Waste Licensing

Waste Disposal Activities (Landfill Sites)

Application by
Fingal County Council
for Waste Licence Application W0231-01
for Fingal Landfill, Co. Dublin

EPA Reg. No.: (Office use only)	W0231-01

Fingal County Council

Comhairle Chontae Fhine Gall
Fingal County Council

Replies to Request for further information in accordance with Article 14(2)(b)(ii) of the Waste Management Regulations

May 2007

RPS

Fingal Landfill Project

Waste License Application
W0231-01
Article 14 Information

DOCUMENT CONTROL SHEET

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Project Title	Fingal Landfill Project					
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Consulting Engineers

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APPENDIX

Appendix 1 **Groundwater levels**

INTRODUCTION

This report has been compiled to supply additional information in response to a Notice sent in accordance with Article 14 (2) (b) (ii) of the Waste Management (Licensing) Regulations from the Environmental Protection Agency dated March 23rd 2007.

INFORMATION REQUIRED IN RELATION TO PREVIOUS ADDITIONAL INFORMATION SUBMISSIONS OF DECEMBER 2006

SECTION E.1.B RESPONSE - INFORMATION WAS SUBMITTED IN RELATION TO DISPERSION MODELLING OF DUST EMISSIONS FROM THE STORAGE OF FLY ASH. PROVIDE THE FOLLOWING CLARIFICATIONS:

Paragraph 2.5.2.5 of Volume 2 of the EIS states that as part of the licence application, permission has been sought to allow inert bottom ash from non-hazardous waste to energy treatment plants to be stored at the landfill. No fly ash from waste to energy plants will be accepted by the proposed landfill.

(i) Detail the meteorological data employed in the ISCST3 modelling study. Was hourly data employed?

A full year of hourly sequenced met data from Dublin Airport for 2004 has been used in this model. This was determined as the worst case meteorological year for the 5 year period assessed from 2000 - 2004.

(ii) Was the impact of the local terrain taken into account?

Terrain data was not taken into account for the Dust Dispersion Model. As the dispersion was assessed for dust levels off-site a set of boundary receptors were included to determine the impact at the site boundary as opposed to the nearest sensitive receptors. As such, while the terrain of the general area has a degree of complexity, the terrain of the site itself is relatively flat.

(iii) Determine the maximum 1-hour and 24-hour particulate concentration at the site boundary (or beyond the site boundary if higher concentration occurs) and identify the PM_{10} composition of the particulate concentrations.

The maximum annual, 24-hour average and 1-hour average of the modelled total suspended particles emissions from the bottom ash storage pile are presented below. In the absence of statutory limits for Total Suspended Particles in Irish Legislation reference has been made to other suitable guidelines such as the TA Luft (German Government "Technical Instructions on Air Quality"). The TA Luft Guideline is from 1986, Section 2.5.2 Health Related Emission Standards and the guideline refers to "Suspended Particles (without considering the components of the suspended particles)". This guideline is 0.15 mg/m^3 as an annual average for suspended particles. There are no 24-hour or 1-hour limits or guidelines for protection of human health from total suspended particles.

Parameter	Boundary Prediction (mg/m^3)	Dust Limit/Guideline (mg/m^3)
Maximum Annual Average at Boundary	0.048	0.150
Maximum 24-hour Average at Boundary	0.654	-
Maximum 1-hour Average at Boundary	5.659	-

There is no data available relating to the particle size analysis. Typically bottom ash is granular and contains a wide range of particle fractions from fine to coarse depending on the waste and type of incinerator. Fractions are typically in the range of 1 – 20 mm with low concentrations of very fine (less than 1mm) or very coarse (>20mm) material. As such, it is assumed that the PM_{10} fraction of the bottom ash would be at most 5%. However, even assuming a highly conservative PM_{10} fraction of 30%, the annual and 24 hour predicted concentrations are significantly lower than the relevant statutory limits for the protection of human health (S.I. 271 of 2002) as presented in the table below.

Parameter	**Boundary Prediction ($\mu g/m^3$)**	**PM_{10} Limit/Guideline ($\mu g/m^3$)**
Maximum Annual Average at Boundary	14	40
Maximum 24-hour Average at Boundary (90th percentile)	30	50

SECTION 1.4 RESPONSE:- IN RELATION TO THE INTERACTION BETWEEN THE GROUNDWATER FLOW AND THE GRAVEL, PLEASE ADDRESS THE FOLLOWING ADDITIONAL POINTS:

(i) Provide groundwater contour maps for the gravel layer for different seasons;

There are insufficient monitoring wells installed spatially in the gravel to enable a separate groundwater contour map to be drawn. The lack of monitoring wells in the gravel is due to its patchy and discontinuous nature across the study area. Groundwater flow in the gravel layer is expected to follow the topographic gradient and hydraulic gradients in the underlying bedrock aquifer, because groundwater levels in the two units are similar (refer to iii below).

(ii) Provide a contour map of depth to gravel across the site;

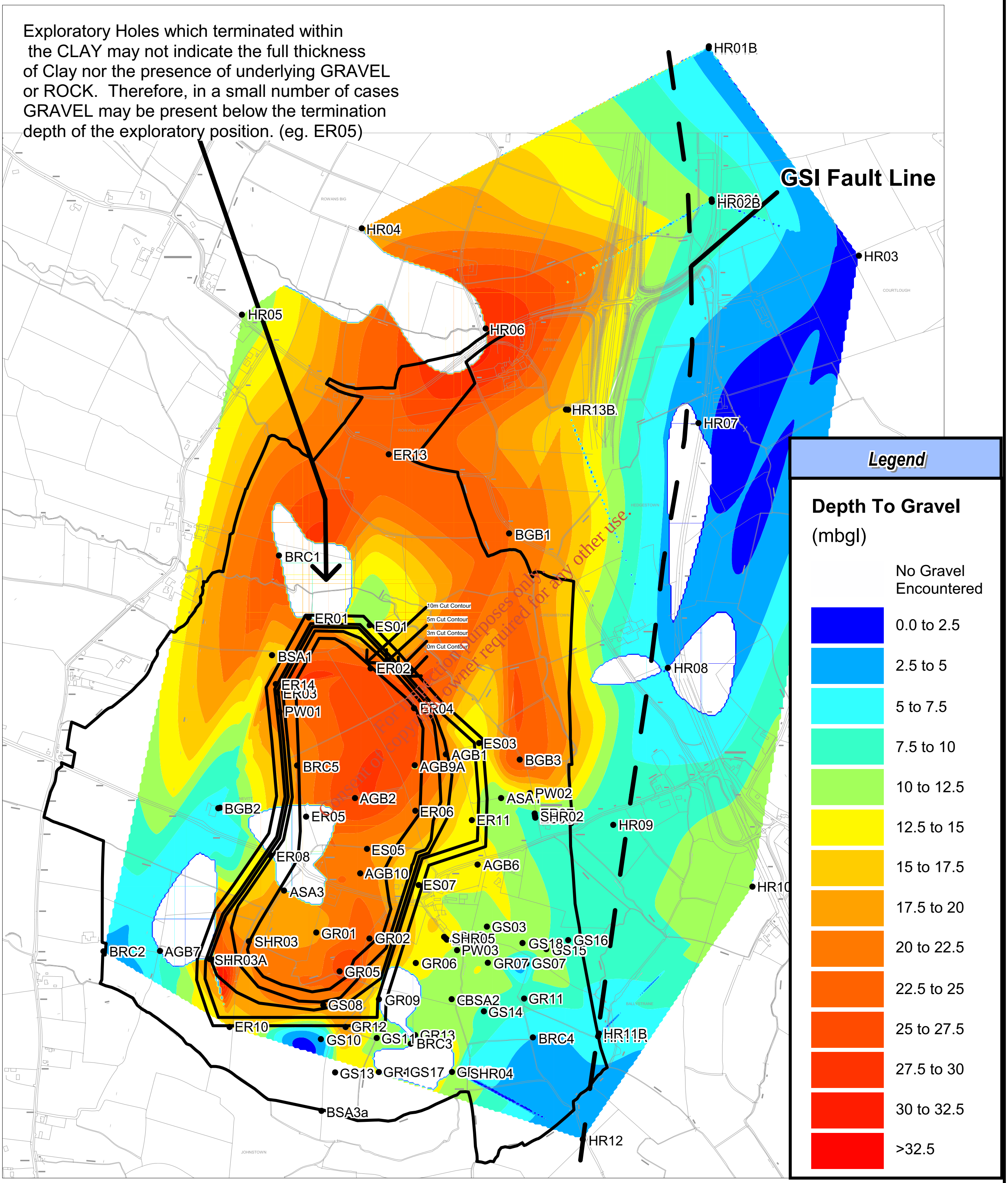
A contour map of depth to gravel across the site is shown in **Figure 1.**

(iii) Discuss the interaction between the gravel and bedrock water tables;

Vertical groundwater movement between the overburden and the bedrock has been assessed in the EIS by using groundwater level data from monitoring wells installed in the different hydrogeological units adjacent to one another at a number of locations across the study area. The relevant hydrographs are given in Appendix A12 of the EIS. Updates to these hydrographs were included as Appendix 5 of Waste Licence Application, Article 14 response of the 18th January 2007.

The results from monitoring in the east of the study area (SHR2) show that groundwater levels in the bedrock are 0.25m higher than in the overlying gravel subsoil, which suggests that there are slight vertical upwards hydraulic gradients between the bedrock and the gravel at this location.

At a number of locations across the study area, namely HR1a/HR1b, HR11a/HR11b and HR13a/HR13b, groundwater levels in the gravel are the same as in the bedrock indicating that there are no vertical hydraulic gradients between these two units.



Ordnance Survey Ireland

Project	Fingal Landfill Project	Figure	1.0
Title	Depth to Gravel (mbgl)		

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Issue Details			
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(iv) ***Discuss the potential for flow in the gravel from the north and northwest of the site towards the Bog of the Ring gravel body;***

For the purposes of this response, it is assumed that the EPA means 'northeast' rather than 'northwest'.

Groundwater is expected to follow the topographical gradient and underlying groundwater flow directions in the bedrock due to the hydraulic contact between gravel and bedrock and the similarity of groundwater levels.

Therefore, groundwater flow direction in the gravel to the northeast of the proposed landfill is from northwest to southeast following the local topographic gradient and the underlying groundwater flow direction in the bedrock, away from the Bog of the Ring.

(v) ***The map of the gravel thickness indicates 1 metre of gravel at ER04, and 0.75 metres of gravel at ER02. These figures are based on borehole data where the drilling ceased due to the inability of the equipment to penetrate the gravel, hence these figures may be considered the minimum gravel distance present. Geophysical data in the area of these two locations indicates a depth to bedrock in the region of 32 metres. This suggests the possibility of 5 – 6 metres of gravel being present in the area. Comment on the accuracy of the reported data and provide an updated gravel thickness map if required.***

Geophysical data is complementary to direct investigation, but is not a stand alone technique and requires ground truthing through direct investigation. Boreholes ER01, BRC5, AGB2 and AGB9A encountered rock at 21m, 22m, 28m and 25m bgl respectively. Boreholes ER04 and ER02 terminated at 27m and 26m bgl and although they did not prove rock, information from adjacent holes indicates that rock is at approximately this level, hence we are satisfied that the map provided reflects the gravels.

(vi) ***Outline the investigations proposed to demonstrate 10 metres of clay will remain in the areas of ASA3, GR01 and the southern landfill boundary area.***

The boreholes listed here, in addition to geophysical information provided as part of the EIS, prove clays to depths of 17.3m and 19.75m bgl. The preliminary design is based on the excavation depths in the area of these boreholes being maintained at 7.2m and 9.65m respectively, in order to ensure 10m of clay cover remains in situ. However, as with all construction projects of this nature, additional site investigation may be necessary to further classify the materials being excavated in order to establish construction methods, and to complete the detailed design. The final detailed design of all of the cells will take these depths into account to ensure that excavations are limited to maintain 10m of clay. As phases of the landfill develop additional site investigation will be employed as necessary to determine clay cover is maintained at 10m, which will provide for an R1 landfill rating.

INFORMATION REQUIRED IN RELATION TO PREVIOUS ADDITIONAL INFORMATION SUBMISSIONS OF JANUARY 2007.

Point III:- In determining the groundwater flow through the aquifer, explain the determination of the hydraulic gradient at 0.032. Demonstrate that this value is representative of the hydraulic gradient for the site area and identify any potential variations throughout the year.

The hydraulic gradient is determined by dividing the vertical change in water table level over the extent of the site by the horizontal distance between the two water table measurements. A hydraulic gradient of 0.032 was calculated over the widest section of the site for June 05. The task was repeated for the next three seasons (September 05, December 05 and March 06) to quantify any seasonal variations. The task was also repeated for the southern section of the site over the same time period. Refer to **Table 1** below for hydraulic gradients.

Table 1 Hydraulic Gradients across the site

	Hydraulic Gradient (Widest area of the site)	**Hydraulic Gradient (Southern section of the site)**
June 05	0.032	0.018
September 05	0.045	0.016
December 05	0.053	0.03
March 06	0.045	0.02

An average gradient considering the above is 0.032.

Point vi:- Based on investigations carried out to date please indicate the potential range of sustainable yields, compared to the existing abstraction rates from the Bog of the ring system, that may be attainable from the area to the south of Decoy bridge. For the maximum and minimum of this range provide a plot of the area of the likely zone of influence.

In order to achieve long-term sustainable yield, it is necessary to site production wells in those areas where (a) there is significant fracturing in the rock to produce good abstraction rates and (b) there is sufficient recharge to maintain a sustainable yield.

Wells located along the fault line south of Decoy Bridge are likely to produce higher yields due to fracturing. Pumping test results, as summarised in Table 5 of Volume 5 of the EIS, together with field observations, driller estimates and pumping tests undertaken at the nearby Bog of the Ring demonstrate that wells located along the fault zone south of Decoy Bridge could probably sustain yields of between 500m^3/day and 1000m^3/day. This is consistent with the GSI's classification of the aquifer. If four hypothetical wells were located at 1km intervals along the fault zone, then the hypothetical yield would be between 2000m^3/day and 4000m^3/day.

Using the recharge rates applied to groundwater abstraction at the Bog of the Ring of 57mm/year for 75% of the area and 322mm/year for 25% of the area, then the minimum and maximum zones of influence of the hypothetical well field is illustrated in **Figure 2**. It is appropriate to apply the same recharge rates to this well field as to the Bog of the Ring well field as the subsoil conditions in the area are similar to that at Bog of the Ring, in that they contain large areas of thick low permeability soils. The rational of using the same recharge rates as those applied at Bog of the Ring was endorsed by Kevin Cullen in his letter to the EPA dated 30th March 2007.

Figure 2 illustrates that there is potential for interference with the existing zone of influence of the Bog of the Ring scheme and that this would have to be considered if developing a well field in the fault zone south of Decoy Bridge. It may also be feasible to develop a well field further south of Decoy Bridge as indicated in **Figure 3**. Although the north-south fault zone has not been mapped to extend further south of the townlands of Colecot and Woodpark, potential groundwater resource development could be possible here assuming that the fault zone continues further south.

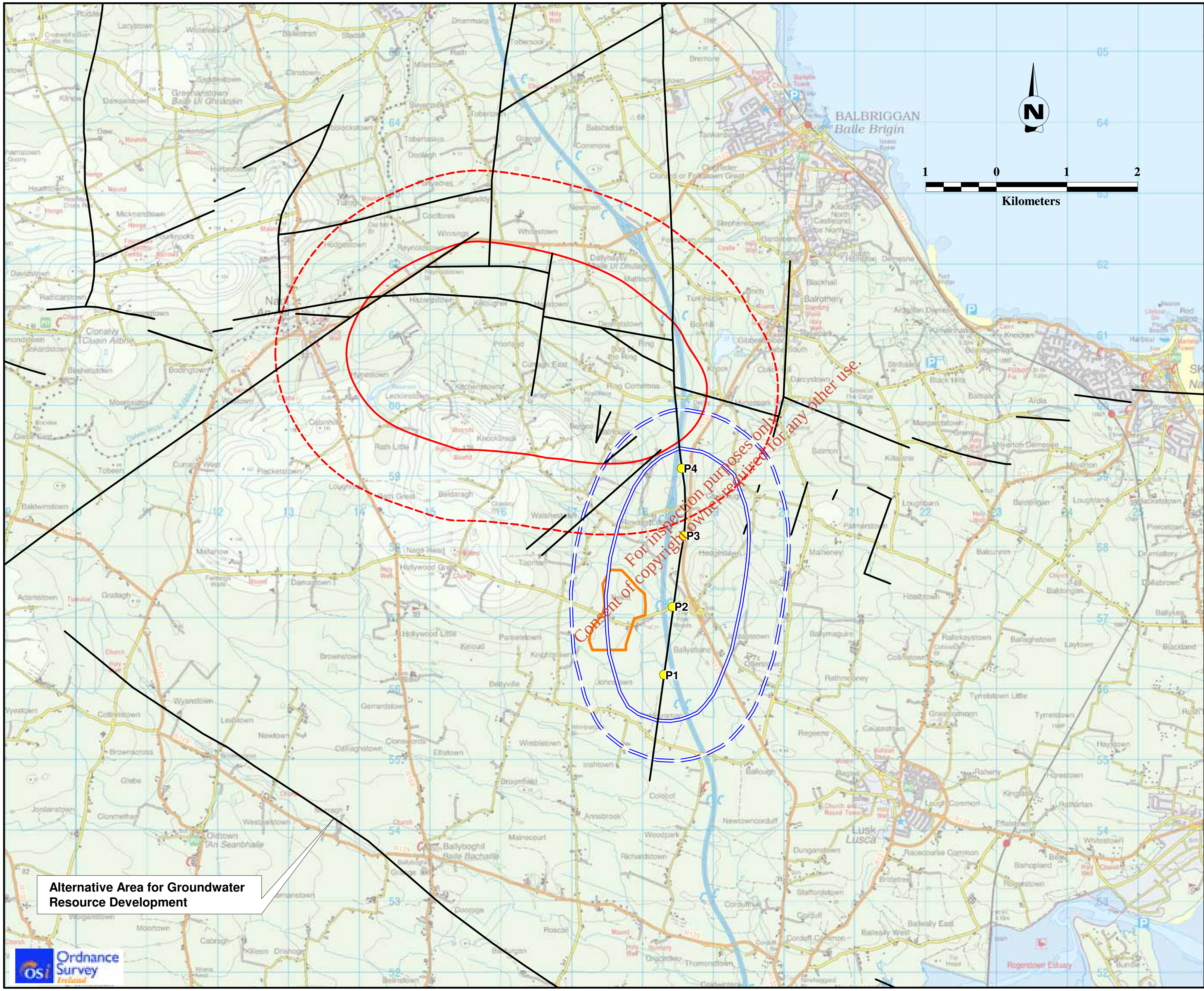
Landowners have reported well yields that are classified as 'Excellent' by the Geological Survey of Ireland in the Loughshinny formation within the townlands of Rathmooney, Ballymaguire and Malheney located 3km east of the landfill footprint and it is likely that further exploration of this area could provide similar sustainable yields.

It may also be possible to exploit water from wells located along the northwest southeast trending fault located 4km south of the proposed landfill site as an alternative to the north – south fault zone south of Decoy Bridge (Refer to **Figure 2**).

To put these hypothetical abstractions in context, it should be noted that Fingal County Council does not propose an additional public groundwater abstraction scheme for the area due to the sustainability and cost implications of such a supply. It should also be noted that working wells can be difficult to obtain in the fault zone due to the degree of fracturing in the rock (well failure occurred at Bog of the Ring Borehole PW1 for example).

In order to meet the county's water demands, the Water Services Department at Fingal County Council have a strategic plan for water supply for the region up to 2031 which is ***surface water based***, including increasing production at Leixlip Water Treatment Plant and potentially piping surface water from the west of the country. Currently groundwater only meets approximately 5% of Fingal's water requirements (approx 80,000m^3/day; of which groundwater from the Bog of the Ring Scheme supplies 3,500 to 4,000m^3/day of this). In the medium to long term, the relevance of groundwater supply in this area will diminish as the treated surface water output from the Leixlip Water Plant increases.

Finally, in protecting the groundwater resource for the area it is considered that the Resource Protection Zone approach as contained in *Groundwater Protection Schemes* (DoELG, EPA, GSI 1999) is the most appropriate method as it considers the groundwater resource as a whole, rather than on hypothetical point sources of abstraction from the groundwater system. This approach as used in the EIS has been used by Irish planning and regulatory authorities for all modern landfill proposals and is current best practice. This methodology is consistent with the assessment of groundwater resource protection as outlined in the *Waste Licensing Guidance Notes* (EPA 2005). The proposed landfill falls within the **R1** Response for Landfill which is the **lowest** risk level in the response matrix. **R1** means "*landfill is acceptable subject to guidelines of the Landfill Design Manual*" (EPA, 2000),



Legend

- Proposed Landfill Footprint
- Hypothetical Pumping Wells
- Estimated 2000 m³/day Zone of Influence
- Estimated 4000 m³/day Zone of Influence
- Bog of the Ring Water Supply Zone of Influence (TES: 2006)
- 100% Expansion of Zone of Influence
- Fault Line (GSI, 1999. Geology of Meath, Sheet 13. Scale 1:100,000)

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Project

Fingal Landfill

Title

Potential Zone of Influence for Hypothetical Boreholes at Yields of 2000m³/day and 4000m³/day

Figure 2

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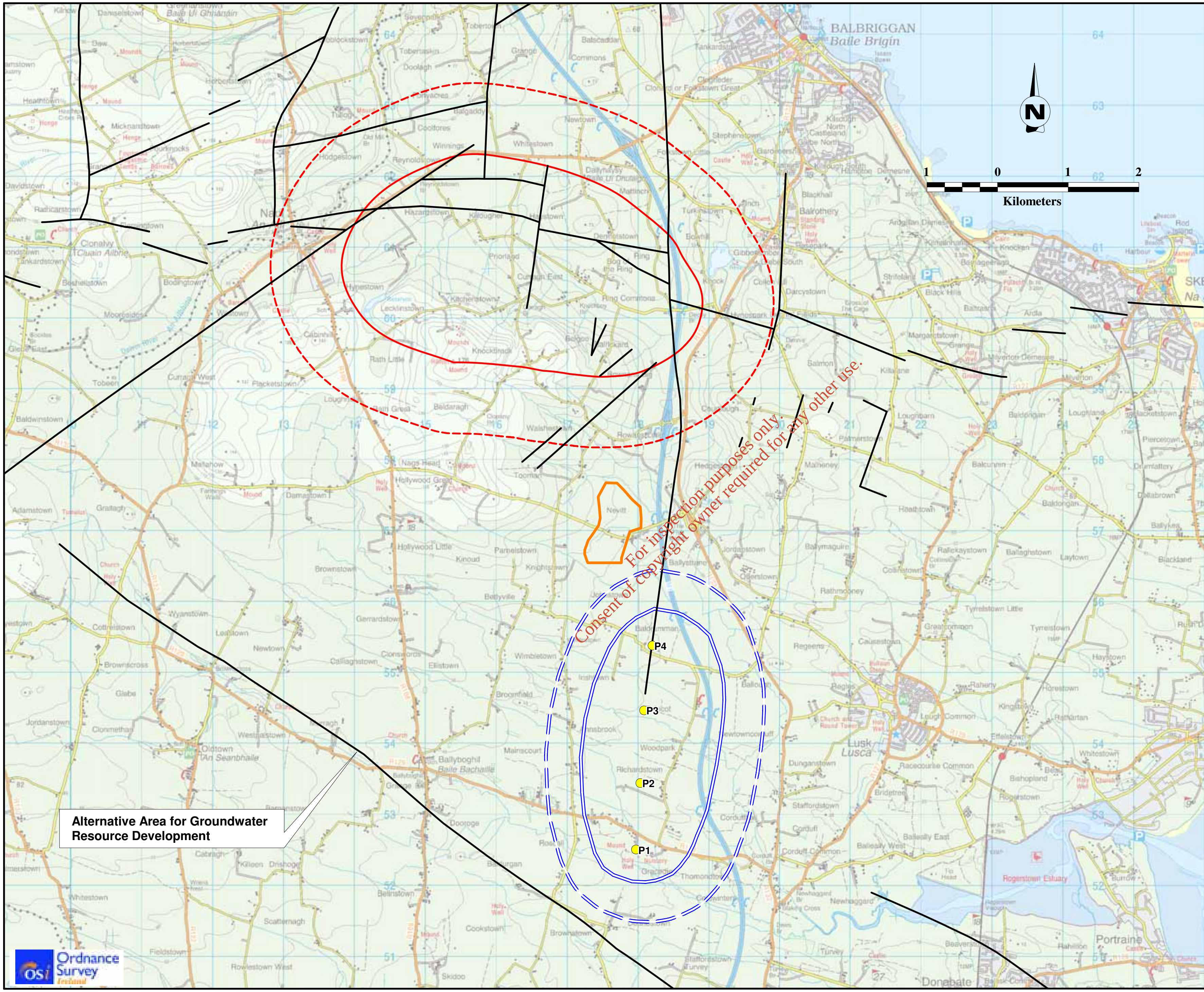

Legend

Proposed Landfill Footprint

Hypothetical Pumping Wells

Estimated 2000 m³/day Zone of Influence

Estimated 4000 m³/day Zone of Influence

Bog of the Ring Water Supply Zone of Influence (TES: 2006)

100% Expansion of Zone of Influence

Fault Line (GSI, 1999. Geology of Meath, Sheet 13. Scale 1:100,000)

Fingal County Council
Comhairle Contae Fhine Gall

Project *Fingal Landfill*

Title Alternative Well Field South of Decoy Bridge

Figure 3

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Appendix 5 – Manual and automated water level data: - Has the applicant identified any specific causes for the variations in water level in bedrock wells ER9 (~ 9 metres) and SHR3A (~ 13 metres)? Please comment on the reported variations. Comment on the impact of these variations on the overall interpretation of the site hydrogeology as detailed in the EIS.

SHR3a

The variation in water table on the 11th of October 2005 is a transcription error. A water table measurement of 20 metres below the top of the casing was entered as metres above ordnance datum resulting in a lower than normal reading. This has now been corrected as shown on the attached graph in **Figure 4.**

There is no change in the interpretation of the hydrogeology in the EIS.

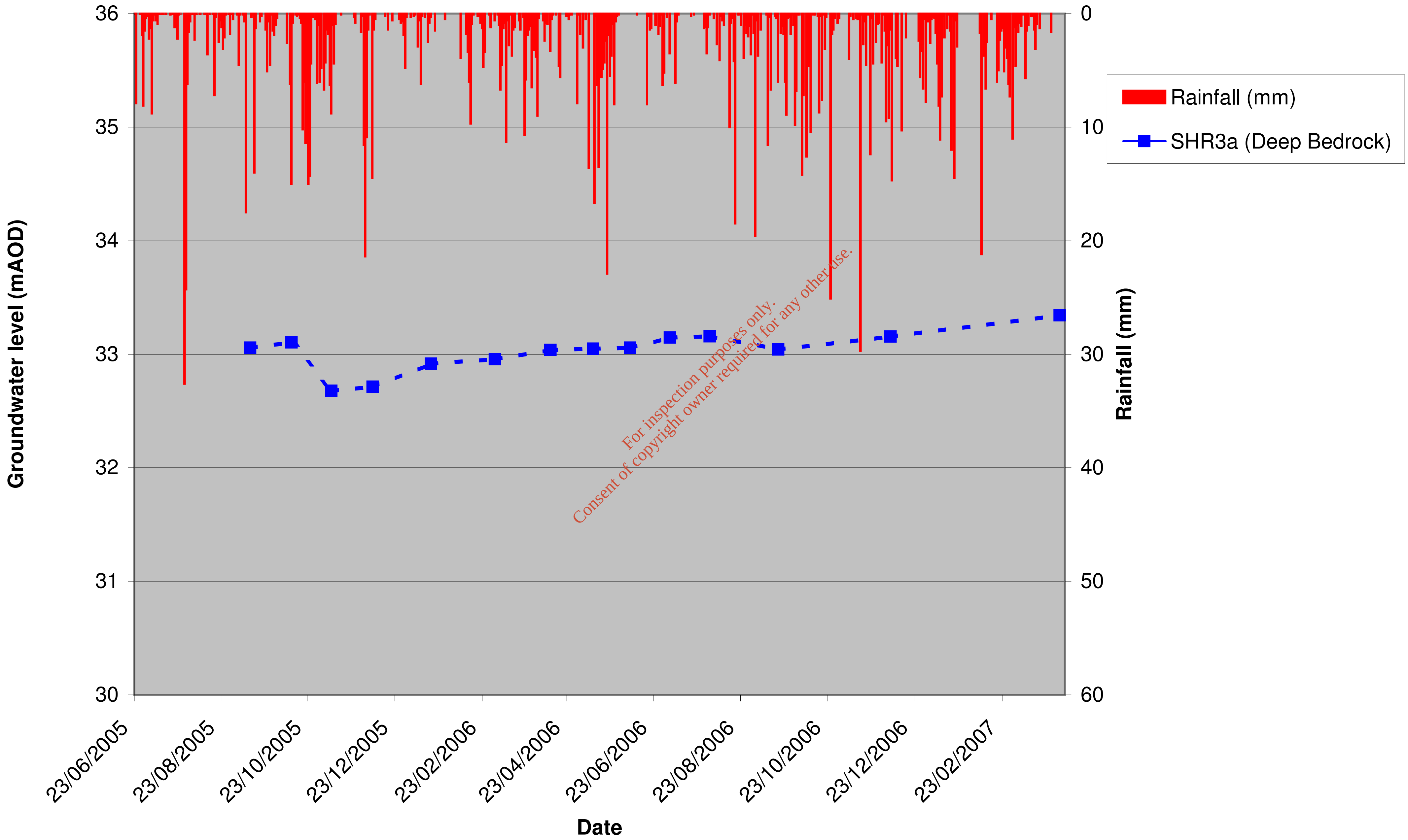
ER9

Borehole ER9 has collapsed or has been compromised. It is possible that previous water level measurements at this location could have been influenced by collapse.

SHR3a, a deep bedrock monitoring borehole is located adjacent to ER9. Data has been collected at SHR3a since September ’05 and at ER9 since December ’05. Monitoring data collected at each borehole from December ‘05 to April ’07 shows a piezometric head difference ranging from 0.2 to 0.7m. In the absence of data from ER9 in April, water levels from SHR3a have been used in April ’07 flow maps.

There is no change in the interpretation of the hydrogeology in the EIS.

Figure 4 Groundwater Levels at SHR3a



ARTICLE 13 COMPLIANCE REQUIREMENTS

BASE AND SLOPE STABILITY AND DEWATERING REQUIREMENTS

Respond to the points raised in Submission 74 (electronic copy attached) with regard to stability and dewatering requirements during the construction, operation and aftercare phase of the landfill. Ensure that a geotechnical engineer is consulted in preparing a response. Take into account all such concerns raised in the submission and also in Submission No. 77 (Point No. 4, 2nd and 3rd bullet point, electronic copy attached).

Undertaking cuttings of 10m depth and greater within glacial till and similar soil conditions with high water tables is a common practice and has been undertaken on numerous motorway and landfill projects throughout Ireland (including Gortadroma Landfill WL0017-3)). Groundwater control is typically undertaken on road projects using herring-bone or counterfort drainage systems with toe drains as permanent drainage systems. In the design of landfills, where groundwater inflow is anticipated, a drainage blanket is placed below the liner system to allow groundwater to be collected and diverted away from the base of the landfill. In this instance the groundwater will need to be controlled until such time that the waste above the liner system offers sufficient pressure to resist uplift forces both from the base and from side slopes. Large scale dewatering in the form of a perimeter deep well point or multi-stage system is not anticipated and neither is the need for a cut-off system as the clays are low permeability and groundwater inflow is controllable during construction through measures inserted on the cut-face such as those used on road cuttings.

DEPTH OF CLAY

2D Resistivity Profile 9long indicates areas across the southern area of the site where depth to gravel of less than 10 metres are present. The area covered by this profile is within the 10 metre cut contour of the landfill. Boreholes GS4 and GS5, adjacent to the profile line do not provide any evidence to indicate a greater depth of clay in this area. Discuss the above with regard to the requirement to maintain 10 metres of clay beneath the landfill footprint. Outline methods proposed to be employed during construction to ensure that 10metres of clay remains beneath the base of the landfill.

2D Resistivity Profile 9 Long is located in the north-west quarter of the investigated area at grid reference 317130E, 257421N. 2D Resistivity Profile 19 Long is located in the vicinity of boreholes GS4 and GS5 at grid reference 317552E, 256728N. Unfortunately the name of the resistivity profile '19 Long' is not clear on the plan drawings provided, Map 1a, Map 1b.

Both boreholes GS4 and GS5 terminate at depths of 9.6m and 10.5m in clay. They were terminated at this level because of the stiffness of the clay and the methods of drilling used for GS4 and GS5 were not adequate to penetrate in those conditions to a deeper level. Different drilling methods were employed at different locations so that different information could be provided. For example the drilling method employed at GS4 and GS5 was cable percussion drilling which can retrieve bulk samples in a relatively short space of time whereas borehole GR5 was drilled using rotary drilling methods and proved clay depths of 25.95m+. GR5 is located approximately midway between GS4 and GS5. Resistivity Profile 19 Long lies close to boreholes GS4, GR5 and GS5 where depths of clay were recorded at 9.6m (cable percussive), 25.95m (rotary), and 10.5 (cable percussive) respectively. The resistivity profile indicates an average depth of clay of 30m+ across the middle of the profile. Resistivity profile 18 Long (to the south of 19 Long) is reflective of clay depths in the location of GR6 and proves clay to 13.9m deep which is why this area remains outside the landfill footprint.

As with all construction projects of this nature, additional site investigation may be necessary to further classify the materials being excavated in order to establish construction methods, and to complete the detailed design. The final detailed design of all of the cells will take the depths already recorded into account and will supplement them as necessary to ensure that excavations are limited in order to maintain 10m of clay. As phases of the landfill develop additional site investigation will be employed as necessary to determine clay cover is maintained at 10m, which will provide for an R1 landfill rating.

GROUNDWATER FLOW AND LEVELS

Video recordings accompanying Submission No. 74 and No. 79 (DVD copies attached) indicates that the boreholes ER8, SHR3a and BSA1 are artesian. This is in disagreement with the monitoring data submitted with the application and with additional supplied information. Please comment on these findings and on the video recordings of boreholes submitted (copy attached).

By definition, an artesian well intersects a confined aquifer in which the static (i.e. non-pumping) water level rests above ground level. Artesian wells will be free flowing if they are not capped and the casing is not high enough to contain the hydraulic head (water level) in the monitoring well.

Measured water levels have been consistently below ground level in ER8, SHR3a and BSA1 and are included in **Appendix 1**. These demonstrate that the monitoring wells are not artesian.

In addition, photographic evidence from the recent monitoring round on 3rd April 2007 shows that none of these wells are overflowing at the surface.

ER8 3rd April 2007

SHR3a 3rd April 2007

BSA1 3rd April 2007

(Note: The water shown within the outer steel casing of BSA1 is not groundwater but rather rainwater which has collected inside the casing).

The following general comments are also made in relation to the DVD submitted to the EPA:

1. The videos demonstrate substantial surface runoff throughout the proposed landfill footprint. This runoff is consistent with **low recharge conditions** throughout the site and consistent with the presence of **low permeability subsoils**, which has been discussed in the EIS and in submissions to the EPA.

2. The volume of water discharging from PW2 described in Title 5 Chapter 3 of the DVD was during the pump test, which sustained 311m^3/day during a 72-hour pump test. This is consistent with well yields from locally important bedrock aquifers.

3. The borehole described as HR8 in the DVD is a damaged borehole from a previous site investigation. It was not drilled as part of the Fingal Landfill Project and has not been used for monitoring purposes because it is damaged. HR8 is located adjacent to the R132 (N1), approximately 300m north of the Five Roads.

4. The borehole described as HR7 in the DVD is HR2a. HR2a is not artesian as evident from monitoring data collected between June 2005 and April 2007. Groundwater levels monitored at HR2a range from 0.27 to 1.79 metres below ground level over this 22-month period.

5. A number of boreholes were incorrectly identified in the DVD as being artesian. Although these were not named and their locations are difficult to ascertain from the DVD, it is apparent that they are **not** artesian. Monitoring data collected and collated over a 22-month period has confirmed those boreholes that are artesian (Refer to 6 below).

6. Boreholes ER1 and BGB1 were correctly identified in the DVD as artesian. Monitoring data collected from June 2005 to April 2007 confirm artesian conditions in ER1 and BGB1 and at HR6, HR7, HR13.

It is proposed in submissions by Mr. Kevin Cullen (submission No. 78, copy attached) that a significant fault is present beneath the landfill footprint which will significantly impact the groundwater flow beneath the footprint compared to the bedrock groundwater contour maps submitted to date. Please comment on Mr. Cullen's interpretation of the data. Identify any potential risk, with regard to the landfill engineering, associated with reactivation of this fault.

The north-south fault zone mapped by the GSI is coincident with the general low lying area east of the proposed landfill. Groundwater flow mapping using an extensive monitoring network has consistently demonstrated convergence of groundwater flow in this lowland area as groundwater flows from the elevated ground east and west of the fault into the north south fault zone. RPS therefore do not agree with Mr. Cullen's interpretation that a fault exists below the proposed landfill that would significantly affect the groundwater flow mapping that has been completed. The bedrock groundwater contour maps produced in the EIS and supplied in additional information are an accurate reflection of groundwater flow across the area and are based on actual measurements of the piezometric surface from an extensive monitoring network. This monitoring has extended over a 22-month period to include seasonal variations from June 2005 to present. The April 2007 groundwater flow map is included as **Figure 5** and confirms the previous hydrogeological interpretation of the area.

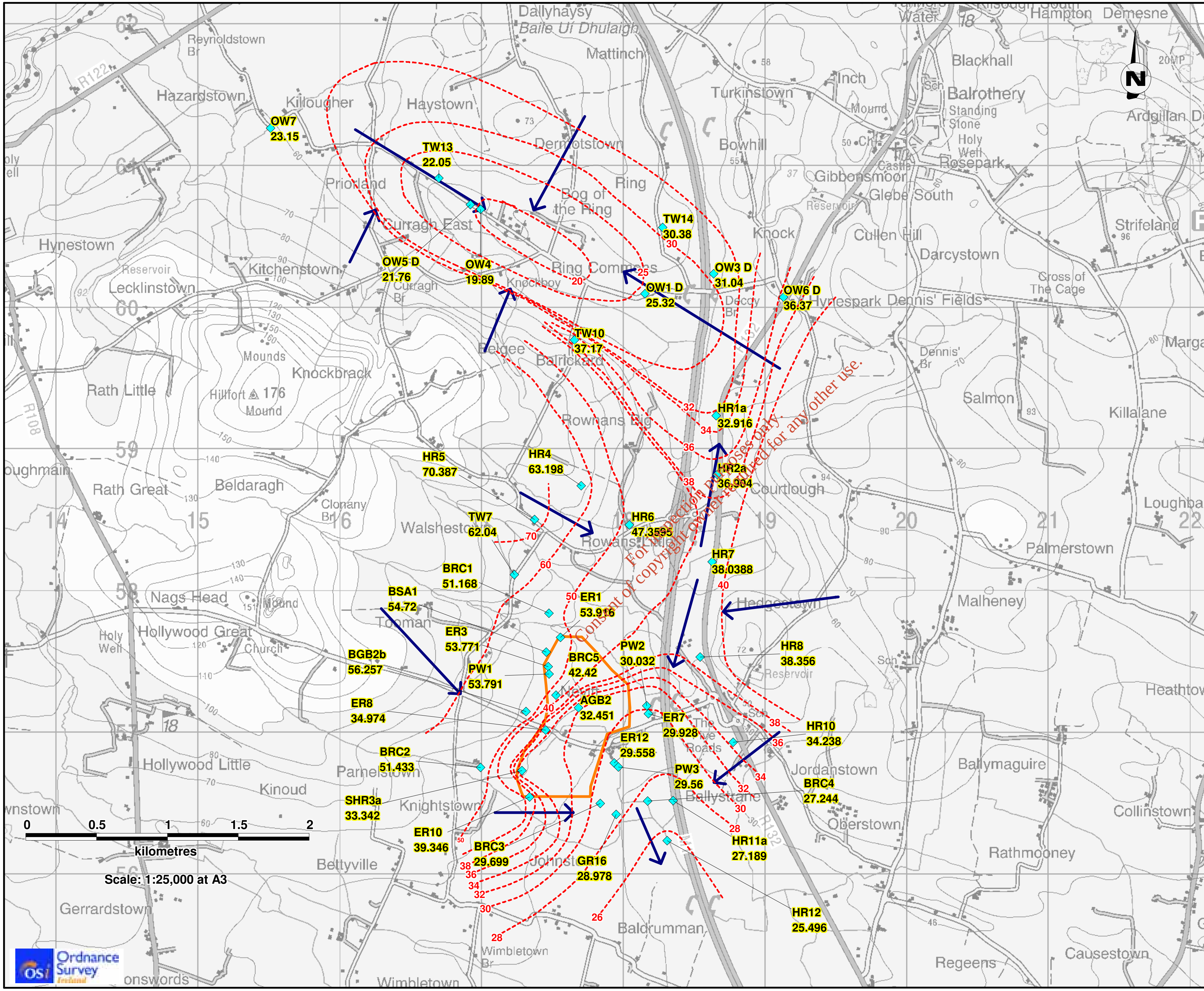
Potential re-activation of the fault is considered unlikely and will not impact on the landfill engineering for a number of reasons;

- The landfill development does not lie directly over / along the N-S fault zone as mapped by the GSI (**See Figure 2**).

- In the unlikely event of seismic activity in the region, the landfill is considered a flexible structure and will be able to resist any potential small movements. Other infrastructure in the area such as the M1 motorway and buildings in the area would potentially be at greater risk to such movements.

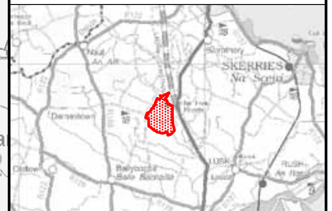
- There is no danger of liquefaction owing to seismic activity as the in-situ subsoil consist of over-consolidated deposits.

It is also noteworthy that Kevin Cullen in his submission to the EPA (No. 86, dated 30-03-07) stated that the fault beneath the proposed landfill is extremely unlikely to ever be reactivated and will not threaten the structural foundation of the landfill.



Legend

- BRC2 (51.72) — Borehole ID (Waterlevel mAOD)
- PWBR2 — Bog Of The Ring Pumping Stations
- 30 — Groundwater Contour (mAOD)
- Groundwater Flow Direction
- Proposed Landfill Footprint



Fingal County Council
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Project

Fingal Landfill

Title

Groundwater Contours (mAOD)
Bedrock
3rd April 2007

FIGURE 5

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2. All levels are referred to Ordnance Datum, Malin Head.
3. NOT TO SCALE, use figured dimensions only, if in doubt ask.
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RESPONSE TO GSI LETTER 4TH APRIL 2007

Four points were raised by the GSI regarding monitoring data, which are addressed below.

1. Data from three boreholes appear to have been omitted from the interpretation of the groundwater head contour map.

The GSI appear to have overlooked that only boreholes that were installed in the bedrock were used to prepare groundwater contour maps, as the bedrock is the main pathway for groundwater flow in the area. BGB1 was not installed in bedrock; it is a nested borehole with one monitoring well installed in clay and the second installed in gravel. Pressure gauges have been installed at ER1 and HR6 and these measurements have been incorporated into groundwater flow maps.

2. The Piezometric level in the artesian boreholes was not constrained.

Piezometric levels in the artesian boreholes have been constrained. Pressure gauges have been installed at all artesian boreholes since June 2006 and these measurements have been incorporated into groundwater flow maps.

3. The seasonal variation in the location of the groundwater divide is not established, particularly for drought situations.

The seasonal variations in groundwater levels were adequately addressed in the EIS as they corresponded with a full year from December 2004 to January 2006 in 17 monitoring wells and from June 05 to Jan 06 in 64 monitoring wells, at a minimum which corresponds with summer (low) and winter (high) levels.

Groundwater level monitoring has been undertaken in 17 boreholes from December 2004 to present and in the remaining 64 constructed boreholes on a monthly basis from June 2005 to September 2006 and quarterly thereafter. The monitoring has been coincident with Bog of the Ring groundwater level monitoring. In addition, automated water level monitoring has been undertaken on an hourly basis within 29 boreholes using downhole data loggers. As of September 2006, the monthly monitoring (including Bog of the Ring boreholes) has been scaled back to quarterly and hourly automatic monitoring has been scaled to daily measurements, as these are considered appropriate following review of the existing data. Manual and automated water level data has been included as Appendix 5 of Waste Licence Application, Article 14 response of the 18th January 2007. The April 2007 groundwater flow map is included as **Figure 5** and this confirms previous flow mapping and conclusions reached in the EIS.

The minimum of 18 months water level data at each of the 81 boreholes across the site give an accurate representation of seasonal variations in groundwater levels and recharge conditions.

There has been no significant change in water level variations not already observed and presented in the EIS between January 2006 and present.

The direction of groundwater flow under the proposed site and local surrounding area and the location of the groundwater divide has been established from comprehensive time series groundwater level monitoring data. Water level monitoring data sets collected from June 2005 to present have consistently demonstrated that groundwater flow below the proposed landfill site is in a southeasterly direction towards Rogerstown Estuary and away from the Bog of the Ring through all seasons.

The period in which the Environmental Impact Assessment has been undertaken has been a relatively dry period as stated in the EIS. Annual rainfall was 703mm in 2004 and was 684mm in 2005 at Dublin Airport, whereas the average is 783.5mm per year (25 year average 1980-2005). Rainfall measured in

2006 to the end of July, when dry weather flow observations were made, was 326.5mm, which is less than half of the annual average. Therefore, the groundwater flow monitoring and mapping that has been conducted during the EIA process has taken place in relatively dry conditions that have lasted for over 2 years. It would be expected that there would be more recharge to groundwater in wetter years and as such the zone of influence to the Bog of the Ring supply wells would be smaller during wetter years. The current zone of influence of the pumping wells delineated by TES has been during over 2 years of relatively dry weather.

Therefore the current zone of influence is considered to be relatively conservative. Under a prolonged drought scenario the zone of influence may expand but there is considerable land area to accommodate this before entering the landfill footprint. Groundwater can also be released from unconfined storage to sustain yields in short term before aquifer recharge occurs. It has been calculated that the zone of influence could expand by greater than 100% and still retain a 500m buffer to the landfill footprint area. This is shown in Appendix 7 of Waste Licence Application, Article 14 response of the 18th January 07.

4. There are insufficient monitoring points in the area between Rowans Little, Courtlough and Hedgestown/The Five Roads to ascertain with a high degree of confidence (a) the location of the groundwater divide and particularly, (b) its lateral migration as a function of seasonal variations in recharge.

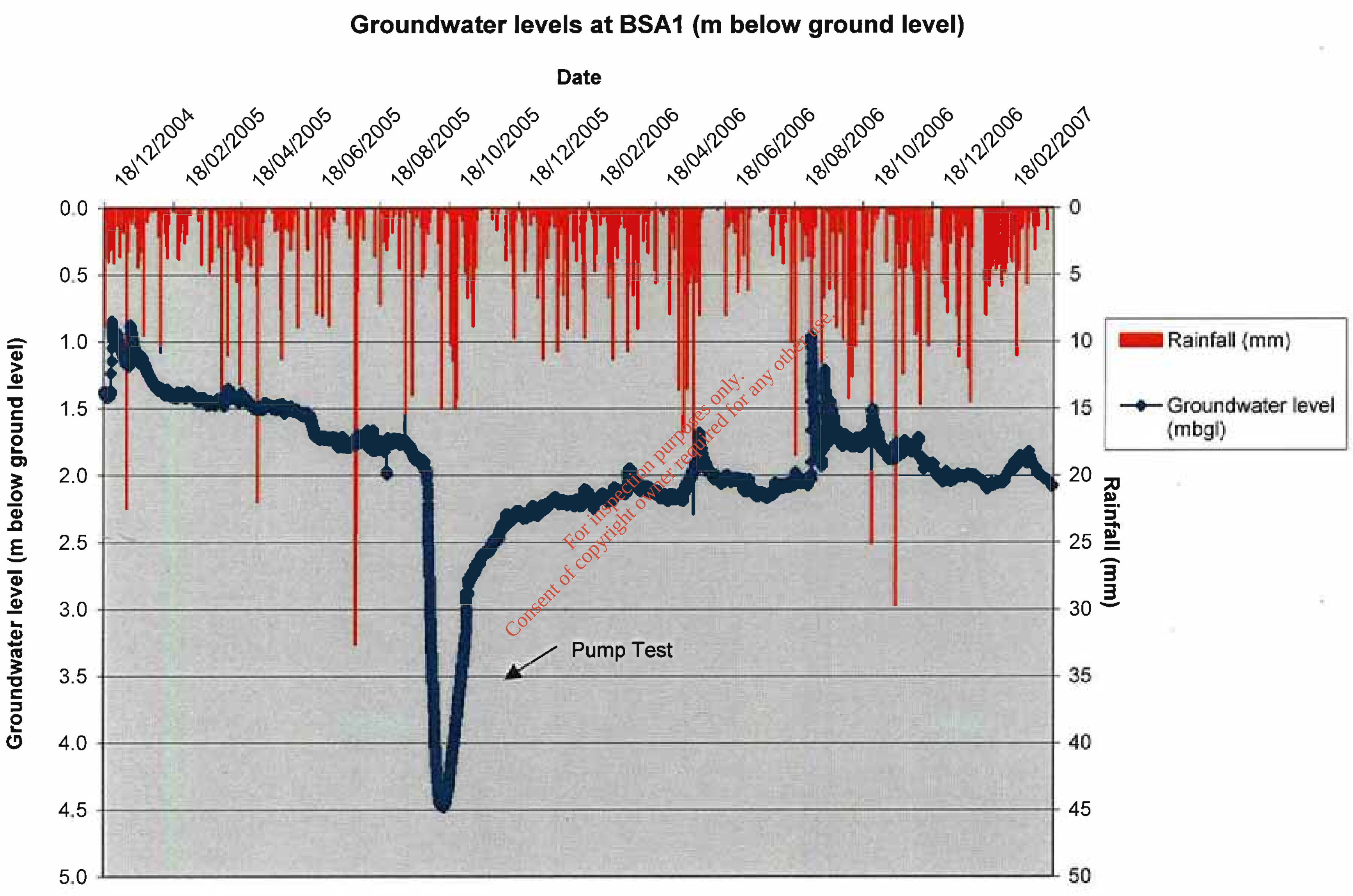
The location of groundwater monitoring boreholes were discussed in advance and agreed with independent consultants retained on behalf of the Nevitt Lusk Action Group (Mott MacDonald). There is sufficient monitoring to determine that the proposed landfill falls in a separate groundwater catchment and does not fall within the zone of influence of the Bog of the Ring.

With regard to the GSI's comment regarding Figure 2 in *Review of Environmental Impact Statement* (Mott MacDonald, 2006), it should be noted that this report has not included Bog of the Ring monitoring well water levels in the contour maps of the area.

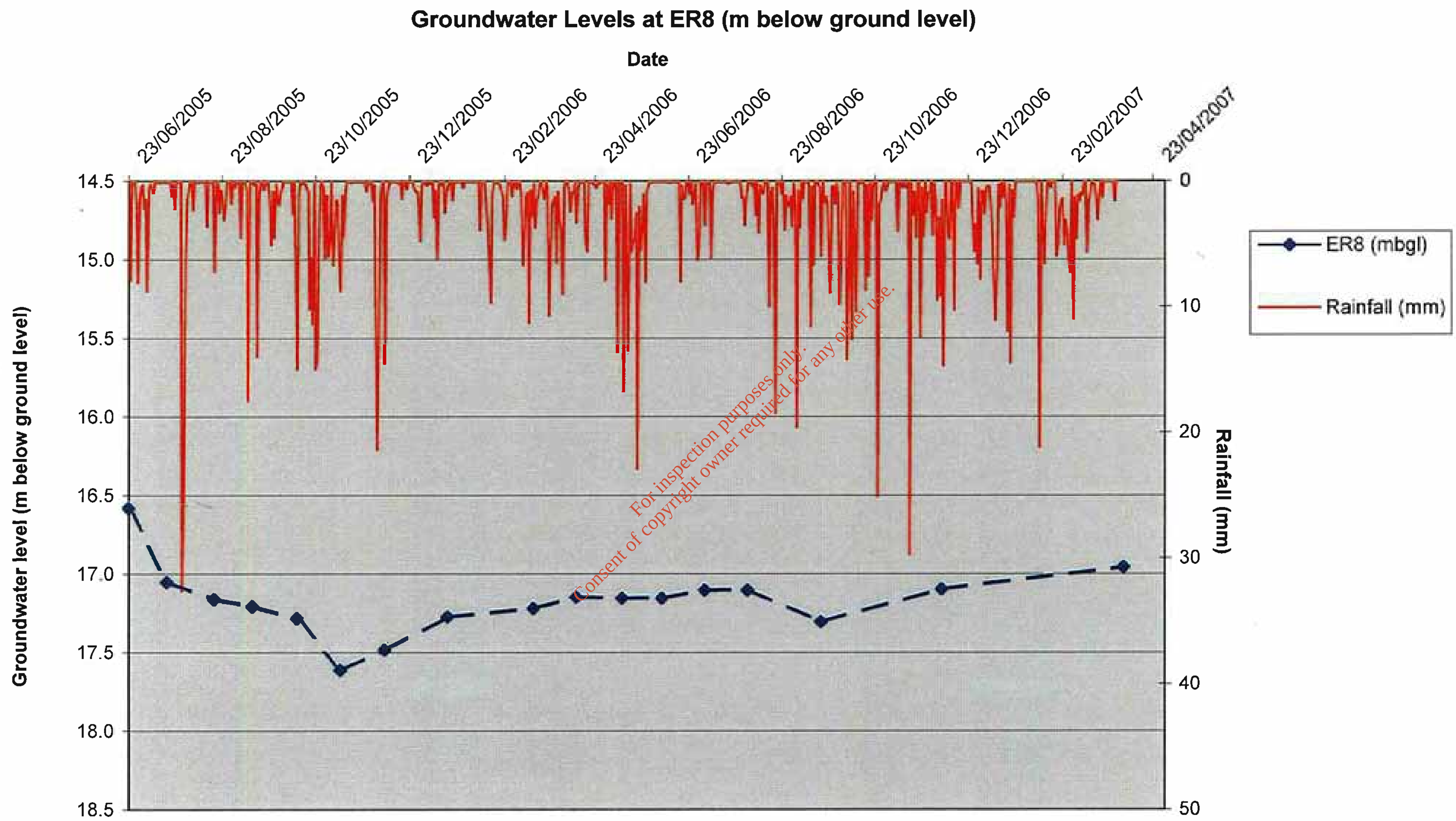
Although additional monitoring points may provide a more exact position of the groundwater divide, there are without doubt sufficient boreholes and associated monitoring data collected over a 22-month period to demonstrate that a groundwater divide exists between the Bog of the Ring zone of influence and the proposed landfill throughout all seasons.

APPENDIX 1

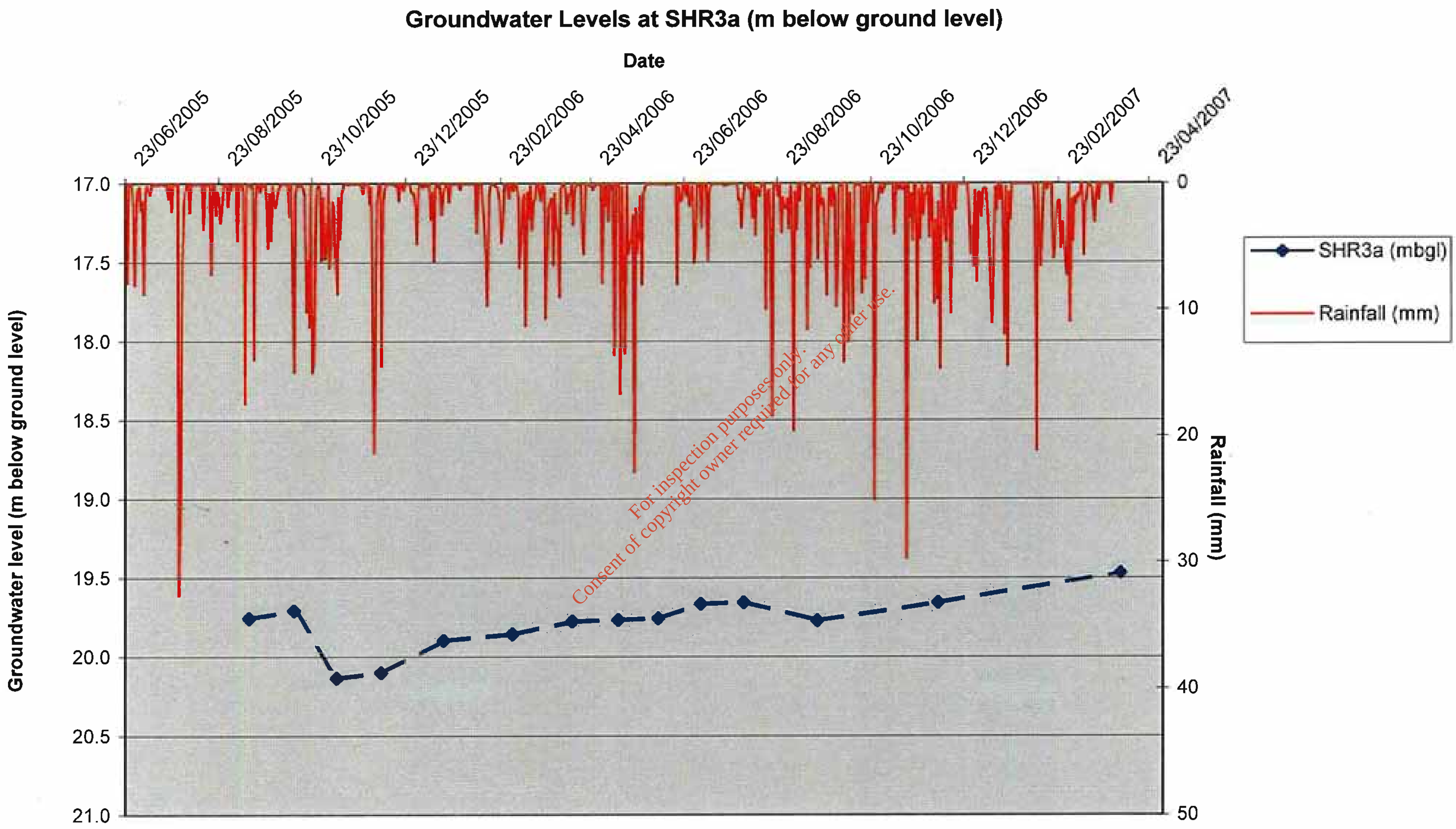
GROUNDWATER LEVELS



Groundwater levels at BSA1 (m below ground level)
Date
18/12/2004
18/02/2005
18/04/2005
18/06/2005
18/08/2005
18/10/2005
18/12/2005
18/02/2006
18/04/2006
18/06/2006
18/08/2006
18/10/2006
18/12/2006
18/02/2007
Groundwater level (m below ground level)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Rainfall (mm)
0
5
10
15
20
25
30
35
40
45
50
Rainfall (mm)
Groundwater level (mbgl)
Pump Test



Groundwater Levels at ER8 (m below ground level)
Date
23/06/2005
23/08/2005
23/10/2005
23/12/2005
23/02/2006
23/04/2006
23/06/2006
23/08/2006
23/10/2006
23/12/2006
23/02/2007
23/04/2007
Groundwater level (m below ground level)
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
Rainfall (mm)
0
10
20
30
40
50
ER8 (mbgl)
Rainfall (mm)



Groundwater Levels at SHR3a (m below ground level)
Date
23/06/2005
23/08/2005
23/10/2005
23/12/2005
23/02/2006
23/04/2006
23/06/2006
23/08/2006
23/10/2006
23/12/2006
23/02/2007
23/04/2007
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
Groundwater level (m below ground level)
0
10
20
30
40
50
Rainfall (mm)
SHR3a (mbgl)
Rainfall (mm)