- Redcar Mudstone Formation;
- Penarth Group;
- Mercia Mudstone Group;
- Roxby Formation;
- Sherburn Anhydrite Formation;
- Billingham Anhydrite;
- Fordon Evaporites.



2.6.4 UNPRODUCTIVE STRATA/NON-AQUIFERS

- Whitby Mudstone Formation.

2.7 GROUNDWATER VULNERABILITY

The Groundwater Vulnerability status of the proposed borehole drilling site, based on the Environment Agency Groundwater Vulnerability Map for the area (Figure 4) is:- **Low:** This status relates to the combined presence of a near-surface Secondary A aquifer and a low vulnerability soil: Low vulnerability soils are soils in which the pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants. Lateral flow from these soils may contribute to groundwater recharge elsewhere in the catchment. They generally have a high clay content and are represented by soils of the Denchworth, Salop and Brickfield Associations (Ref. 8). This status has been confirmed by reference to the current EA online groundwater vulnerability maps located within the general web address <http://maps.environment-agency.gov.uk/wiyby>.

2.8 SURFACE WATERS

Based on the results of a site visit, and the Ordnance Survey map (1:25,000 scale), the nearest surface waters to the proposed borehole drilling site are:-

SURFACE WATER	DISTANCE (m)	AZIMUTH
Pond, East of Knaggy House, with discharge surface water drain leading to Rigg Mill Beck.	300	ENE
Surface water drain leading from spring in Windmill Hill Plantation.	200	NW

2.9 HYDROLOGICAL FEATURES

The nearest relevant hydrological features (such as springs, wetlands, bogs etc.) are:-

HYDROLOGICAL FEATURE	DISTANCE (m)	AZIMUTH
Spring, Doves' Nest Farm	740	SE
Probable Spring, Moor House Farm	900	SW
Spring at Windmill Hill Plantation	200	NW
Covered Reservoir	380	SW

2.10 FLOOD RISK

The Environment Agency On-line Floodrisk map shows the site is outside any area at risk of flooding from rivers and sea.

2.11 DRILLING METHOD STATEMENT

A detailed drilling method statement is being prepared by the York Potash Drilling Supervisor. The following constitutes a general summary of the drilling method statement as it relates to the proposed boring, and ultimately the safe completion/abandonment of the exploration borehole, to prevent pollution of controlled waters.

We understand drilling is likely to be undertaken using a lorry mounted drilling platform and drawworks, together with a power generator and mud pumps. Topsoils and subsoils will be stripped and stockpiled. The drill rig will be established on a level drilling platform comprising approximately 0.25 m of suitable, compacted, imported, crushed, inert stone if earthworks are required at this site in order to achieve a level drilling platform.

It is planned to drill the exploration borehole using a two casing system, as has been discussed previously with the Environment Agency. This would be in line with other oil and gas drilling programmes in the North Yorkshire area. The borehole will be cased from surface to the base of the Eskdale Group/Brockelschiefer. The casing diameter will decrease progressively downhole. Proposed casing depths, based on the borehole prognosis, are given in Figure 5.

A concrete-lined pressure vessel sump will be established from ground level to approximately 2 m bgl. This will prevent interaction between any return drilling fluids and the superficial deposits/rockhead. A conductor pipe will be installed within the concrete cellar, and sealed into the cellar to prevent any discharge of fluids from the conductor pipe or cellar. Following drilling of the first casing section, a metal casing will be advanced from surface to the first casing point. The external annulus of the casing will be cemented in place at the proposed casing depths identified in Figure 5, and pressure tested, before commencement of the next stage of drilling. Permanent casings are cemented to prevent interaction between the drilling muds and groundwater in the intercepted aquifer units, and/or pollution/interaction of groundwaters from different depths.

Our current proposal is as follows:-

Drill from surface down to the Whitby Mudstone Formation (WMF) – install a permanent casing and cement this section. This will mean all the shallow Secondary

Aquifers (principally in the Ravenscar Group) locally utilised for water supplies, or providing baseflow to rivers etc., will be protected.

The second permanent casing will be placed at the base of the Eskdale Formation above the Zechstein Evaporite sequence (at around 1230 mbgl) (Figure 5). The borehole will therefore intercept the Cleveland Ironstone Formation (CIF), the Staithes Sandstone Formation (SSF) and the Sherwood Sandstone Formation prior to installation and cementing of the second casing. The detailed geological log for the nearest York Potash exploration boreholes (SM 2, 3, 7 and 11) have been used to estimate the geological deposits and thicknesses likely to be present at the Knaggy Farm site based on geological cuttings:-

FORMATION	GEOLOGY	FROM (mbgl)	TO (mbgl)	THICKNESS (m)
Cleveland Ironstone Formation	Mudstone, siltstone and silty sandstone bands, mid to light grey, occasionally pyritic.	190.16	214.38	24.22
Staithes Sandstone Formation	Sandstone, silty, light to mid grey, argillaceous with beds of "cleaner" sandstone, occasionally pyritic	214.38	257.02	42.64

Based on the BGS/EA report ("The physical properties of minor aquifers in England and Wales" (EA R&D Publication 68), the CIF comprises a succession of around 20 m of mudstones, siltstones and ironstones. The formation is essentially an argillaceous non-aquifer with a potential to impact on groundwater flow in areas where it has been mined. Current information indicates no mining of the CIF in the York Potash area of interest.

The SSF, based on the EA R&D Publication 68, is described as a less significant aquifer than the Ravenscar Group and thins to the south of Staithes (within the YP area of interest) with the development of shales and mudstones. Primary utilisation of this aquifer is to the south and west of the YP exploration area, around Thirsk and Northallerton.

The geological evidence from borehole SM7 would suggest only the "cleaner" beds of sandstone could act as aquifer units. Whilst the thickness of these units is not known, they are not considered to make up a substantial part of the Staithes Sandstone Formation.

Thus within the area of the Knaggy House site, the CIF and SSF may be regarded as equivalent to Secondary B/non-aquifers. The Redcar Mudstone and Penarth Group (Rhaetic), which lie between the WMF and the MMG, are both Secondary B/non-aquifers, and thus will not be affected. So the section currently isolated using a second casing between the WMG and the MMG is effectively a non-aquifer and does not warrant the level of protection afforded by the three-casing exploration borehole programme to date. The only aquifer present below the WMG that will be intercepted before emplacement of the 2nd casing at the base of the Eskdale Group will be the Sherwood Sandstone Formation (which is typically saline).

The borehole will be cored from the base of the Roxby Formation (Eskdale Group) to the termination of the borehole at the base of the Fordon Evaporite Formation.

Previous boreholes intercepting the Brotherton Formation indicate the potential for inflow of saline groundwater into the underlying Fordon Evaporite is limited. Therefore it has been considered unnecessary to temporarily case the Brotherton Formation in order to prevent interaction between (saline) groundwater and the Fordon Evaporites. Termination of the borehole near the base of the Fordon Evaporites prevents interaction between the (saline) groundwaters of the Kirkham Abbey Formation (if present and exhibiting sufficient flow) and the overlying Fordon Evaporite sequence.

It is proposed to drill the borehole from surface to the Whitby Mudstone Formation using overpressured drilling muds containing only non-hazardous materials, namely water, bentonite and pH adjusters such as a small amount of caustic soda. Thus there will be no anticipated groundwater inflow into the borehole during drilling, and no potential for contamination of near-surface groundwaters. Any substantial aquifer units encountered from surface to the Whitby Mudstone Formation during drilling will be sealed off, as necessary, using a cement grout. Once the casing is installed and cemented in position, any aquifer units will effectively be isolated from the borehole and from each other. The shallow Secondary A aquifers down to the Whitby Mudstone Formation will be isolated from the drilling fluids to be used in the next stage of drilling from the Whitby Mudstone Formation down to the top of the Zechstein Evaporite Formation, and from interaction with any ingress of saline groundwater from the Sherwood Sandstone Formation aquifer. The second casing string will be cemented in place prior to drilling the evaporates with saturated brine drilling fluids and so there will be two casing strings and two cements protecting the shallow Secondary A aquifers of the Ravenscar Group.

The drilling platform will be located a minimum of 10 m from a water course, >50 m from any spring or well, or from any borehole not used to supply water for domestic or food production purposes; and >250 m from any well, spring or from any borehole used to supply water for domestic or food production purposes in order to be compliant with Environment Agency Standard rules for environmental permits.

2.12 BOREHOLE COMPLETION STATEMENT

The borehole completion objectives are to:-

- 1) remove the hazard of a deep, open hole;
- 2) prevent the borehole from acting as a conduit for contamination to enter groundwater;
- 3) prevent the mixing of saline and potentially potable groundwaters from different aquifer units;
- 4) prevent the flow of groundwater from one geological horizon to another, and;
- 5) prevent access of water to the salt formations where uncontrolled dissolution could occur, and a hazard presented to future mineworkings.

On completion of drilling to the required depth within the Fordon Evaporites, the borehole will be logged by standard wireline geophysical methods that involve the lowering of a sonde with a radiation source to the full depth of the borehole. Best efforts will be made to recover any radiation sources from the well. Where radiation sources cannot be successfully recovered, these will be notified to the Environment Agency, as appropriate.

On completion of drilling, primary and secondary permanent barriers will be installed in the cased borehole based on current guidelines (Ref. 2). There is no anticipated requirement for a through-tubing abandonment. The internal annulus of each borehole will be infilled with a suitable cement grout from the base upwards, up to the base of the pressure vessel sump at 2 m bgl. The drill casing will then be cut off at 2 m bgl and the site restored to the specification agreed with the relevant Local Authorities.

3 RISK ASSESSMENT

A summary of the risks associated with various relevant criteria covered in this document is tabulated in Table 2.

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Groundwater Source Protection Zone

The site is not within an Environment Agency Zone I/II/Total Catchment Groundwater Source Protection Zone. There are no utilised potable drinking water spring discharges located within 250 m from the identified proposed drillsite boundary. The nearest licensed/known groundwater abstraction borehole (at Moorside Supply South) is approximately 850 m west-south-west of the site. Therefore there is a **LOW** risk to potable drinking water/Groundwater Source Protection Zones.

Groundwater Vulnerability

The groundwater vulnerability of the proposed site is **LOW**. The site is designated as a Low Soil Class vulnerability and overlies a Secondary A aquifer (the Moor Grit). The depth of the water table in this aquifer is not known, but is potentially < 10 m bgl. The proposed site is underlain by topsoil and a low permeability boulder clay to a proven depth of between 1.10 and 2.3 m bgl. The groundwater vulnerability risk is **LOW**.

Groundwater Contamination

The shallowest bedrock (Secondary A) aquifer is the Moor Grit. Further aquifer units containing groundwater potentially suitable for utilisation, discharge to springs, or to provide baseflow to surface waters within the Ravenscar Group are present beneath this unit. A number of groundwater issues/springs occur in the area, but most are more than 500 m from the proposed site and are therefore at **LOW** risk. The nearest spring discharge to the proposed site is at Windmill Hill Plantation 200 m to the northwest of the site. However, this is not utilised as a potable water supply and, as it is more than 50m from the proposed site, meets the EA guidance on springs at potential risk from drilling activities. There is also a pond located 300 m to the east of the site which discharges to the Rig Mill Beck.

The bedrock secondary A aquifer is located between 1.70 and 3.10 m below the proposed site and the groundwater level in this aquifer is unknown. Springs emerging to the W and E of the site coincide approximately with the interface between the Moor Grit and the underlying Scarborough Formation, and probably represent discharge of shallow groundwaters infiltrating the superficial deposits and moving down into the largely unsaturated Moor Grit before being discharged at the Moor Grit/Scarborough Formation contact. There is a **MEDIUM** risk of groundwater contamination from drilling muds on this shallow groundwater aquifer.

The Environment Agency's What's in your backyard (WIYBY) website page indicates that the Environment Agency **DO NOT** restrict activities that may pollute water supplies in the area identified for the proposed drilling platform.

Prior to drilling, a cellar and conductor pipe will be installed and adequately sealed and tested to ensure no drilling fluids can migrate out of the conductor pipe/cellar into the surrounding bedrock. This should provide protection against contamination of shallow groundwater in the Moor Grit (and ultimately into Rig Mill Beck) from drilling fluids. The borehole will be drilled with drilling muds containing no hazardous substances, and will be permanently cased, from surface to the Whitby Mudstone Formation, thus mitigating the risk of any hazardous substances within the drilling mud or surface contamination entering the Secondary A aquifers via the borehole once the casing is installed. During drilling, any significant drilling fluid losses, once identified, are sealed using a cement grout to prevent loss of drilling fluids to formation. The permanent casing will also mitigate the risk of any contamination of these shallow aquifer units from interaction with the drilling muds whilst drilling through the underlying Lias Group and into the Mercia Mudstone Group. This second cased section will be cemented in place prior to drilling into the Sherwood Sandstone Group. This will prevent interaction between the saline/poor quality groundwater in the Sherwood Sandstone and the groundwater in the overlying Lias Group Secondary A/B aquifers. On completion, the borehole will be filled with cement grout to within approximately 2 m of ground level thus removing any potential preferential pathway to/from surface.

The implementation of the identified mitigation procedures above leaves a residual **LOW** risk of contamination.

Nearest Surface Water/Other Hydrological Features

Current EA regulations specify a minimum distance for any potentially polluting activity of 10 m from any water course, 50 metres from any spring or well, or from any borehole not used to supply water for domestic or food production purposes; and 250 metres from any well, spring or from any borehole used to supply water for domestic or food production purposes. These criteria are met by the drill site location and thus the risk to the nearest surface water/hydrological feature is **LOW**.

Flood Risk

The site is not at risk from flooding.

4 CONCLUSION

Based on the information above for the proposed borehole drilling site at Knaggy House, we consider the highest level of risk to Controlled Waters (surface water and groundwater) to be **MEDIUM**. Mitigation measures, including the presence of natural bunds, distances from the proposed drill site and the use of conductor pipes/cellars, permanent casing of the well and utilising non-hazardous drilling mud in geological formations above the Whitby Mudstone have been identified that will reduce the overall risk to **LOW**.

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TABLE 1 BOREHOLE PROGNOISIS - KNAGGY HOUSE - REVISED JAN 2013

Based on intersections encountered at SM11 (to date - 22/01/2013), SM2, SM3, and SM7 and surface ground level of 203m AOD

STRATIGRAPHIC UNIT		FROM	TO	THICKNESS
		(m bgl)	(m bgl)	(m)
Quaternary	Devensian glacial drift	0.00	4.00	4.00
Middle Jurassic	Ravenscar Group and Dogger Formation	4.00	110.43	106.43
Lower Jurassic	<u>Lias Group</u>			
	- Whitby Mudstone Formation	110.43	190.16	79.73
	- Cleveland Ironstone Formation	190.16	214.38	24.22
	- Staithes Sandstone Formation	214.38	257.02	42.64
	- Redcar Mudstone Formation			
	Ironstone Shales, Banded Shales and Pyritous Shales	257.02	349.21	92.20
	Siliceous Shales	349.21	394.43	45.22
	Calcareous Shales	394.43	495.11	100.68
Triassic	<u>Penarth Group (Rhaetic)</u>	495.11	516.06	20.95
	<u>Mercia Mudstone Group</u>			
	- Upper Triton Formation	516.06	527.77	11.72
	- Keuper Anhydrite Member	527.77	560.14	32.36
	- Lower Triton Formation	560.14	642.82	82.68
	- Upper Dowsing Formation	642.82	751.91	109.09
	- Röt Salt	751.91	791.60	39.69
	- Upper Bunter Shale	791.60	799.66	8.06
	<u>Sherwood Sandstone Group</u>			
	- Upper Bunter Sandstone	799.70	893.45	93.75
	- Middle Shale Unit (Red Marl)	893.45	936.66	43.21
	- Middle Bunter Sandstone	936.66	1035.98	99.32
	Permian	<u>Eskdale Group</u>		
- Roxby Formation				
Transition Beds		1035.98	1134.30	98.32
Lower Bunter Shales		1134.30	1213.04	78.74
Brockelschiefer Member		1213.04	1246.06	33.02
- Littlebeck (Top) Anhydrite		1246.06	1246.91	0.85
- Sleights Siltstone		1246.91	1249.40	2.49
<u>Staintondale Group</u>				
- Sneaton Halite (Unit E)		1249.40	1253.45	4.05
- Sneaton Halite (Unit D)		1253.45	1269.85	16.40
- Sneaton Potash (Unit C)		1269.85	1274.90	5.05
- Sneaton Halite (Unit B)		1274.90	1281.50	6.60
- Sneaton Halite (Unit A)		1281.50	1291.97	10.47
- Sherburn Anhydrite		1291.97	1300.33	8.30
- Carnallitic Marl		1300.33	1318.60	18.68
<u>Teesside Group</u>				
- Boulby Halite (Unit D)		1318.60	1320.73	2.14
- Boulby Potash (Unit C)		1320.73	1324.50	3.37
- Boulby Halite (Unit B)		1324.50	1353.68	32.17
- Boulby Halite (Unit A)		1353.68	1367.64	10.88
- Billingham Anhydrite		1367.64	1383.16	15.50
- Brotherton Formation		1383.16	1430.58	47.37
- Grauer Salztou		1430.58	1431.46	1.00
<u>Aislaby Group</u>				
- Fordon Evaporite Formation				
Halite and anhydrite		1431.46	1462.89	31.40
Upper Anhydrite		1462.89	1496.34	33.45
Upper Polyhalite Deposit		1496.34	1538.52	42.19
Halite with minor polyhalite and anhydrite		1538.52	1594.79	56.27
Lower Polyhalite Deposit (May be present. If not, then expect sulphatic halite)		1594.79	1634.79	40.00
Halite & Anhydrite	1634.79	1654.79	20.00	
- Kirkham Abbey Formation	1654.79			

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TABLE 2: KNAGGY HOUSE BOREHOLE – HYDROLOGICAL RISK ASSESSMENT SUMMARY SHEET

CRITERIA	RESULT	EVIDENCE	RISK TO CONTROLLED WATER	RESULTANT RISK AFTER MITIGATION
Protection of major groundwater abstractions	Outside groundwater source protection zone and no drinking water spring discharge or groundwater borehole within 250 m of the proposed drilling site.	EA Groundwater source protection zone map and response from Local Authority.	LOW	LOW
Groundwater vulnerability	Low vulnerability status	EA Groundwater vulnerability map	LOW	LOW
	No superficial deposit aquifer	Online Superficial deposit aquifer designation map.		
Groundwater contamination	Superficial deposits: Between 0.82 and 2.05 m of stiff to very stiff boulder clay over weathered sandstone and/or sandstone rockhead.	Site investigation trial pits	MEDIUM	LOW
	Secondary A bedrock aquifers potentially providing baseflow to surface waters	Online Bedrock aquifer designation map and Ref. 4.		
	Shallowest aquifer: Moor Grit/Scarborough Formation estimated at < 10m bgl. No reported utilisation of groundwater spring discharge.	BGS Geology Map and Ref. 4 Site observations, discussions with land owner, Local Authority and Environment Agency records		
Nearest surface waters	Pond located 300 m to the east of the proposed site.	Ordnance survey map	LOW	LOW
Other hydrological features (e.g. springs, wetlands, bogs etc)	Multiple spring discharges providing baseflow to surface waters. Nearest spring providing baseflow to surface waters is approximately 200 m from proposed drillsite.	Site observations and OS map	MEDIUM	LOW
Flood risk	None – outside EA flood zone	EA online flood risk map	LOW	LOW



SCALE: 1:25000

SCALE: 1:2500

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22 FEB 2013

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KNAGGY HOUSE
DRILLING PLATFORM
PLANNING LAYOUT

DRAWN BY: P. CHATER
DATE: 23.11.2012

Sheet Numbers: Y001-YPL-01-1100-MP-DGA-00011
1 of 1

REV	NO	DATE	DESCRIPTION	APPROVED
A	00	10.01.2013	ISSUED FOR INFORMATION	
			REVISION BASE REVISION 1	



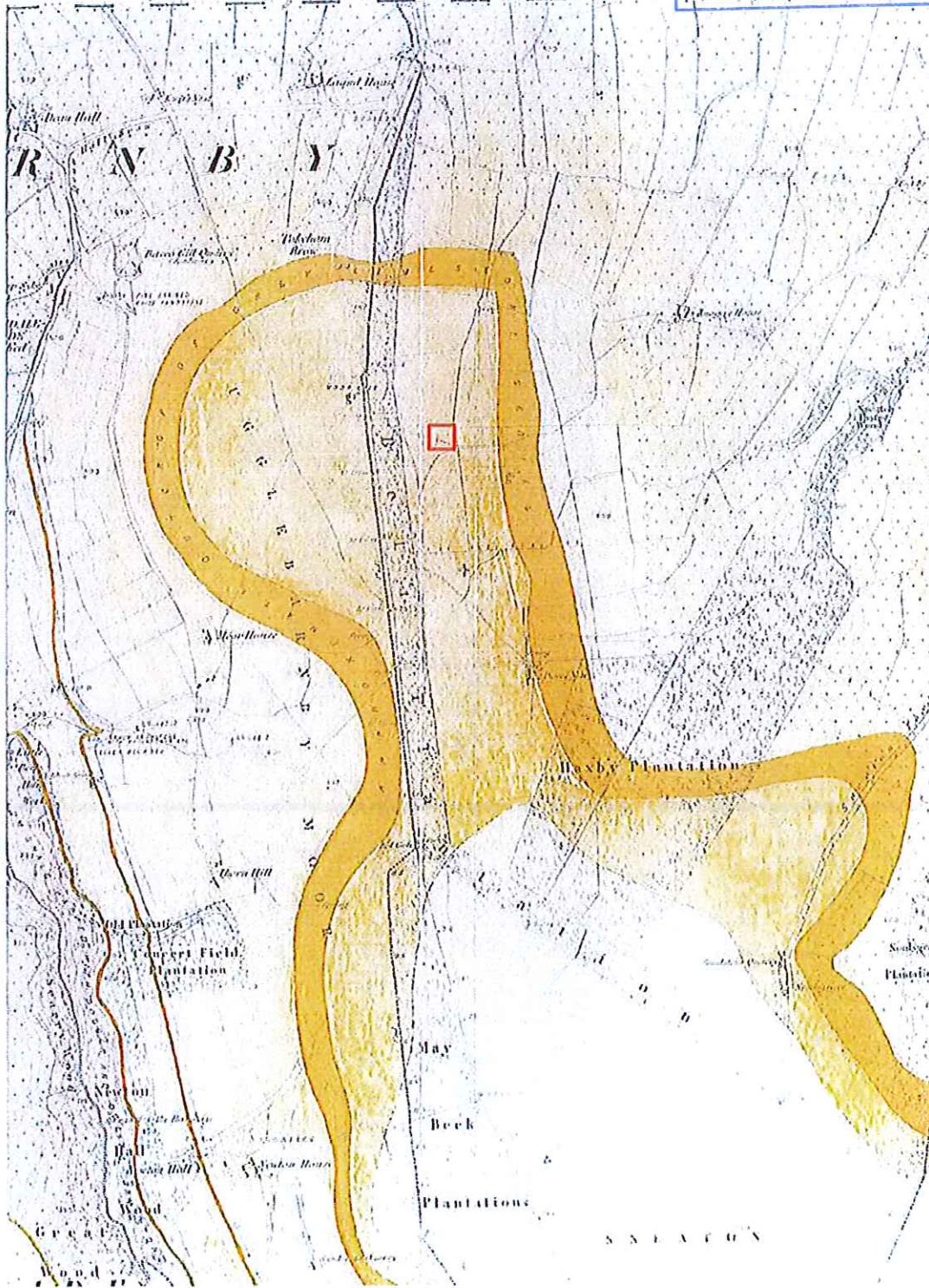
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Key

Approximate location of Knaggy House Exploration Borehole -



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JOB TITLE

Project 40 - Hydrological Risk Assessment, Proposed
Exploration Borehole (SM12), Knaggy House, North
Yorkshire

DRAWING TITLE

Extract from 1:10,500 scale geology map (Ref. 5)

CLIENT

York Potash

DRAWING NUMBER

Figure 2

STATUS

DATE
January 2013

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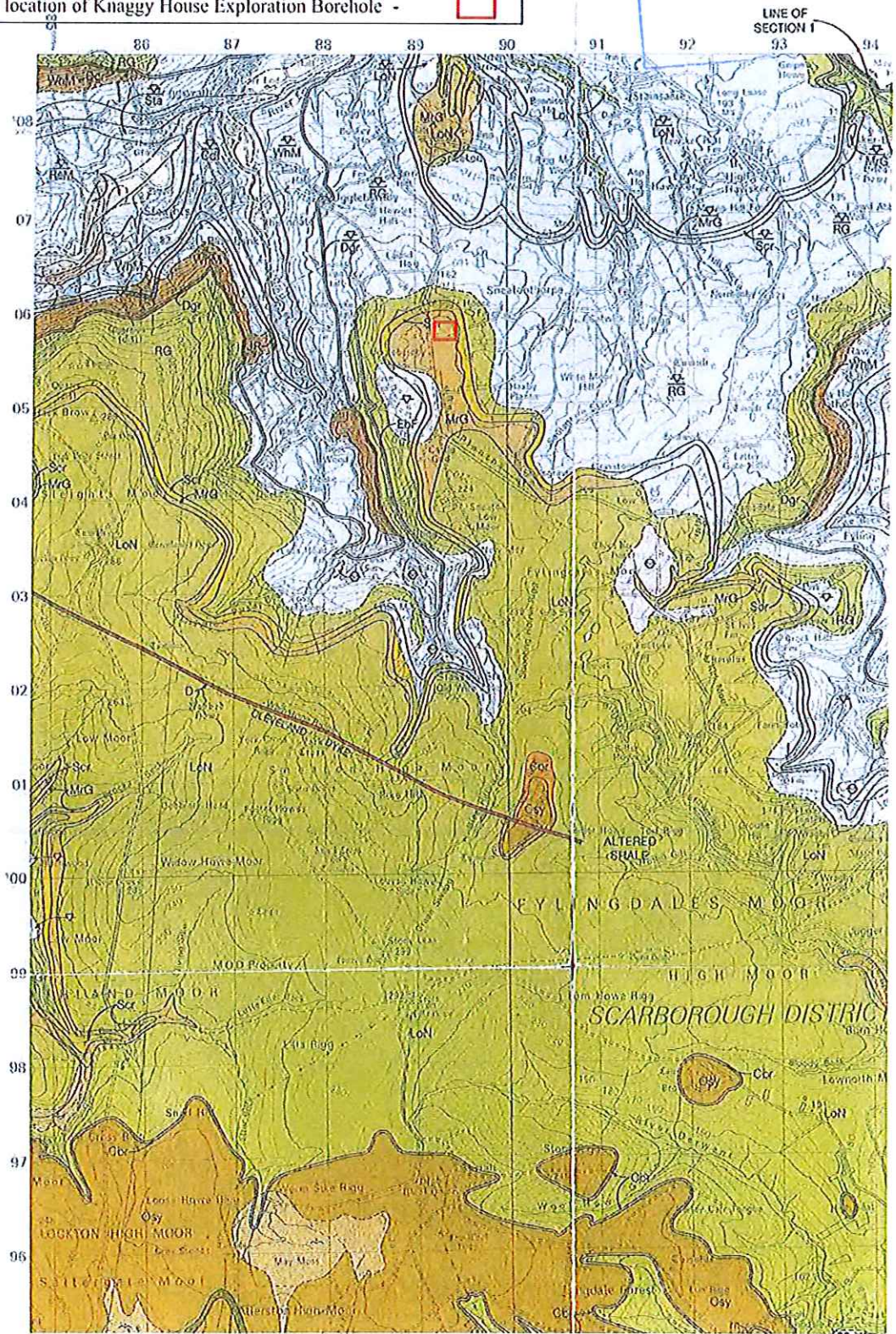
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Approximate location of Knaggy House Exploration Borehole -



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JOB TITLE

Project 10 - Hydrological Risk Assessment, Proposed
Exploration Borehole (SM12), Knaggy House, North
Yorkshire.

DRAWING TITLE

Extract of 1:50,000 scale geology map (Ref. 6)

CLIENT

York Potash

DRAWING NUMBER

Figure 3

DATE

January 2013

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Approximate location of Knaggy House Exploration Borehole - □



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JOB TITLE

Project 49

CLIENT

York Potash

DATE

Jan 2013

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DRAWING TITLE

Extract of groundwater vulnerability map (Ref. 8)

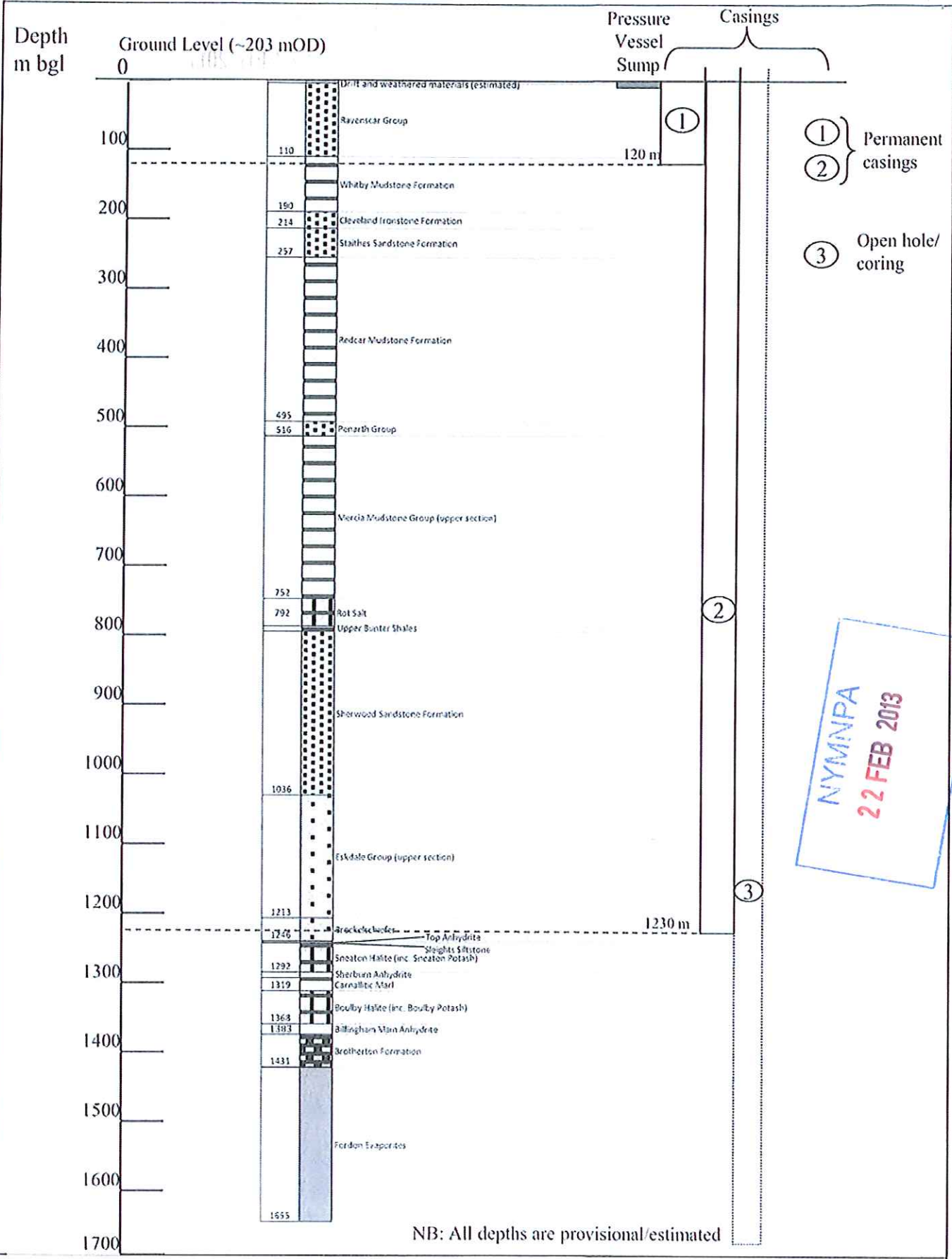
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Figure 4

STATUS

SCALE

NTS



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	DRAWING TITLE Proposed borehole casing depths	DRAWING NUMBER Figure 5	STATUS	DRAWN BY CB
			SCALE NTS	

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APPENDIX 1
NOTES ON LIMITATIONS

NOTES ON LIMITATIONS

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- 1 FWS Consultants Ltd (FWSC) has prepared this report solely for the use of the Client and/or his agent on the basis of exchange(s) of proposals and instructions, and FWSC accepts no responsibility or liability:-
 - a) for use of this report by any party other than the person for whom it was commissioned, or;
 - b) for the consequences of the report being used for any purpose other than that for which it was commissioned.

Should any third party wish to use or rely upon the contents of the report, written approval from FWSC must be sought. Furthermore, it is strongly recommended that independent advice is sought by that third party with respect to its specific proposals or requirements.

- 2 The conclusions and recommendations in this report represent our professional opinions, derived from currently accepted industry practices, exercising all reasonable skill and care to be expected of a professional environmental consultancy of similar size and experience. The assessments and judgments given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed, taking account of the resources devoted to it by agreement with the client and/or his agent (whether in writing, or subsequent verbal instructions).
- 3 Environmental desk studies/audits comprise a study of readily available information obtained from various identified sources, authorities and parties. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. Cost benefit analyses and estimations of income potentially available from sustainable resource systems are undertaken using current utility prices that may be subject to change. Any identified risks in desk study/audit reports are perceived risks based on the information available at the time. Actual risks can only be assessed after carrying out a physical investigation of the site.
- 4 Data acquisition during site investigations is subject to the limitations of the methods of investigation used and access constraints. Exploratory holes undertaken during fieldwork, particularly boreholes, investigate a small volume of ground in relation to the size of the site and thus can only provide an indication of site conditions. There may be some conditions relating to the site and the proposed development, such as localized "hotspots" of contamination that have not been disclosed by the investigation. The nature and extent of variations between these explorations may not become evident until further investigation. If variation or other latent conditions then appear evident, it will be necessary to re-evaluate the recommendations of this report.
- 5 The findings and opinions are relevant to the dates of the site works and should not be relied upon to represent conditions at substantially later dates. Site conditions will change over time due to natural variations and human activities. Groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations. Variation in the types and concentrations of contaminants and variations in their flow paths may occur due to seasonal water table fluctuations, past disposal practices, the passage of time, or subsequent developments or activities on the site or adjacent area.
- 6 The opinions expressed in this report regarding any contamination are based on simple statistical analysis and comparison with available guidance values. No liability can be accepted for the retrospective effects of any changes or amendments to these values.