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

January 2007

RPS

Fingal Landfill Project

Waste License Application W0231-01 Article 14 Information

DOCUMENT CONTROL SHEET

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Consulting Engineers

TABLE OF CONTENTS

INTRODUCTION

This report has been complied to supply additional information in response to a Notice in accordance with Article 14 (2) (b) (ii) of the Waste Management (Licensing) Regulations from the Environmental Protection Agency dated November 16th 2006.

ARTICLE 12 COMPLIANCE REQUIREMENTS

I. REQUEST FOR INFORMATION

Using available data from the studies carried out to date, comment on the likely accuracy of the location of the various geological formations underlying the site as detailed in GSI Geological Map Sheet 13 and Figure 4 of Volume 5 Appendix H. Provide a revised plan view of the bedrock geology underlying the site. It is suggested that you liaise with the Bedrock Section of the GSI in relation to this geological interpretation.

Response to request

Bedrock geology beneath the landfill footprint has been presented in the Environmental Impact Statement using the published Geological Survey of Ireland (GSI) Bedrock Sheet 13. This is standard practice for geological descriptions in Environmental Impact Statements for this type of development. A detailed description of the bedrock recovered through rotary borehole cores drilled on the proposed site are contained within Volume 5 of the EIS along with colour photographs, which are consistent with the GSI descriptions of the bedrock at each location, therefore we consider that redrawing of the published map is not necessary to assess the environmental impacts of this development on geology and hydrogeology.

The geological formations beneath the footprint comprise similar types of fractured bedrock (shale and limestones) which have been classified by the GSI as one hydrogeological unit, i.e., a Locally Important, Generally Moderately Productive Bedrock Aquifer (Lm). This grouping has been reiterated by Dr. Eibhlin Doyle, Principal Geologist at the GSI in evidence given at the An Bord Pleanala Oral Hearing (**see Appendix 1**). According to the GSI, the Lm designation of the aquifer was assigned in 2003 following extensive review of data for the region and remained unchanged following subsequent additional work for Water Framework Directive.

This has been further substantiated by the Geological Survey of Ireland Bedrock Mapping Section in their letter to the EPA dated 19th December 2006. The GSI state that the underlying bedrock formations are quite similar. While an alternative interpretation is offered by the GSI which may shift boundaries slightly, it "*makes no practical difference to the overall picture of the geology or its influence on groundwater. Any minor lithological differences between the different formations, as far as groundwater behaviour is concerned, are likely to be negligible".*

II. REQUEST FOR INFORMATION

Develop a vulnerability map for the study area based on site investigations carried out to date.

Response to request

A vulnerability map has been provided, refer to **Appendix 2** 'Proposed Fingal Landfill Groundwater Vulnerability Map'. This map is based on the thickness of subsoil derived from borehole logs for the site. The vulnerability rating for the landfill footprint is **LOW**. Where sand and gravel is present beneath the landfill footprint, there is a minimum of 10m of low permeability clay above it so the vulnerability rating remains **LOW**.

III. REQUEST FOR INFORMATION

Provide an assessment of the likely leakage rates from the landfill, including fate and transport, based on the calculations provided in the EPA Landfill Site Design Manual Appendix C. Provide details of the assumptions made as part of the calculations.

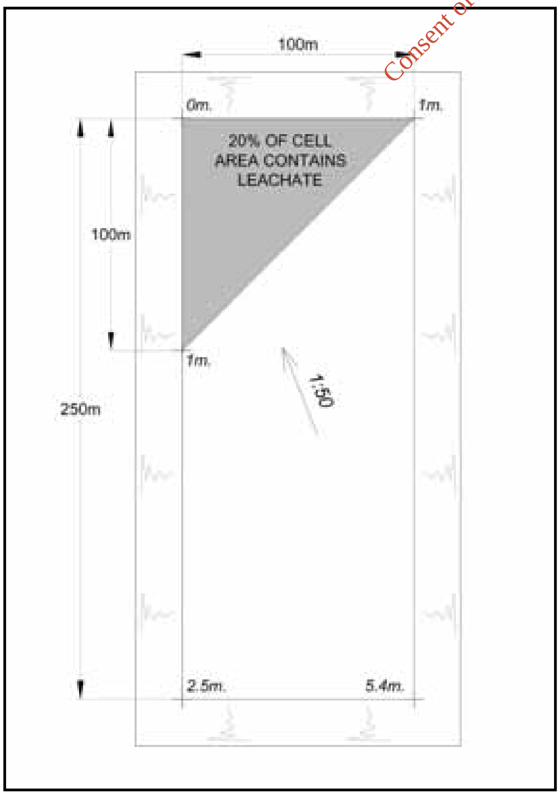
Response to request

Calculations and assumptions

In order to quantify the potential risk from the landfill to the underlying groundwater, the potential leakage rate has been estimated from equations given by Giroud & Bonaparte (1989) and tabulated by the EPA for various conditions of head and hydraulic conductivities as outlined in the EPA Landfill Site Design Manual (2000).

The following assumptions have been made:

- That a lined landfill area of 570,000m^2 is constructed and used at one time
- That the lined landfill area is divided in to cell areas of 25,000m^2 with basal gradients of 1:50 towards the sump and 1:100 crossfall
- That 2no. 2mm defects exist per 4,000m^2 in the geomembrane after construction (equating to a defect area of 1x10^{-5}m^2
- That a head of leachate of 0.7m exists across 20% of the lined area (this excludes side slopes where leachate head will be 0m.) This is based on a typical cell size of 25,000m^2 as illustrated in the figure below. In order to be conservative, 0.2m of leachate head across an additional 40% of the lined area is included in the calculations.



In Appendix C3 of the Landfill Site Design Manual, the equation to determine Q (the leakage rate) in m^3/s for good contact is:

$$Q = 0.21\, a^{0.1}\, h^{0.9}\, k^{0.74}$$

Where

- Q is the leakage rate (m^3/s)
- a is the defect area of the geomembrane (m^2)
- h is the hydraulic head on top of the liner (m)
- k is the hydraulic conductivity of the compacted soil (m/s)

This is calculated as follows:

From Table C4 and Figure C4 of the EPA Manual and using k= 1x10^{-9}m/s with a leachate head of 0.7m, the leachate rate is approximately 5l/ha/d.

As stated above, the conservative assumption is that 20% of the landfill area is covered by this head of 0.7m, therefore equalling a leachate leakage rate of = 5 x 57(*ha*)/1000 m^3/d x 20% = 0.057m^3/d.

In addition, conservatively, it is assumed that 40% of the cell is covered by a leachate head of 0.2m, therefore equalling a leachate leakage rate of = 0.0228 m^3/d.

Therefore the total leachate leakage rate across the landfill lining system for both average leachate heads = 0.057 + 0.0228 = 0.08m^3/d. This is rounded up to 0.1m^3/d.

This is a conservative estimate and in reality the area of defects will be substantially less than this given that the lining system will be constructed under full-time CQA supervision and a leak location survey will be completed on each cell after placement of the leachate drainage stone.

Comparison to Septic Tanks

In order to put this leakage rate in context the total ammonia load based on this rate has been compared with the load from a household septic tank. The effluent from a septic tank servicing a household of 4-6 people has an average ammonia concentration of 50mg/l and an average discharge of 500 l/d.

In comparison:

- assuming an average ammonia concentration of ammonia of 500mg/l in leachate the ammonia load of leachate is 500 x 100 = 50,000mg/day
- the ammonia load per litre of septic tank effluent is 50 x 500 = 25,000mg/day

Therefore the conservative estimate of leakage from a landfill of 57ha has an ammonia load equivalent to two typical domestic septic tanks.

Dilution Factor in the aquifer

The groundwater flow through the aquifer below the landfill can be calculated using Darcy's Law:
Q = T * i * width, where:

Variable	Definition	Assumption
Q	Groundwater flow (m^3/d)	
T	Transmissivity (m^2/d)	Estimated to be 47m^2/d (average of all pumping test results)
i	Hydraulic gradient	Measured at 0.032 on June 2005
Width	Width of aquifer (m)	Approximately 1000m measured perpendicular to the groundwater flow direction

Q (groundwater flow) = 1504 m^3/d

Using a worst case scenario where there is no attenuation of this leachate leakage in the (>10m) clay subsoil below the landfill cells, these calculations can be used to estimate that there will be a very high dilution factor of over 15,000 times (= groundwater discharge / leakage rate = 1504 / 0.1) of any leachate reaching groundwater in the underlying aquifer.

It should be noted that this is a conservative estimate for the following reasons:

1. It assumes that an outward hydraulic gradient exists between the leachate in the cells and the surrounding perched groundwater in the subsoil. In reality, the majority of the landfill will be located below this water level such that there will be an inward hydraulic gradient to the cells;
2. It also takes no account for natural attenuation in the low permeability natural subsoil as the leachate percolates through the subsoil to groundwater in the bedrock aquifer.

IV. REQUEST FOR INFORMATION

The Geophysical investigation report (part of Volume 5 of the EIS) resistivity profiles suggest a number of potential faults, changes in lithology, fracture zones and areas of increased gravel contents. Please assess these further and comment on their importance in relation to the overall geological and hydrogeological assessment of the site. If necessary take this information into account in the reassessment of the underlying geology detailed in Point (i) above.

Response to request

The geophysical investigation did interpret a number of potential faults or changes in lithology within the 2D resistivity data. This usually took the form of sudden lateral changes in resistivity values. These features are interpreted at depths greater than 20 m below clay rich overburden. These faults/lithology changes cannot be proven by the geophysical data but do agree reasonably well with the geological setting and direct investigation data. Bedrock geology in the area is varied as discussed in Section 3.2.1. Regional Bedrock Geology in Volume 5 of the EIS and changes in lithology, as interpreted by the geophysical data, may represent local changes in bedding or interlaying of different rock types within individual formations. The changes in lithology as indicated by the geophysical data are located within the Lucan, Naul and Loughshinney Formations. These formations consist of a number of different inter-bedded rock units and local variations would be commonplace and would not effect the overall geological and hydrogeological assessment as outlined within the EIS. As mentioned above the possible faults identified by the geophysical data are interpreted within bedrock at depths greater than 20 m, below clay rich overburden. Local faulting / fracturing is likely across the site as discussed in section 3.2.1 & 3.2.2 in Volume 5 of the EIS with fractured bedrock recorded, and structural deformation leading to a patchwork of underlying geology dissected by faults. Their presence would not significantly alter the previous geological assessment. As shown within the EIS and confirmed by the Geological Survey of Ireland, these units/formations are all mapped together hydrogeologically as a Locally Important Aquifer.

The 2D resistivity data has interpreted localised higher resistivity values within the clay overburden as possible increases in gravel or boulder content. These would be isolated lenses or bands consistent with typical glacial till deposits as discussed in Sections 3.3.1 & 3.3.2 in Volume 5 of the EIS. Their presence would not significantly alter the previous geological assessment within the EIS.

The geophysical data was incorporated into the original geological model as outlined in the EIS and the geophysical interpretation evolved with increased direct information obtained during drilling investigations.

V. REQUEST FOR INFORMATION

The report completed by Mott McDonald (dated 7th September 2006) submitted on behalf of Nevitt Lusk Action Group queries the cause for the change in hydraulic gradient from the west of the site to the east of the site as demonstrated in the groundwater contour maps in Appendix A5 of Volume 5 Attachment H of the EIS and also in the groundwater contour plots included in the Mott McDonald report. It is suggested that this may be related to the groundwater discharging into a stream on the site, indicating that the clay overburden is not a barrier to groundwater flow. Please comment on the potential reasons for the change in hydraulic gradient and on the likely cause of the change based on information gathered as part of the study investigation.

Response to request

The change in hydraulic gradient from the west to the east of the site is not considered to be caused by groundwater seepage to surface water in this area. Dry flow observations made in July 2006 (refer to **Appendix 3**) support this, as the stream draining this part of the site was dry.

Transmissivity in the bedrock was found to increase from west to east in the landfill study area, which correlates with the change in hydraulic gradient. The hydraulic gradient flattening out also corresponds with the surface topographic gradient that also flattens out in the area. The general increase in transmissivity due to the location of the N-S fault and the change in topography are more likely explanations for the flattening of the hydraulic gradients in this area.

VI. REQUEST FOR INFORMATION

In a submission to the EPA from the GSI (in response to a request for information from the EPA), the GSI indicates that in their opinion, the most fruitful area for exploration for further groundwater supplies would be south of Decoy Bridge along a zone that is roughly parallel to the M1. In the event that abstraction wells were located in this area in the future as part of a public supply scheme it is anticipated that this may have an impact on/interaction with the zone of contribution from the current Bog of the Ring abstraction scheme. Please undertake a numerical modelling study (using MODFLOW or similar industry-accepted code) to determine (a) the impact on the groundwater flows at the proposed landfill area of the additional abstraction wells along indicated area of land, and (b) the combined zone of contribution for the existing Bog of the Ring abstraction system and the theoretical new abstraction wells. Indicate the additional sustainable yield that maybe attainable from boreholes along the area of land already mentioned. Document all model assumptions and input data.

Response to request

If continuous long term abstraction wells with average yields of 1,000m^3/day were located south of Decoy Bridge along a zone that is roughly parallel to the M1 and east of the proposed landfill, then the proposed landfill would potentially fall within the zone of contribution of these wells. However, it must be noted that:

1. A hydrogeological report entitled ‘Bog of the Ring Groundwater Development Report on Hydrogeological Investigations and Proposals for the Short Term Development of the Aquifer’, (PH McCarthy, 1994) concluded that “*the limestone aquifer identified in 1984 does not extend to the southern end of the syncline”* [i.e. the proposed landfill area] *“and is not related to primary permeability but rather to structural faulting*” ;

2. Well yields in the general area are variable (output ranges differ from 336 - 1,512m^3/day at nearby Bog of the Ring for example). In addition, trial wells drilled as part of the Bog of the Ring Scheme had yields as low as 200m^3/day (at TW3 and TW6 for example);

3. Working wells are difficult to obtain in the fault zone itself due to the degree of fracturing in the rock. This problem was encountered at Bog of the Ring boreholes TW3 and PW1 for example;

4. Thick deposits of low permeability clays in the area impede infiltration of rainwater and recharge of the aquifer. It is this low recharge which is a greater constraining factor to long term sustainable groundwater yield rather than the transmissivity of the bedrock. This has been discussed in detail with respect to the Bog of the Ring supply in the Final Hydrogeological Assessment Report, TES, 2006;

5. Groundwater potential in the area was over-estimated at initial stages of Bog of Ring investigations, and water levels and well efficiency have dropped significantly in the Bog of the Ring pumping wells over a relatively short time period (3 years approximately). Operating hydraulic efficiency of boreholes PW2, PW3, PW4 and PW5 have declined by approximately 54%, 65%, 56% and 78% respectively (TES, 2006);

6. A cost benefit analysis shows that it is significantly more economic to provide water supply from expansion of the Leixlip Water Treatment Works, rather than engage in drilling test wells, infrastructural requirements of laying collector mains, expanding the water treatment works (owing to the high Iron and Manganese concentrations in the groundwater) and pumping to service reservoirs. According to Fingal County Council Water Services Department, the overall cost per litre for supply from Bog of the Ring is at least 2.6 to 3 times higher than that from

Leixlip Water Treatment Works due to higher electricity and manpower costs at the Bog of the Ring.

7. As a result of the above, a public groundwater abstraction scheme for the area is not envisaged by Fingal County Council due to the sustainability and cost implications of such a supply. 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 80ML/day of which groundwater from the Bog of the Ring Scheme supplies just 3.5 to 4ML/day of this). In the medium to long term, the relevance of groundwater will diminish further as the treated surface water output from the Leixlip Water Plant increases.

In light of these factors, a numerical modelling study to determine the impact of hypothetical increased abstractions on groundwater flows beneath the landfill and on the extent of the resultant zone of contribution is not considered necessary as it is not Fingal County Council's plan to further develop groundwater resources in the area.

VII. REQUEST FOR INFORMATION

The Mott McDonald report referred to in Point (v) above includes calculations of vertical and horizontal groundwater flow and concludes that the downward vertical migration of groundwater (potentially including leachate) may form a significant proportion of the horizontal groundwater flow through the underlying bedrock. The applicant is requested to complete a more detailed assessment of the likely vertical and horizontal groundwater flow components beneath the site and to take into consideration the leakage rates as calculated under Point (iii) above.

Response to request

The risk of downward migration from the proposed landfill is limited by the fact that that once constructed; there will be an inward hydraulic gradient from the surrounding subsoil into the landfill cells across much of the site, such that it will not be possible for leachate to migrate outwards from the cells. The Mott McDonald Report over estimated the risk of downward migration from the proposed landfill by:

1. Ignoring the inward hydraulic gradients to the landfill cells;
2. Assuming that there are downward hydraulic gradients across the entire landfill, which is not the case;
3. Overestimating the amount of downward groundwater flow from the subsoil to the bedrock aquifer in their calculations. It is possible to check calculations given in the report by simply dividing the volume of downward flow that was calculated (432 m^3/d or 157,680 m^3/yr) by the landfill area used (500,000 m^2) to estimate recharge to the underlying aquifer below the landfill, which works out to be 0.315 m/yr (315 mm/yr). This is considerably greater than that estimated in the EIS (18 – 54 mm/yr) and by the GSI (57mm/yr) in the Bog of the Ring Source Protection Zone (2005). If Mott McDonald calculations were correct, it would be expected that groundwater levels in the bedrock aquifer would respond by several metres to seasonal rainfall (because the aquifer is confined fractured bedrock), which is not the case. For example, groundwater levels in monitoring well BRC5 located within the footprint (contained in Appendix H-11 of Volume 5) illustrate that groundwater levels have only fluctuated by approximately 0.5m from December 2004 to January 2006. Mott McDonald calculations are also at variance to the observed surface runoff estimates in the EIS, because these calculations would suggest that 88% of the effective rainfall (rainfall – evapotranspiration) for the area recharges groundwater below the proposed site which is not the case.

A calculation of leakage rate and dilution in the aquifer (excluding natural attenuation in the subsoil) has been submitted in (iii).

Vertical groundwater movement between the overburden and the bedrock has been assessed 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 Volume 5 (Technical Appendices H and I). The main conclusions are:

- There is a downward gradient between the clay subsoil and the bedrock in the northwest of the study area (SHR1);
- There are vertical upwards hydraulic gradients between the bedrock and the subsoil (gravel) in the east of the study area (SHR2);

- There is a downward groundwater hydraulic gradient between the subsoil and the bedrock in the south study area (SHR5). This area is outside the landfill footprint.

At a number of locations across the study area outside the footprint, 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.

ARTICLE 13 COMPLIANCE REQUIREMENTS

VIII. REQUEST FOR INFORMATION

Reassess the accuracy of the information provided in Geological Cross Section A-A" and B – B' presented in Appendix A1 of Technical Appendix H, taking into account queries on these cross sections submitted by K. Cullen in his submission to the EPA dated 12/09/06.

Response to request

Geological Cross Section A-A' and B-B' presented in Appendix A1 of Technical Appendix H has been amended and is submitted now in **Appendix 4**. Explanations for amendments are outlined below:

1. The log for SHR3 was used as opposed to SHR3a in the amended drawing as SHR3 was closer to the line of the section and did potentially encounter gravel in the logs (20m to completion of borehole at 31.5). It must be stressed that SHR3 was drilled by open hole methods and that recovered material is difficult to classify (i.e. it could be weathered rock or gravel). This borehole was included as it is possible that the gravel exists but because there isn't 100% certainly that it is gravel, a question mark has been added;

2. The vertical scale and folded beds means that formations can appear too thin or thick based on the dip of the formation. The vertical exaggeration of the Loughshinny Formation has been corrected;

3. The extent of the landfill footprint was revised to include that area that intersected the landfill only.

These changes are not considered significant because the geological formations underlying the landfill footprint contain similar types of fractured bedrock (shale and limestones), all of which are classified as Locally Important, Generally Moderately Productive Bedrock Aquifers (Lm) by the GSI. Therefore, changes in extent of any one formation does not change the classification of the aquifer beneath the site. Additionally, because any gravel encountered beneath the landfill footprint is overlain by 10m of low permeability clay following cut, the Low vulnerability classification of the site does not change. The site falls within the lowest risk category (R1) for landfill siting.

IX. REQUEST FOR INFORMATION

The Mott McDonald report also suggests that the potential seasonal variations in groundwater levels are not adequately assessed in the EIS as the assessment period covers June 2005 to January 2006 (include groundwater levels and flow directions). Include comments on the impact of drought and periods of high rainfall.

Response to request

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 (2 years) 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**.

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 December 2006.

Groundwater flow maps are provided in **Appendix 6**. The direction of groundwater flow under the proposed site and local surrounding area has been established from comprehensive time series groundwater level monitoring data. Water level monitoring data sets collected from June 2005 to December 2006 have consistently demonstrated that groundwater flow below the proposed landfill site is in a south-easterly 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 cone of depression to the Bog of the Ring supply wells would be smaller during wetter years. The current cone of depression of the pumping wells delineated by TES has been during over 2 years of relatively dry weather.

Therefore the current cone of depression is considered to be relatively conservative. Under a prolonged drought scenario the cone of depression 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 cone of depression could expand by greater than 100% and still retain a 500m buffer to the landfill footprint area. This is shown in **Appendix 7**.

X. REQUEST FOR INFORMATION

The notice issued by the EPA on October 11th 2006 regarding Article 14 (2) (b) (i) of the Waste Management Licensing Regulations*, Section I.4 (ii) required a more rigorous assessment of the groundwater flows in the area of abstraction wells P1, P8 and P10.*

The data was not available to do so at the time of issue of our response, therefore an update is provided below.

Response to request

Further to our response to the first notice submitted on the 19th December 2006 in relation to Article 14, a contour map for December 2006, which includes data for Kerrigan's well, is included in **Appendix 6**. It can be seen that the overall groundwater flow direction in that area is to the south east and away from the proposed landfill site. This is consistent with the overall groundwater flow pattern for the area and any groundwater originating beneath the landfill is not likely to flow towards Kerrigan's well.

RESPONSE TO SOME THIRD PARTY SUBMISSIONS

Submission No 48, K T Cullen (Extrapolation of Transmissivity and Resource Potential of the Bedrock)

Mr Cullen is correct to point out that the test wells were drilled into the upper section of the bedrock, as this is the zone that was of most interest for the EIS. In the event of leachate escaping through the engineered mitigation measures and through the natural low permeability subsoil (minimum thickness of 10m), it is groundwater in the upper bedrock that will be potentially impacted. Therefore the upper bedrock was the target for the investigation. However, the submission is incorrect to state that only the upper zone has been assessed through the pumping tests because deeper monitoring wells, (installed 25-35m depth in the bedrock) in addition to shallow bedrock wells were monitored and analysed during the pumping test to calculate transmissivity of the bedrock. Transmissivity is calculated from measured water level changes in observation wells located at distance from the pumping wells. The pumping test response in the deeper wells at each pumping test location in the bedrock displayed a similar response to that of the shallow wells, indicating that the transmissivity calculations are representative of a larger vertical section (at least 35m thickness) of the aquifer than the test well screen length as Mr Cullen suggests. This is clearly illustrated in the table below:

Test Well	Monitoring Well	Response Zone (metres depth within bedrock)	Transmissivity (m^2/d)
PW1	ER3	0 - 10.4	14.4
	SHR1	17 - 29	14.1
PW2	ER7	0.5 - 10.5	69.9
	SHR2	26 - 35	65.9
PW3	ER12	0.5 - 10	32.8
	SHR5	24.9 - 34.5	37.6

Whereas it is accepted that **if** the objective of the investigation was to provide groundwater resource wells, deeper test wells would be required in order to sustain larger drawdown during sustained pumping (as at the Bog of the Ring), these were not required to assess the aquifer characteristics for the purposes of the proposed landfill as a widespread response to the pumping tests was achieved because the aquifer is confined.

Submission No 63, White Young Green (WYG)

Item 3 – Source Protection Zones of private wells downgradient of the proposed landfill

Moore's Well

WYG have not taken into account the measured direction of groundwater flow in their delineation of the source protection zone (SPZ) for Moores well. The failure to take accurate reflection of the groundwater flow mapping has resulted in the SPZ being incorrectly placed beneath the landfill. The regional groundwater flow in the vicinity of Moores Well is from the northeast, not from beneath the proposed landfill.

Kerrigan's Well

The abstraction rate quoted for Mr. Kerrigans well is over estimated by WYG, therefore the zone of contribution is also over estimated and should be based on actual abstraction rates. The WYG figure of 1,962 m^3/day is based on a drillers yield estimate. In reality, during winter, the abstraction rate is low and is reported to be 6.5m^3/day (for vegetable washing) (T. Kerrigan pers comm.). During summer the maximum abstraction rate is 612 m^3/day (for irrigation) (T. Kerrigan pers comm.), less than a third the rate quoted by WYG. The regional groundwater flow in the vicinity of Kerrigans well is from the northwest, not from beneath the proposed landfill footprint.

APPENDIX 1

GSI CORRESPONDENCE

Siobhan White

From: Eibhlin Doyle [Eibhlin.Doyle@gsi.ie]
Sent: 18 October 2006 16:30
To: White Siobhan (E-mail)
Subject: Proposed landfill at Tooman/Nevitt ref 06FEL2051

Dear Ms. White,

The GSI has recently had contact with various parties to the hearing on the Proposed Landfill at Tooman/Nevitt, North County Dublin (Board Ref. 06FEL2051) in relation to the GSI aquifer classification scheme.

The aquifer classification is a robust National scheme that is based on considerable experience, knowledge, and assessment of many data nationally according to a clear set of criteria.

We wish to confirm the aquifer classification of the Upper Impure Limestone in the North Co. Dublin area as Lm. The GSI does not envisage re-evaluating the aquifer classification at this time, as this would require a significant body of new data of suitable quality. The GSI has not received such data at this time.

Any re-assessment, based on new data of suitable quality, of existing aquifer classifications may or may not lead to changes in the classifications already indicated by the GSI.

Information on the GSI's aquifer classification methodology is available on the GSI's website at <http://www.gsi.ie/workgsi/groundwater/gwintro.htm>.

The GSI is at the disposal of the hearing should it wish to hear from us in more detail concerning the aquifer classification scheme in general, or the particular classification in the region of the proposed development.

Yours sincerely,

Dr. Eibhlín Doyle

Principal Geologist

Geological Survey of Ireland

Dr. Eibhlín Doyle PGeo
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Geological Survey of Ireland,
Beggars' Bush,
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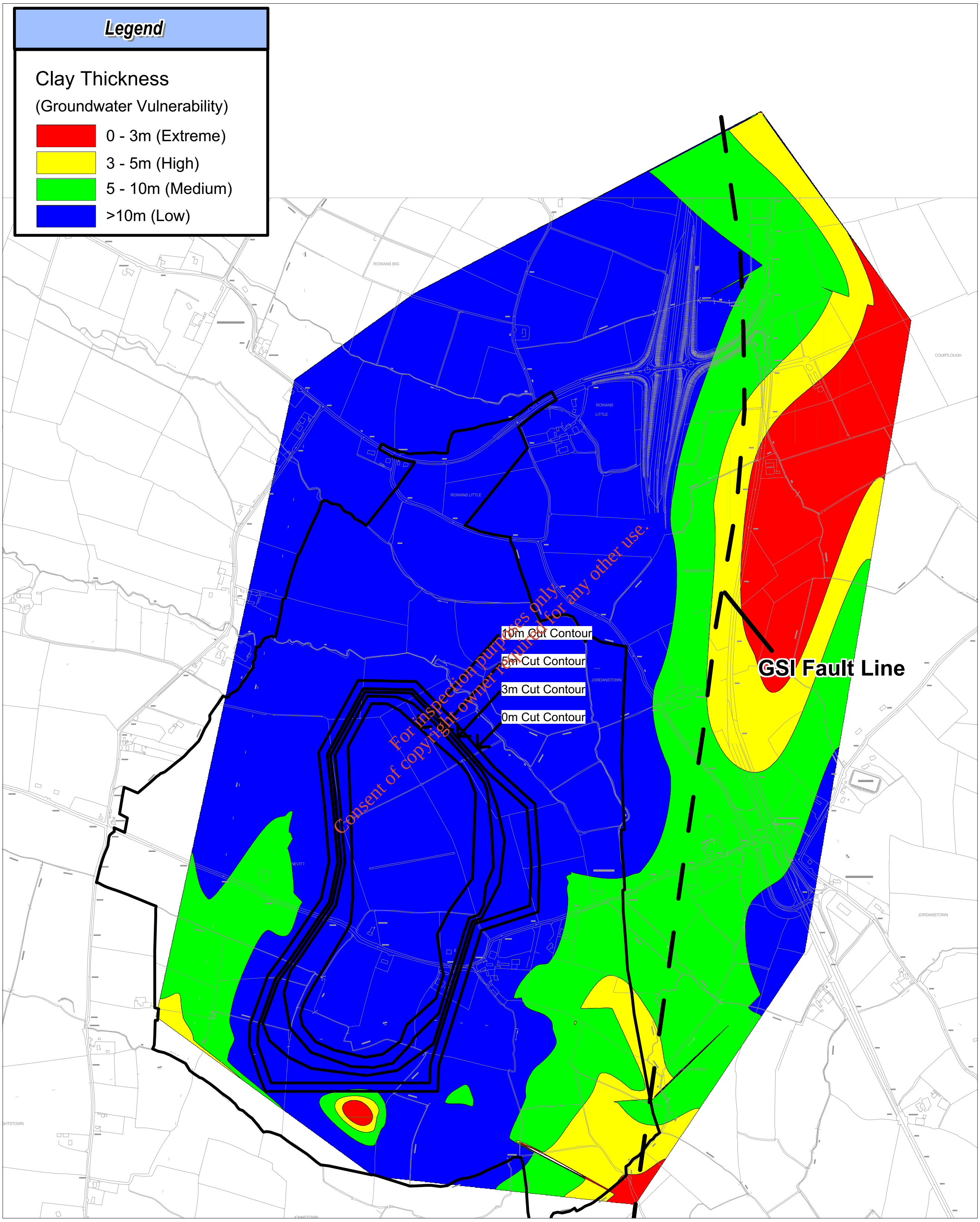
Dublin 4,

18/10/2006

APPENDIX 2

GROUNDWATER VULNERABILITY MAP & CLAY THICKNESS



Note: Based on Gound Investigation Exploratory Boreholes ONLY.

Project	Fingal Landfill Project	Appendix 2
Title	Groundwater Vulnerability & Clay Thickness	

Fingal County Council
Comhairle Contae Fhine Gall

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E: ireland@rpsgroup.com
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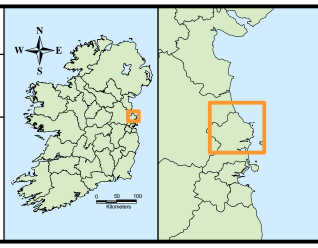

Ordnance Survey Ireland

Issue Details			
Drawn: DF		Project No. MDR0303	
Checked: WO		File Ref.	
Approved: FC		MDR0303MI0005A01	
Scale: 1:15,000 @ A4		Drawing No.	Rev.
Date: 13.12.2006		MI0005	A01

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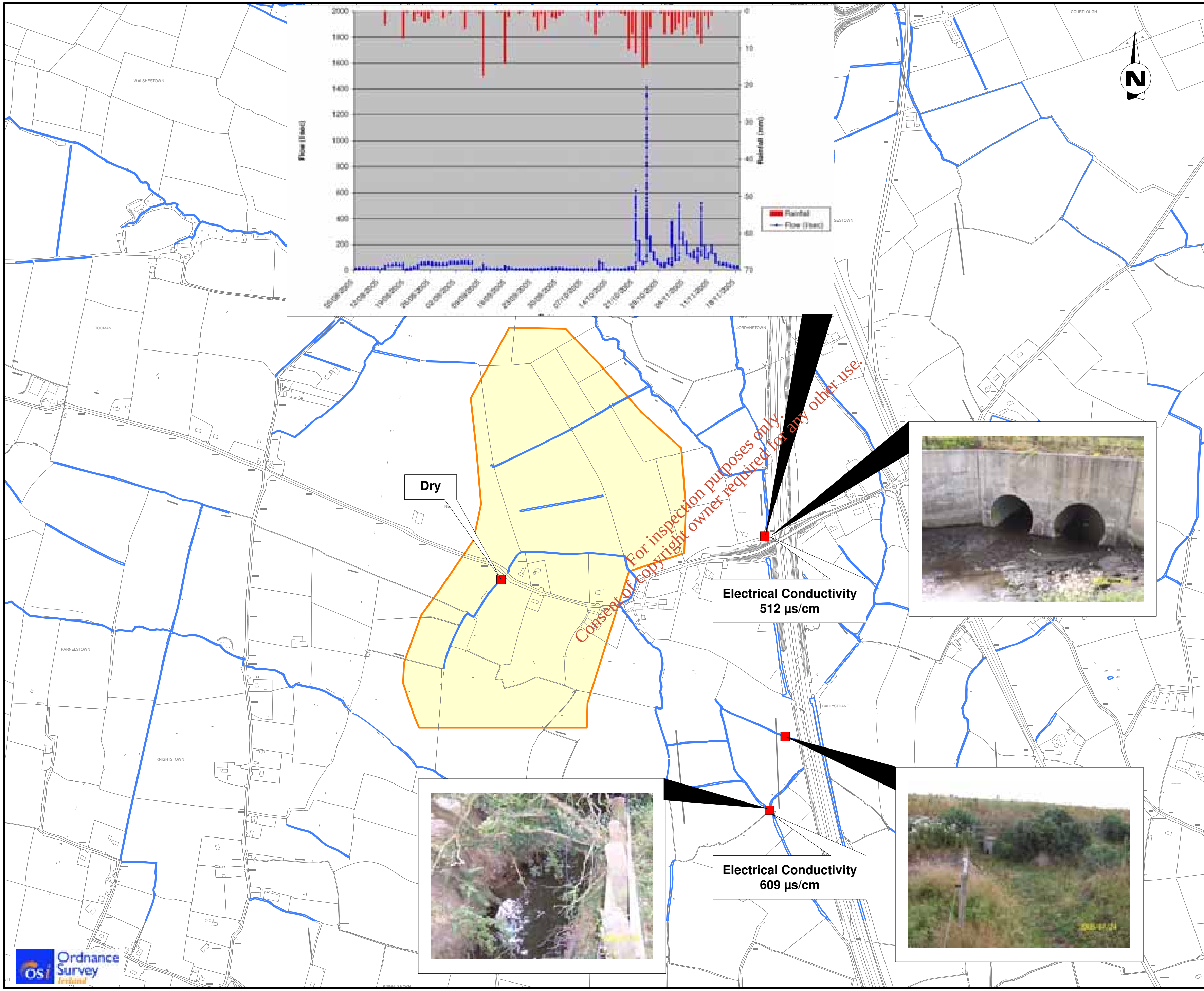
APPENDIX 3

DRY FLOW OBSERVATIONS



Legend

- Photos Location
- Proposed Landfill Footprint

Fingal County Council

Project

Fingal Landfill

Surface Observations (July 2006)

Figure: C.1

RPS Consulting Engineers

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Issue Details

Drawn:	S. Khan	Project No.	MDR0303
Checked:	S.Herlihy	File Ref.	MDR0303MI0228A01
Approved:	S.Herlihy		
Scale:	1:25000 at A3	Drawing No. MI0228	Rev. A01
Date:	16/01/2007		

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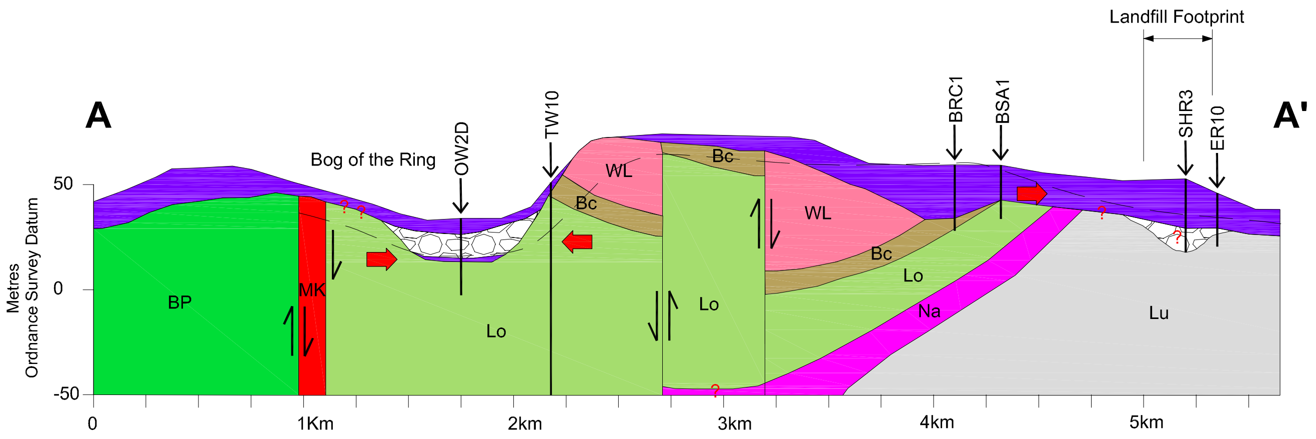
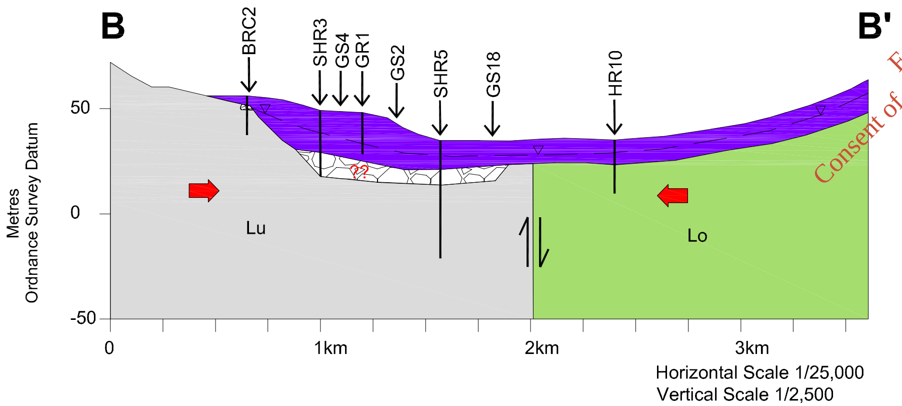
APPENDIX 4

GEOLOGICAL CROSS SECTION A-A' AND B-B'



GEOLOGICAL CROSS SECTION A-A'



GEOLOGICAL CROSS SECTION B-B'

LEGEND

Bedrock Formations

- WL – Walshestown
- Bc – Balrickard
- Lo – Loughshinny
- Na – Naul
- Lu – Lucan
- MK – Mudbank Limestone
- BP – Belcamp

Subsoils

- Clay
- Gravel
- Fault Throw
- Direction of Groundwater Flow
- Groundwater Table/ Piezometric Surface (Bedrock)

NOTES

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2. All Levels refer to Ordnance Survey Datum, Malin Head.
3. DO NOT SCALE, use figured dimensions only, if in doubt ask.
4. Source GSI (1999) Geology of Meath Sheet 13.

No.	Date	Drn./Chk.	Amendment / Issue	App.
A03	Oct '06	BH/YC	Issue For Approval	YC
A02	Oct '06	BH/YC	Issue For Approval	YC
A01	Oct '06	BH/NM	Issue For Approval	SH

Client: Fingal County Council

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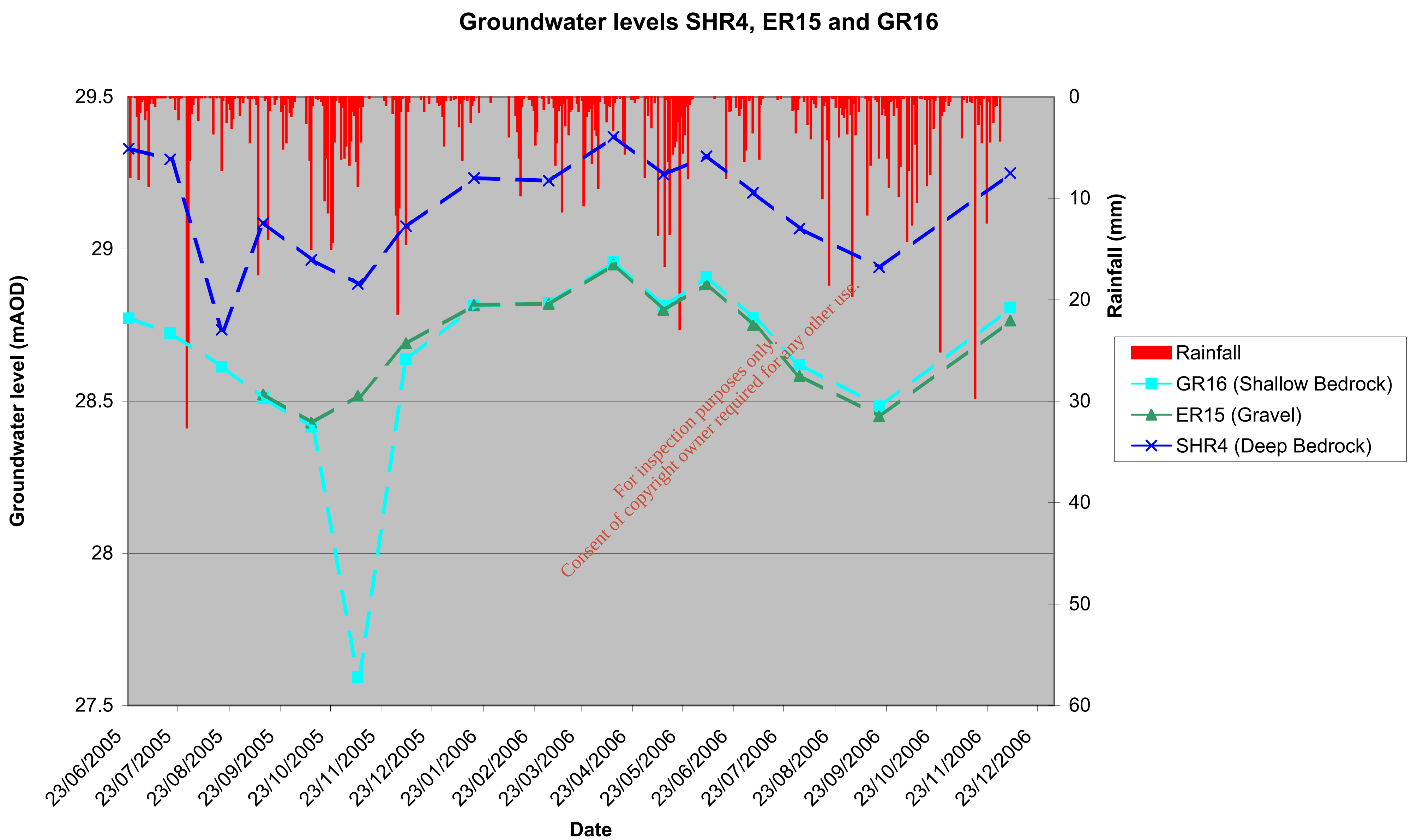
Project: FINGAL LANDFILL PROJECT

Title: GEOLOGICAL CROSS SECTIONS A-A' & B-B'

Drawn by:	PH	Job No:	MDR0303
Checked by:	FC	File No:	MDR0303SK0002A03
Approved by:	SH	Fig. No:	Appendix D 1.2
Scale:	1:25,000 @ A3		
Date:	April 2006		

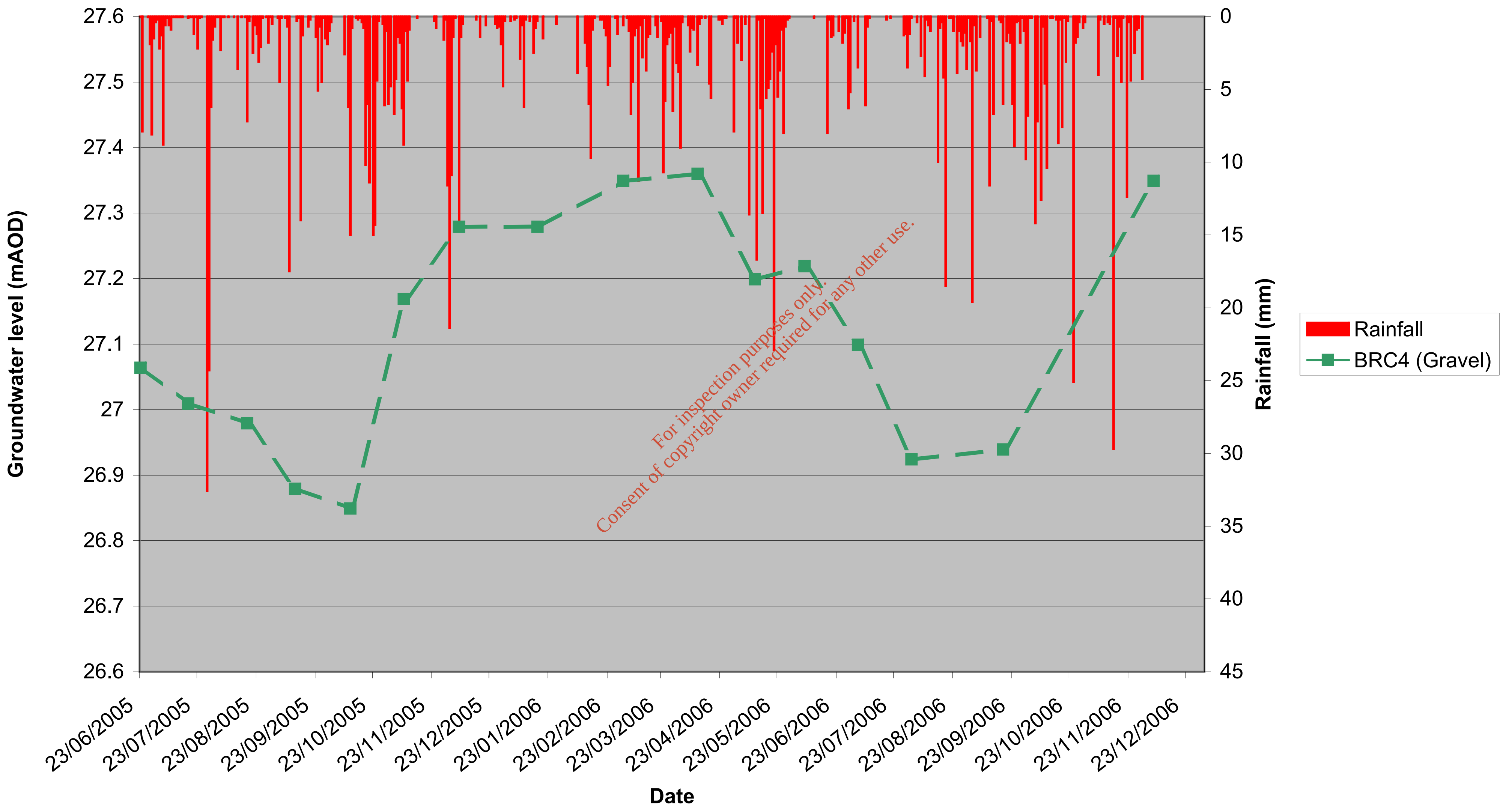
APPENDIX 5

MANUAL AND AUTOMATED WATER LEVEL DATA

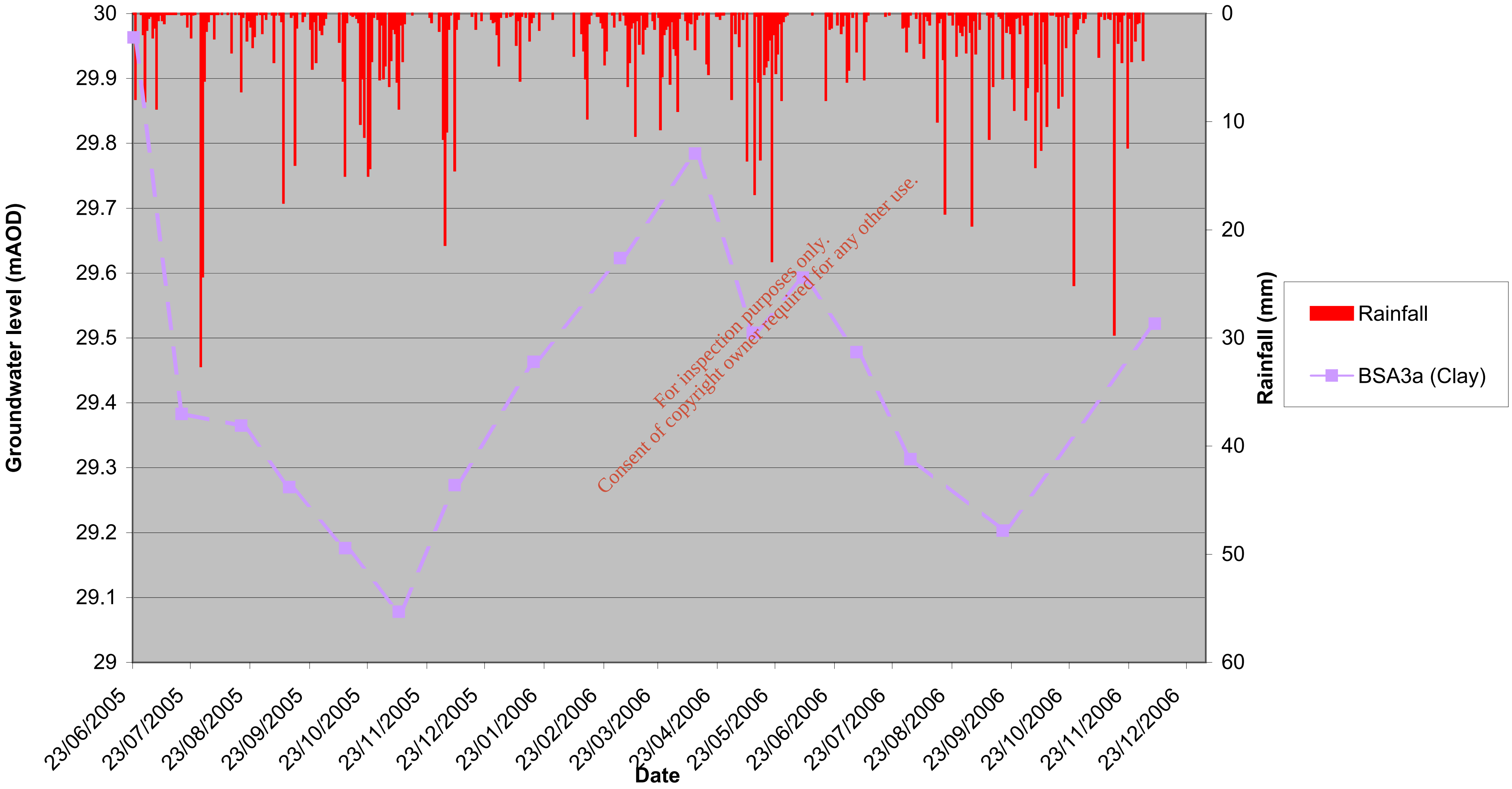


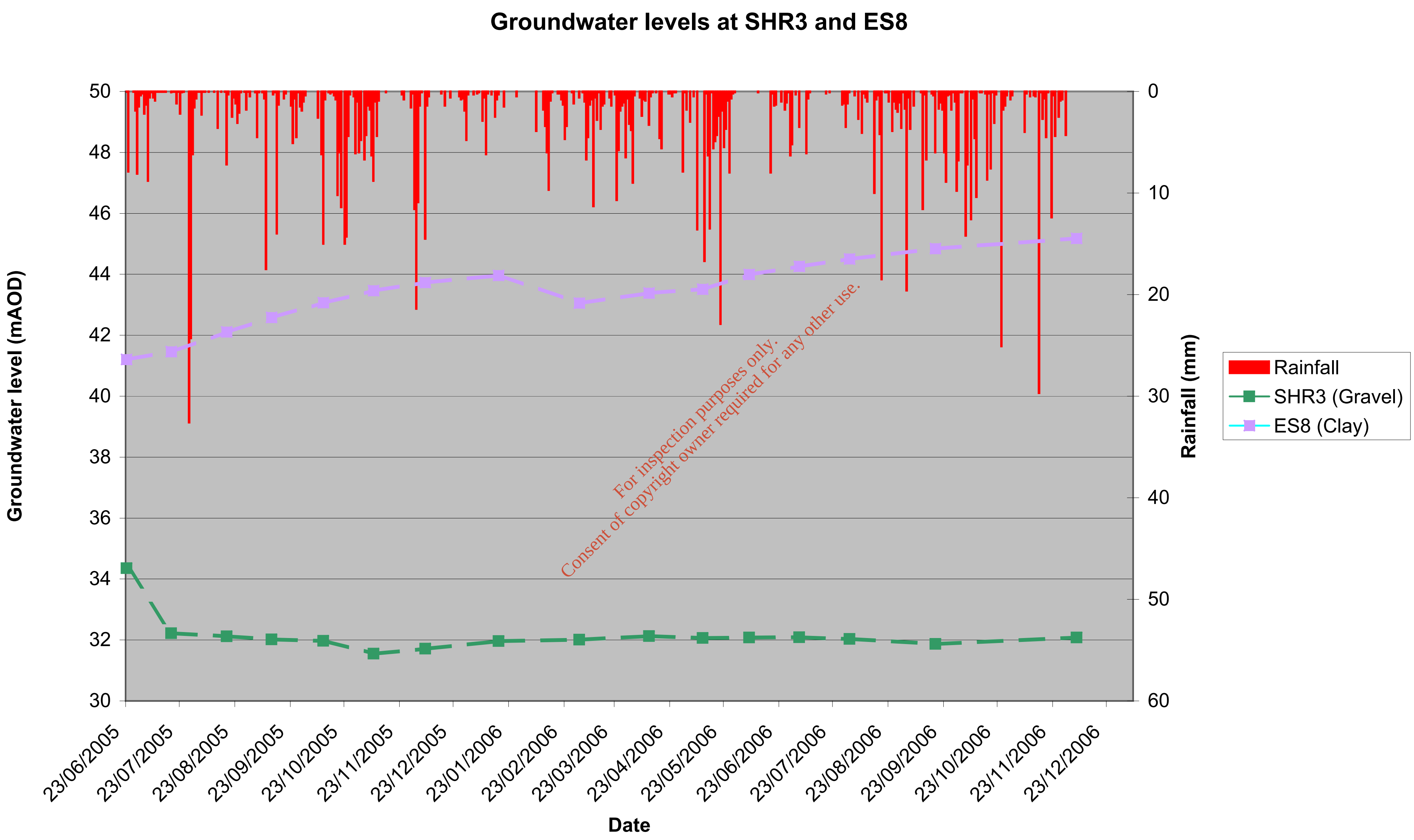
Groundwater levels SHR4, ER15 and GR16
Groundwater level (mAOD)
29.5
29
28.5
28
27.5
Rainfall (mm)
0
10
20
30
40
50
60
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
23/06/2006
23/07/2006
23/08/2006
23/09/2006
23/10/2006
23/11/2006
23/12/2006
Date
Rainfall
GR16 (Shallow Bedrock)
ER15 (Gravel)
SHR4 (Deep Bedrock)

Groundwater level (BRC4)

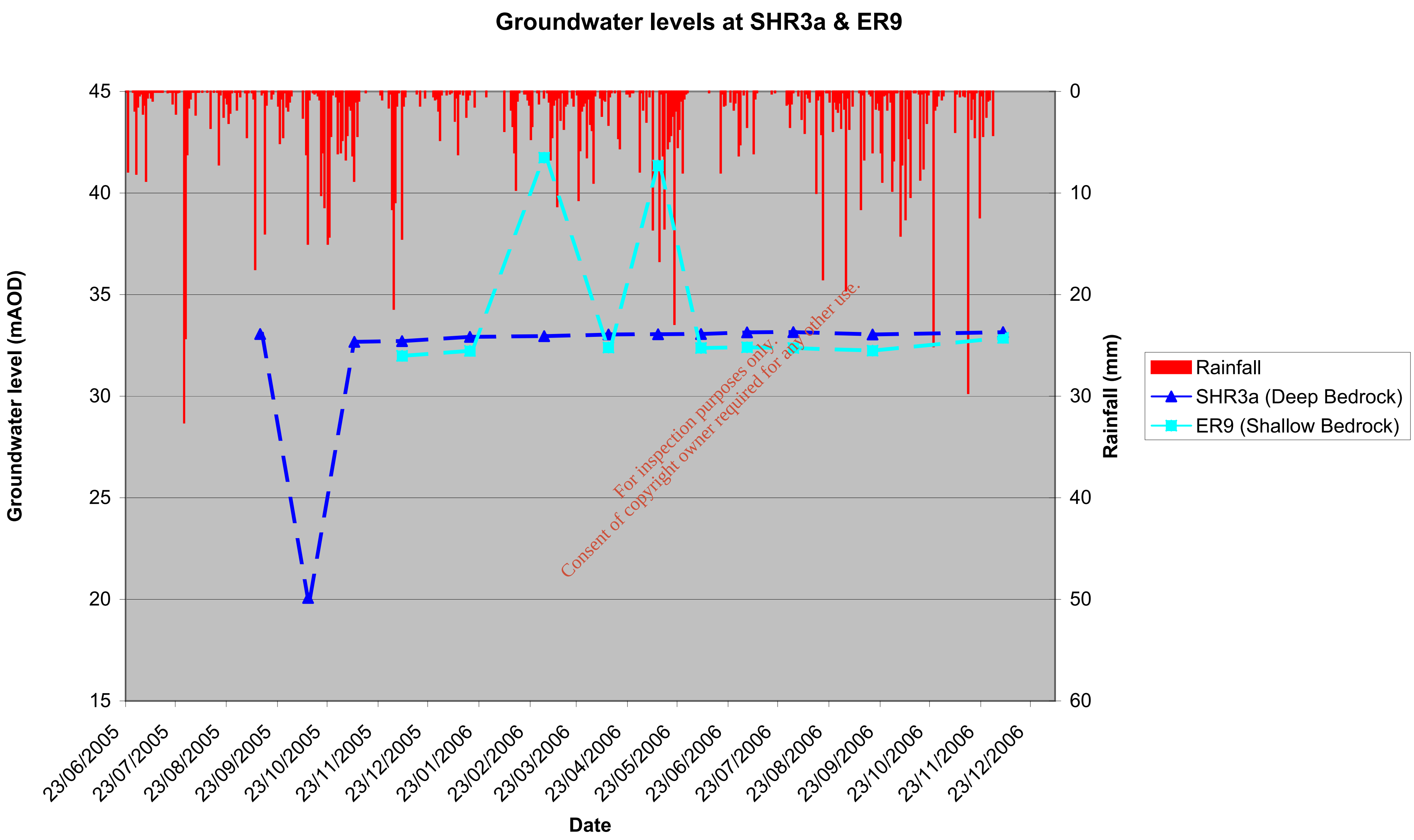


Groundwater levels BSA3a





Groundwater levels at SHR3 and ES8
Groundwater level (mAOD)
Rainfall (mm)
Date
50
48
46
44
42
40
38
36
34
32
30
0
10
20
30
40
50
60
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
23/06/2006
23/07/2006
23/08/2006
23/09/2006
23/10/2006
23/11/2006
23/12/2006
Rainfall
SHR3 (Gravel)
ES8 (Clay)



Groundwater levels at SHR3a & ER9
Groundwater level (mAOD)
45
40
35
30
25
20
15
Rainfall (mm)
0
10
20
30
40
50
60
Rainfall
SHR3a (Deep Bedrock)
ER9 (Shallow Bedrock)
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
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23/07/2006
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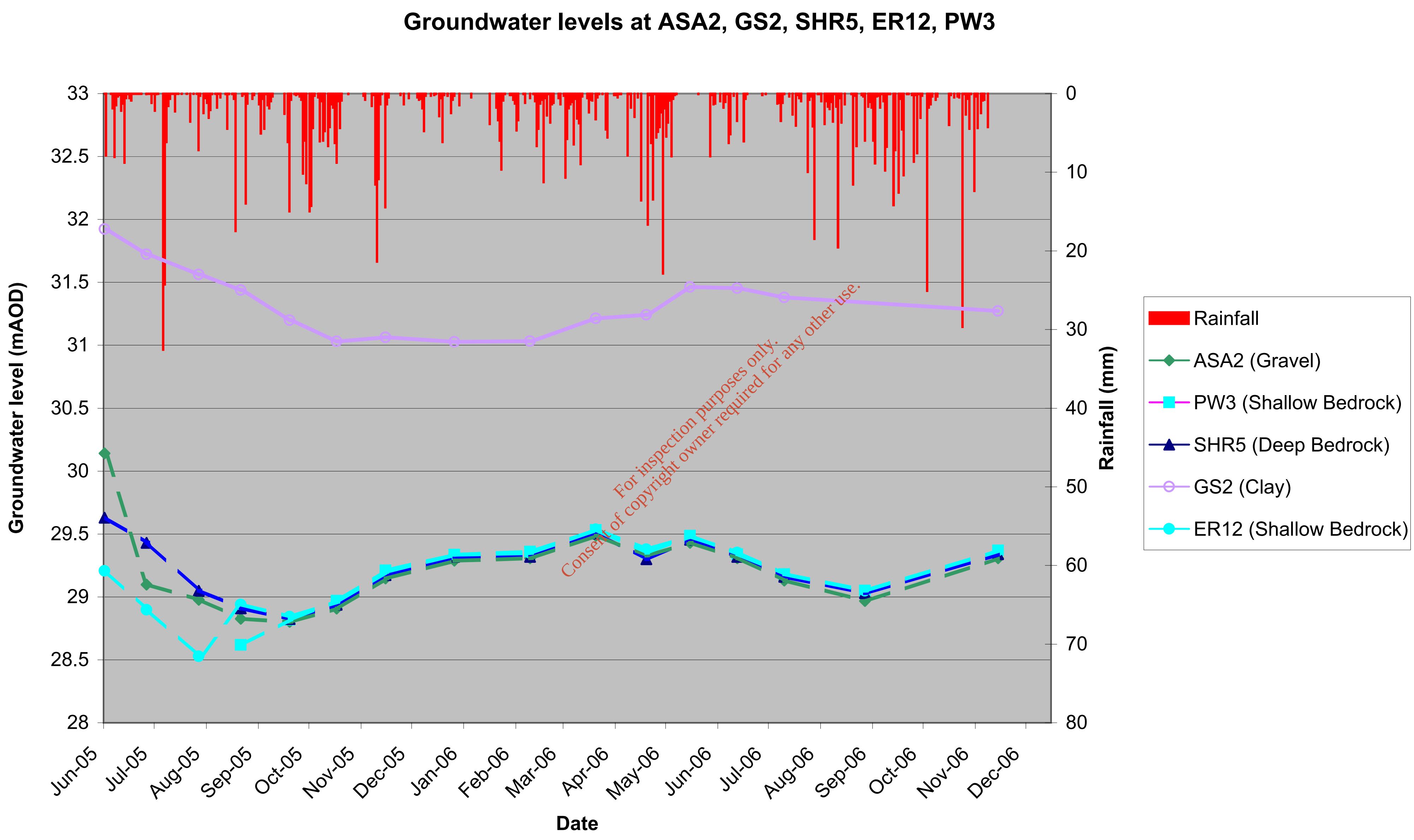
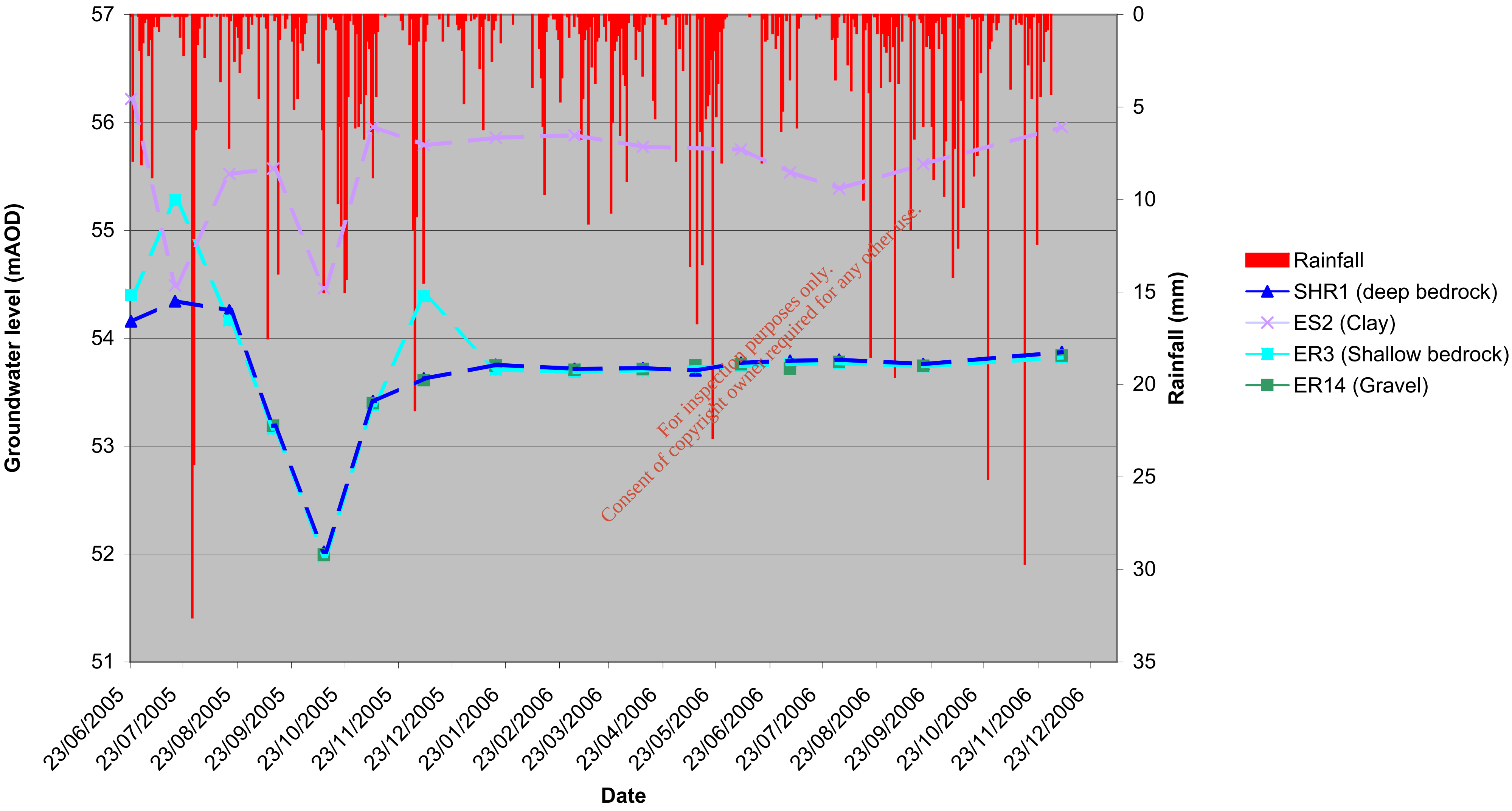
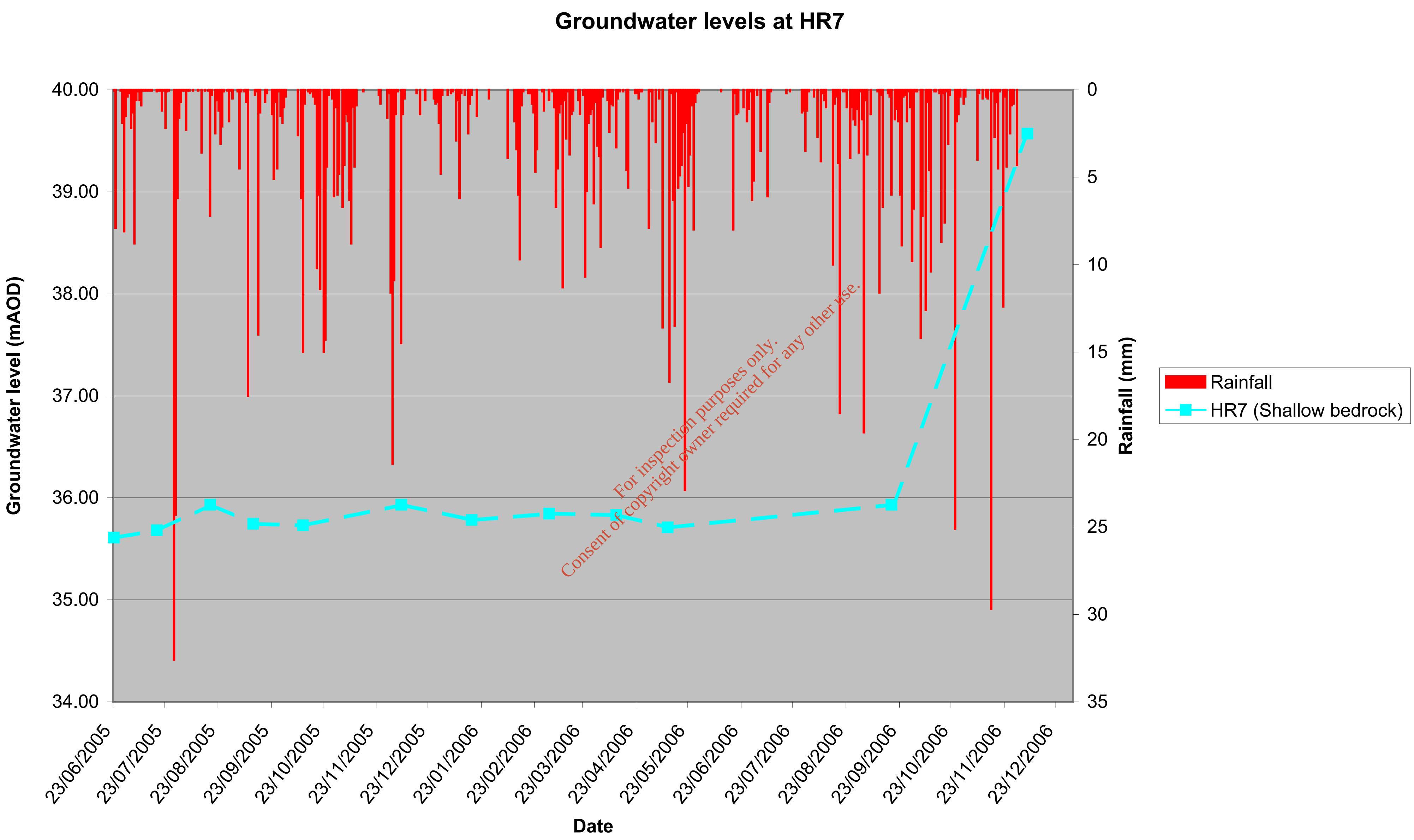
23/10/2006
23/11/2006
23/12/2006
Date



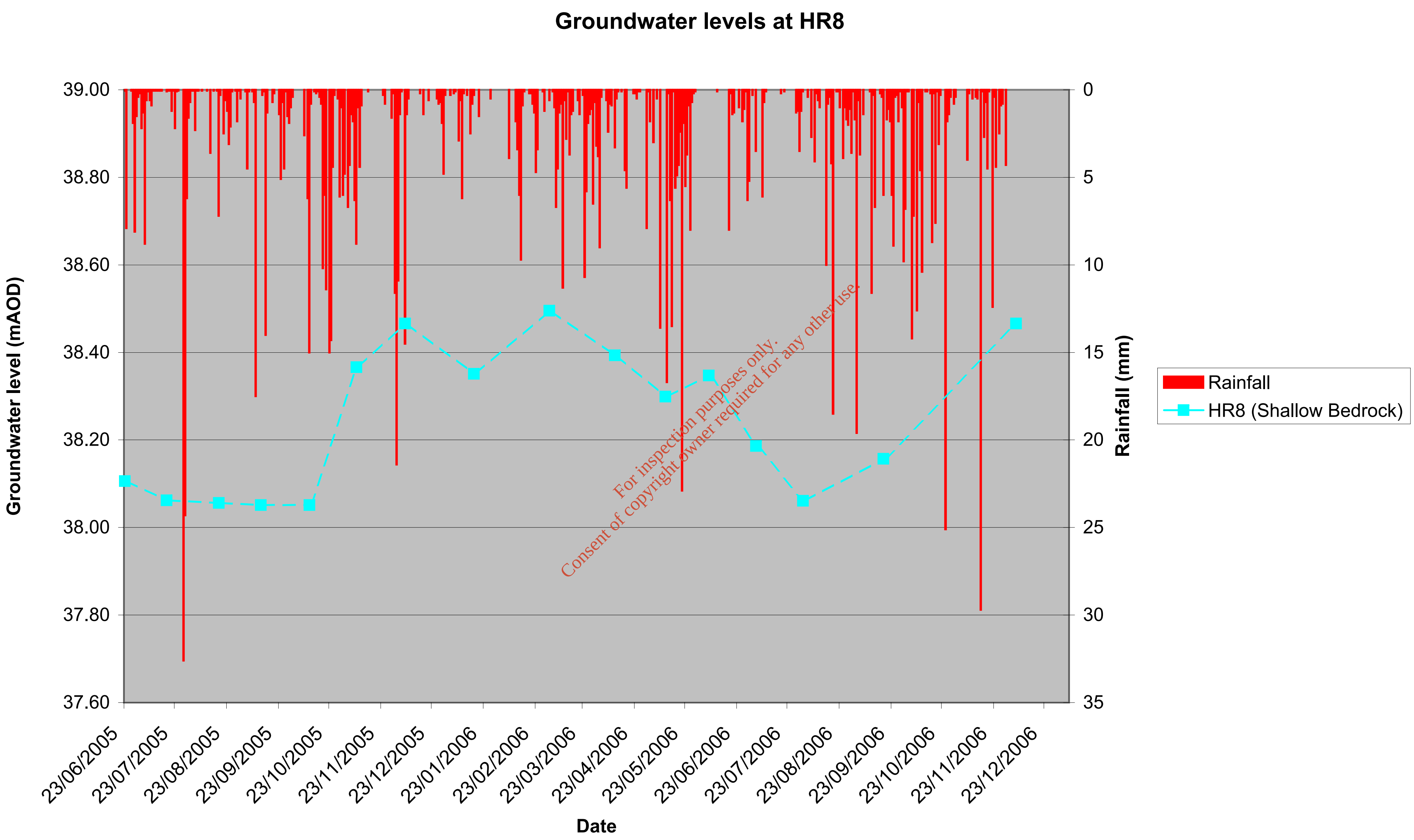
Groundwater levels at ASA2, GS2, SHR5, ER12, PW3
Groundwater level (mAOD)
33
32.5
32
31.5
31
30.5
30
29.5
29
28.5
28
Rainfall (mm)
0
10
20
30
40
50
60
70
80
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Date
Rainfall
ASA2 (Gravel)
PW3 (Shallow Bedrock)
SHR5 (Deep Bedrock)
GS2 (Clay)
ER12 (Shallow Bedrock)

Groundwater levels at ER14, SHR1, ES2 and ER3

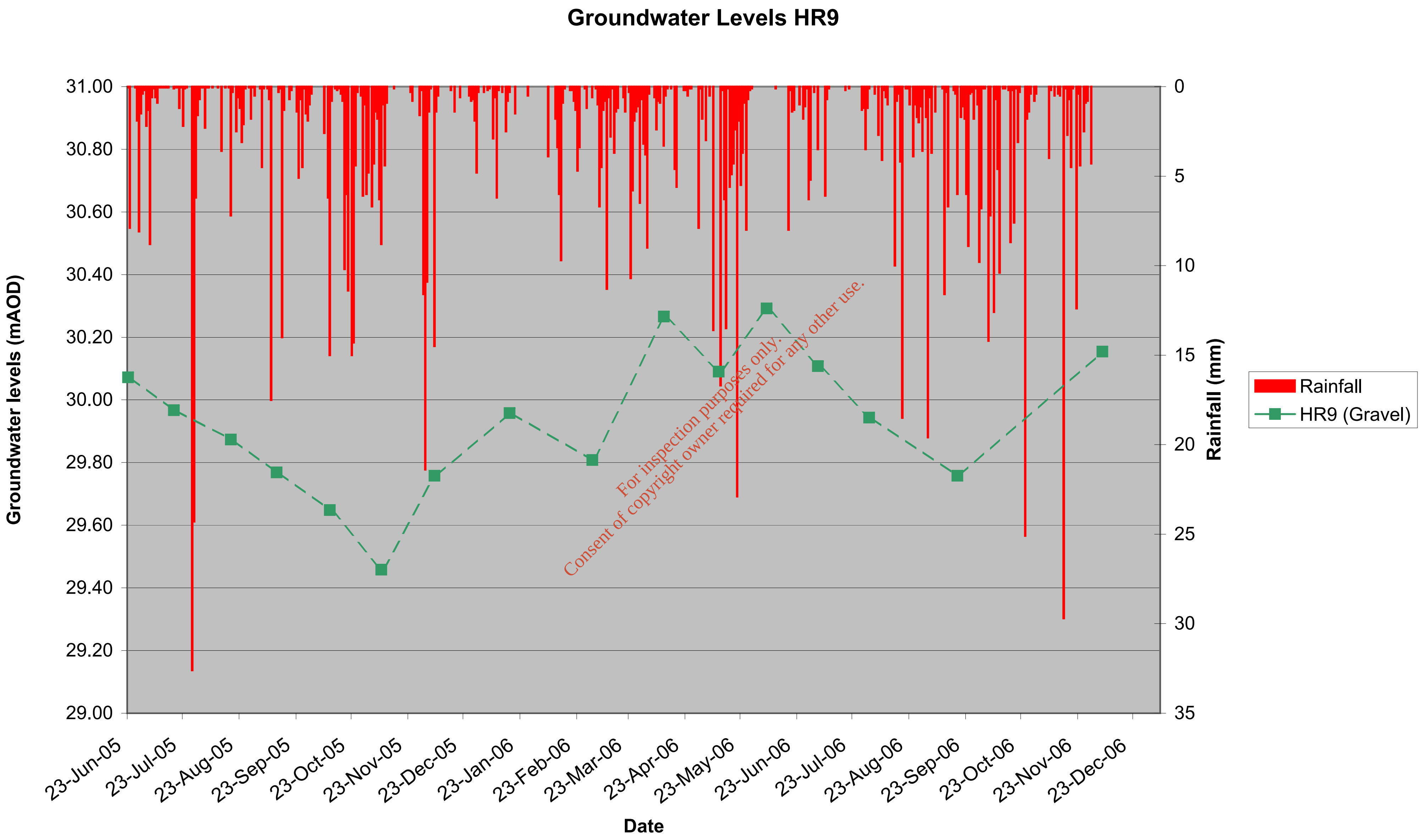




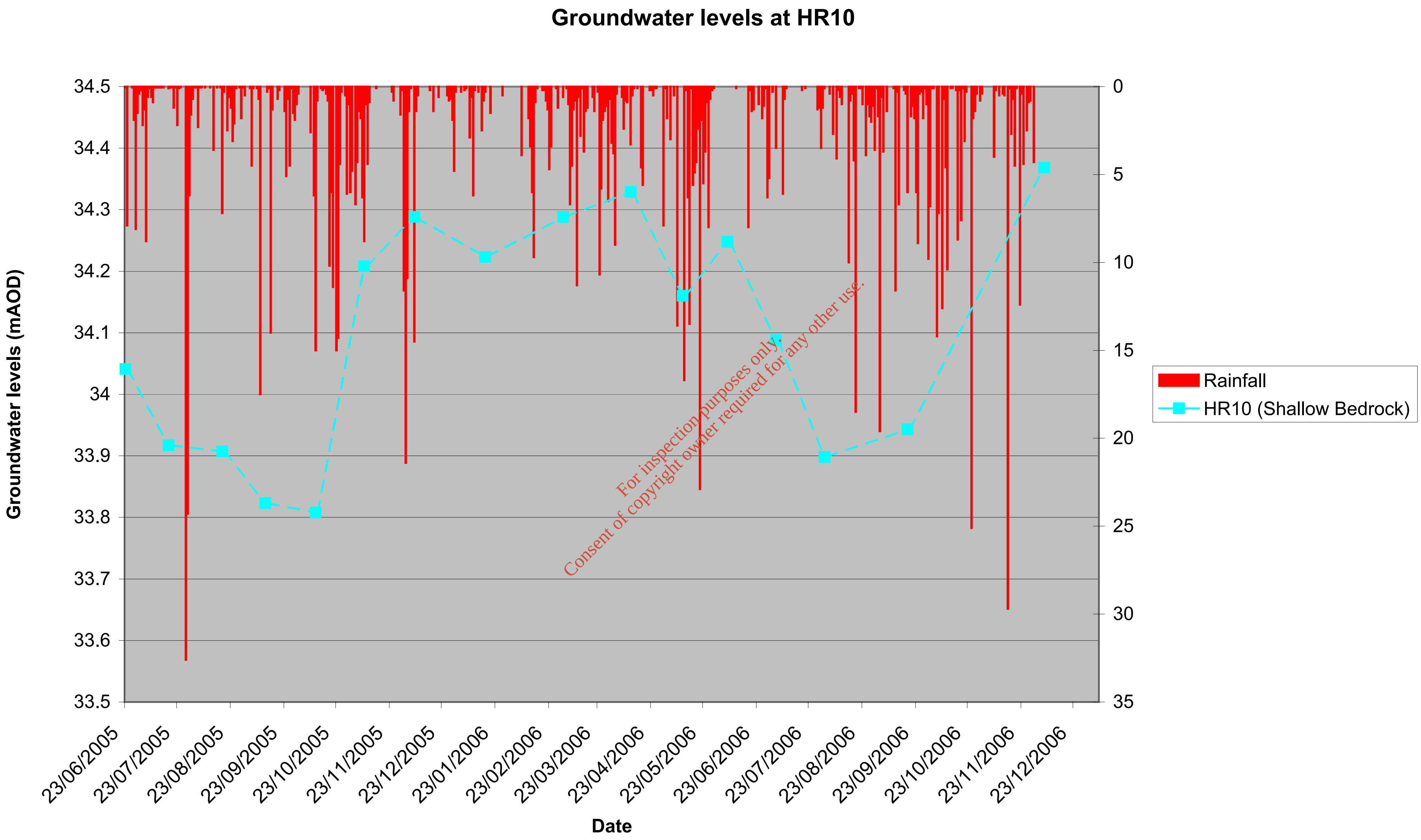
Groundwater levels at HR7
Groundwater level (mAOD)
40.00
39.00
38.00
37.00
36.00
35.00
34.00
Rainfall (mm)
0
5
10
15
20
25
30
35
Date
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
23/06/2006
23/07/2006
23/08/2006
23/09/2006
23/10/2006
23/11/2006
23/12/2006
Rainfall
HR7 (Shallow bedrock)



Groundwater levels at HR8
Groundwater level (mAOD)
39.00
38.80
38.60
38.40
38.20
38.00
37.80
37.60
Rainfall (mm)
0
5
10
15
20
25
30
35
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
23/06/2006
23/07/2006
23/08/2006
23/09/2006
23/10/2006
23/11/2006
23/12/2006
Date
Rainfall
HR8 (Shallow Bedrock)



Groundwater Levels HR9
Groundwater levels (mAOD)
31.00
30.80
30.60
30.40
30.20
30.00
29.80
29.60
29.40
29.20
29.00
Rainfall (mm)
0
5
10
15
20
25
30
35
23-Jun-05
23-Jul-05
23-Aug-05
23-Sep-05
23-Oct-05
23-Nov-05
23-Dec-05
23-Jan-06
23-Feb-06
23-Mar-06
23-Apr-06
23-May-06
23-Jun-06
23-Jul-06
23-Aug-06
23-Sep-06
23-Oct-06
23-Nov-06
23-Dec-06
Date
Rainfall
HR9 (Gravel)


Groundwater levels at HR10
Groundwater levels (mAOD)
34.5
34.4
34.3
34.2
34.1
34
33.9
33.8
33.7
33.6
33.5
0
5
10
15
20
25
30
35
23/06/2005
23/07/2005
23/08/2005
23/09/2005
23/10/2005
23/11/2005
23/12/2005
23/01/2006
23/02/2006
23/03/2006
23/04/2006
23/05/2006
23/06/2006
23/07/2006
23/08/2006
23/09/2006
23/10/2006
23/11/2006
23/12/2006
Date
Rainfall
HR10 (Shallow Bedrock)
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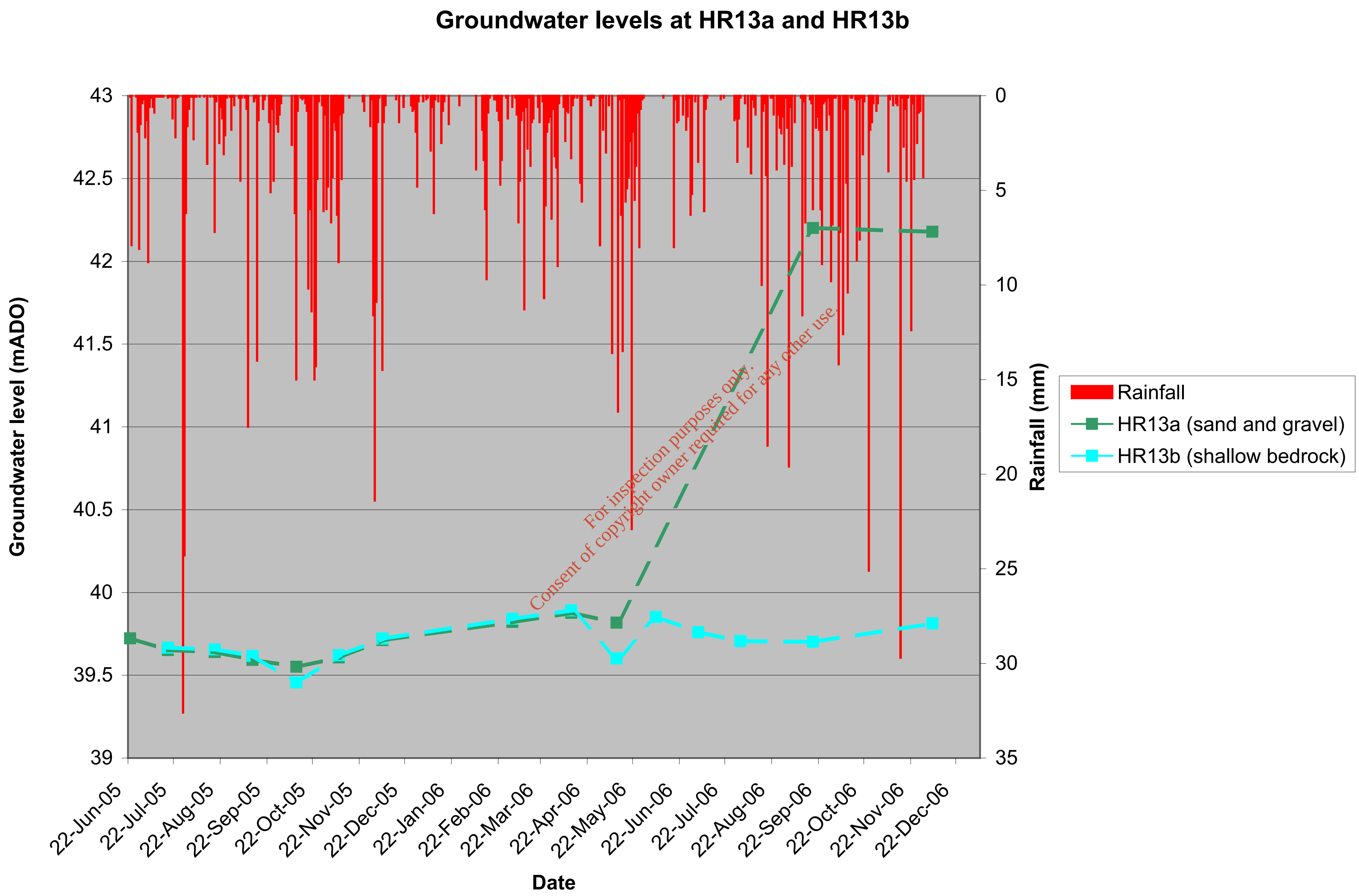
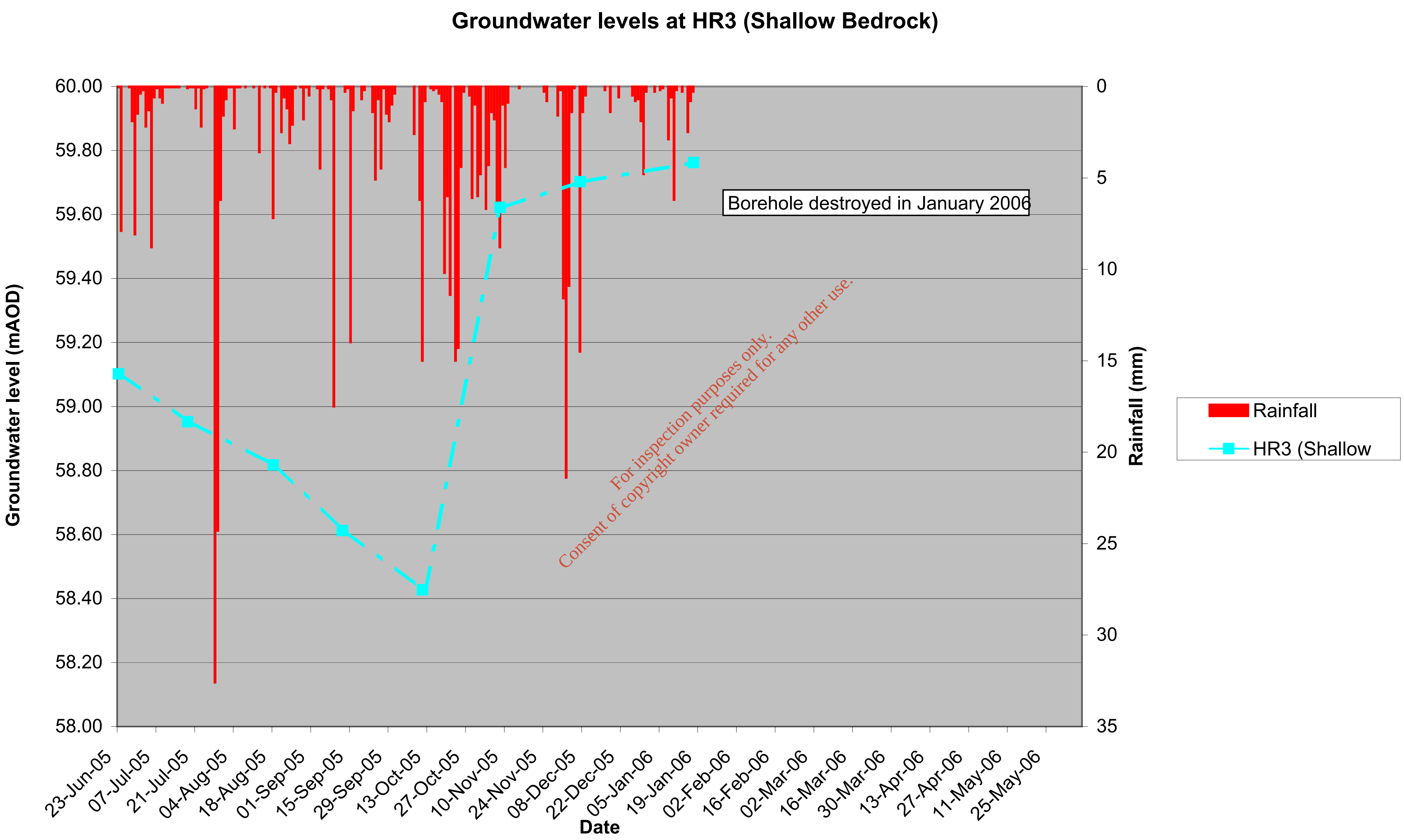
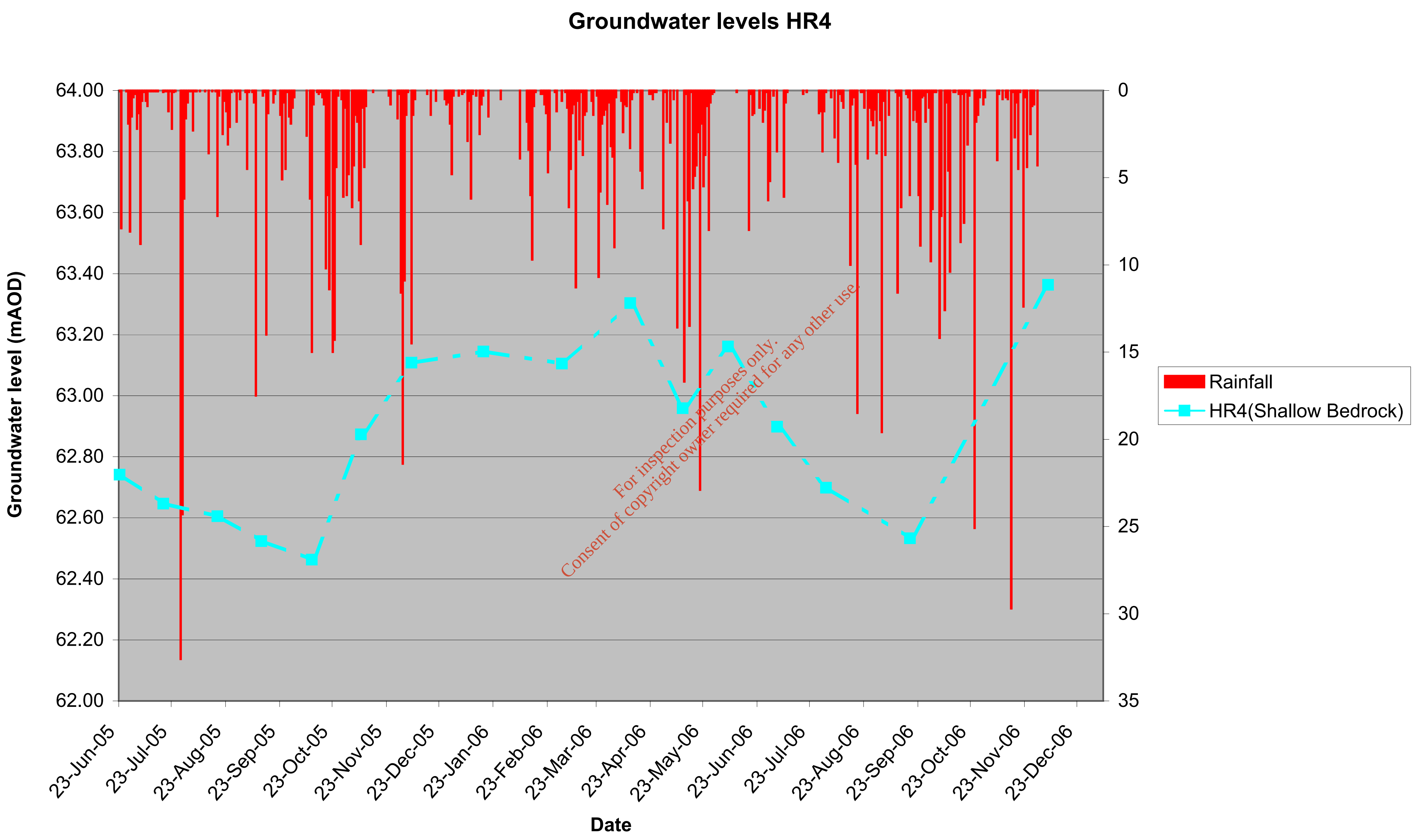
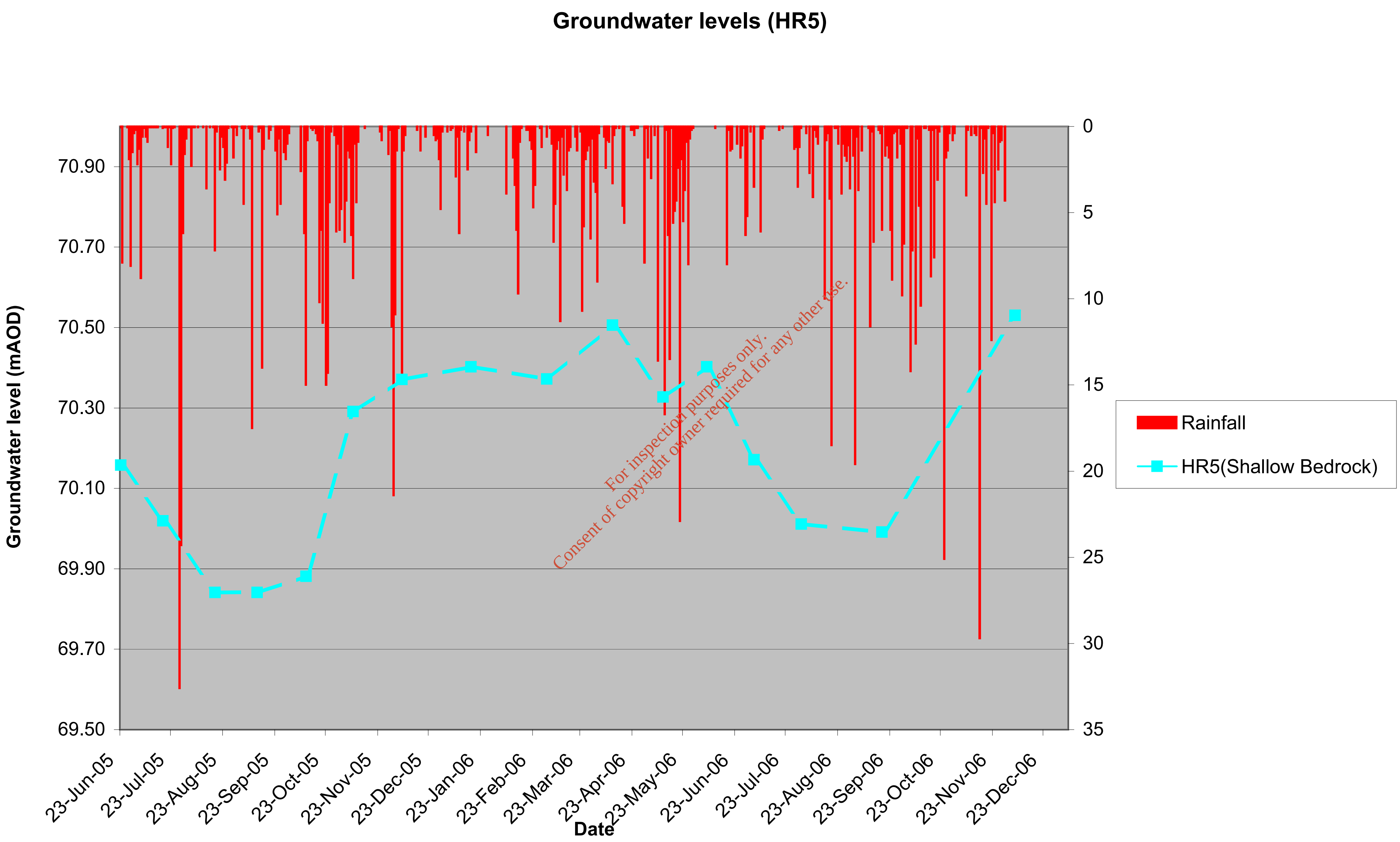


Groundwater levels at HR13a and HR13b
Groundwater level (mADO)
Rainfall (mm)
Date
43
42.5
42
41.5
41
40.5
40
39.5
39
0
5
10
15
20
25
30
35
22-Jun-05
22-Jul-05
22-Aug-05
22-Sep-05
22-Oct-05
22-Nov-05
22-Dec-05
22-Jan-06
22-Feb-06
22-Mar-06
22-Apr-06
22-May-06
22-Jun-06
22-Jul-06
22-Aug-06
22-Sep-06
22-Oct-06
22-Nov-06
22-Dec-06
Rainfall
HR13a (sand and gravel)
HR13b (shallow bedrock)


Groundwater levels at HR3 (Shallow Bedrock)
Groundwater level (mAOD)
60.00
59.80
59.60
59.40
59.20
59.00
58.80
58.60
58.40
58.20
58.00
Rainfall (mm)
0
5
10
15
20
25
30
35
Borehole destroyed in January 2006
Rainfall
HR3 (Shallow
23-Jun-05
07-Jul-05
21-Jul-05
04-Aug-05
18-Aug-05
01-Sep-05
15-Sep-05
29-Sep-05
13-Oct-05
27-Oct-05
10-Nov-05
24-Nov-05
08-Dec-05
22-Dec-05
05-Jan-06
19-Jan-06
02-Feb-06
16-Feb-06
02-Mar-06
16-Mar-06
30-Mar-06
13-Apr-06
27-Apr-06
11-May-06
25-May-06
Date



Groundwater levels HR4
Groundwater level (mAOD)
64.00
63.80
63.60
63.40
63.20
63.00
62.80
62.60
62.40
62.20
62.00
0
5
10
15
20
25
30
35
23-Jun-05
23-Jul-05
23-Aug-05
23-Sep-05
23-Oct-05
23-Nov-05
23-Dec-05
23-Jan-06
23-Feb-06
23-Mar-06
23-Apr-06
23-May-06
23-Jun-06
23-Jul-06
23-Aug-06
23-Sep-06
23-Oct-06
23-Nov-06
23-Dec-06
Date
Rainfall
HR4(Shallow Bedrock)



Groundwater levels (HR5)
Groundwater level (mAOD)
70.90
70.70
70.50
70.30
70.10
69.90
69.70
69.50
0
5
10
15
20
25
30
35
23-Jun-05
23-Jul-05
23-Aug-05
23-Sep-05
23-Oct-05
23-Nov-05
23-Dec-05
23-Jan-06
23-Feb-06
23-Mar-06
23-Apr-06
23-May-06
23-Jun-06
23-Jul-06
23-Aug-06
23-Sep-06
23-Oct-06
23-Nov-06
23-Dec-06
Date
Rainfall
HR5(Shallow Bedrock)
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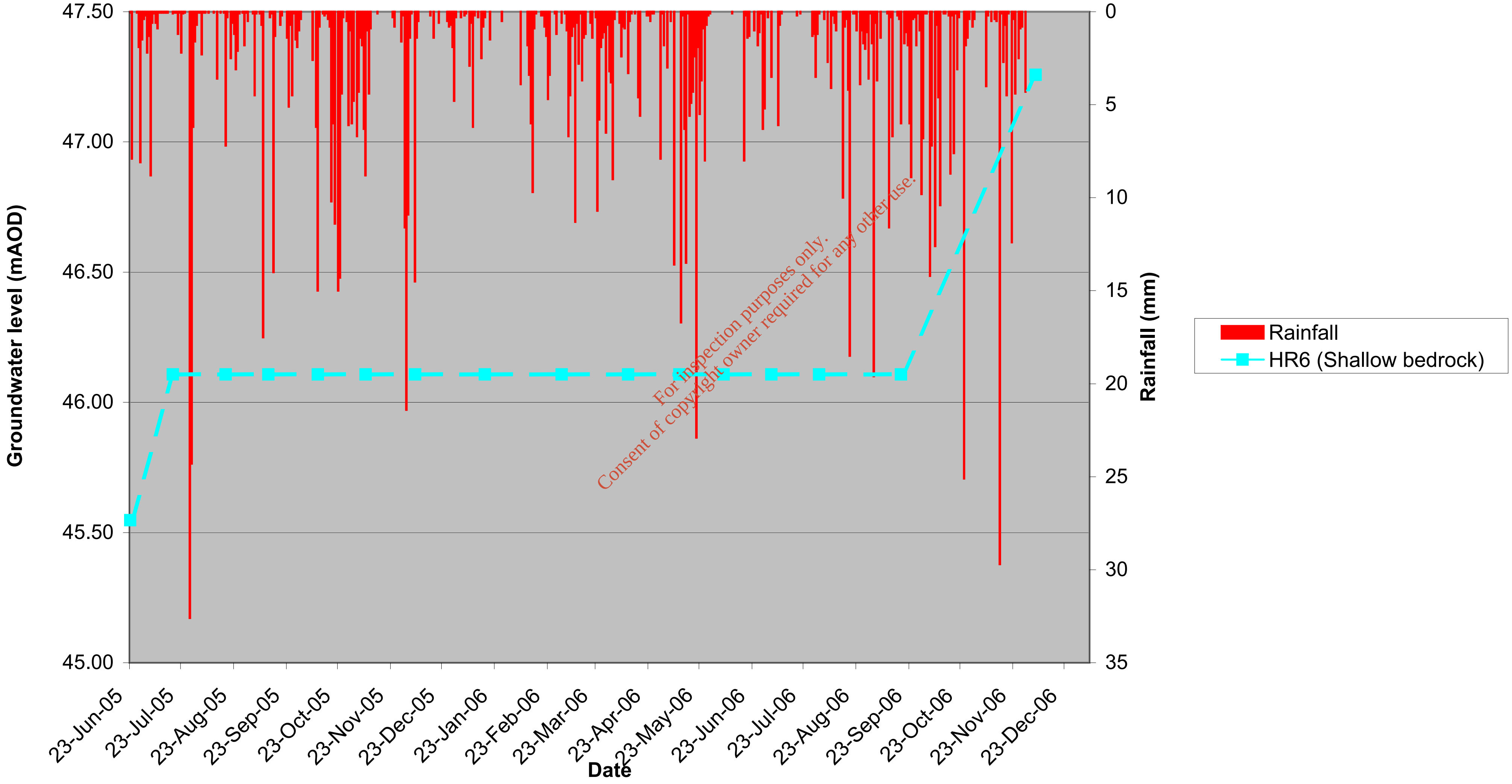
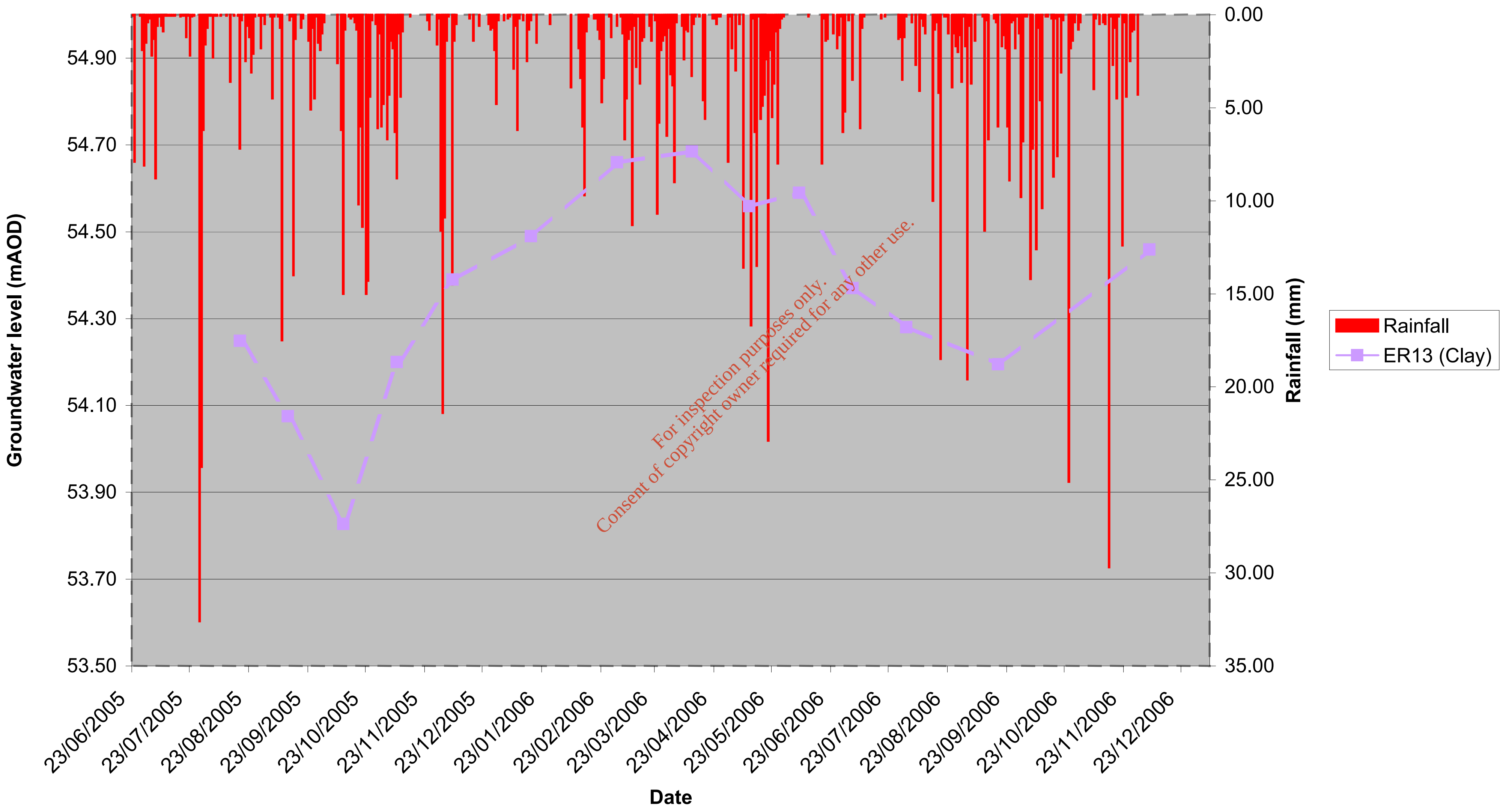
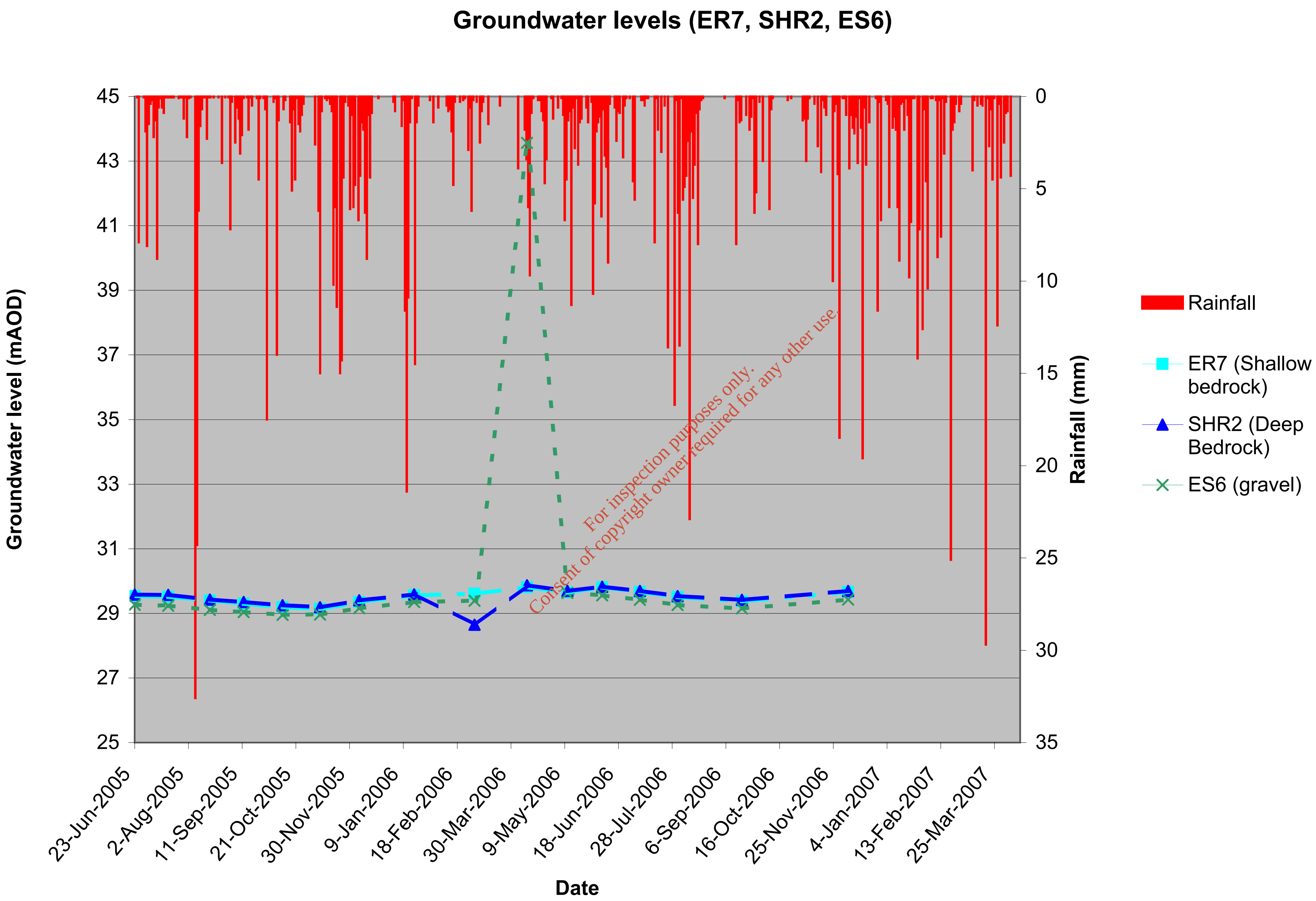
Groundwater levels at HR6

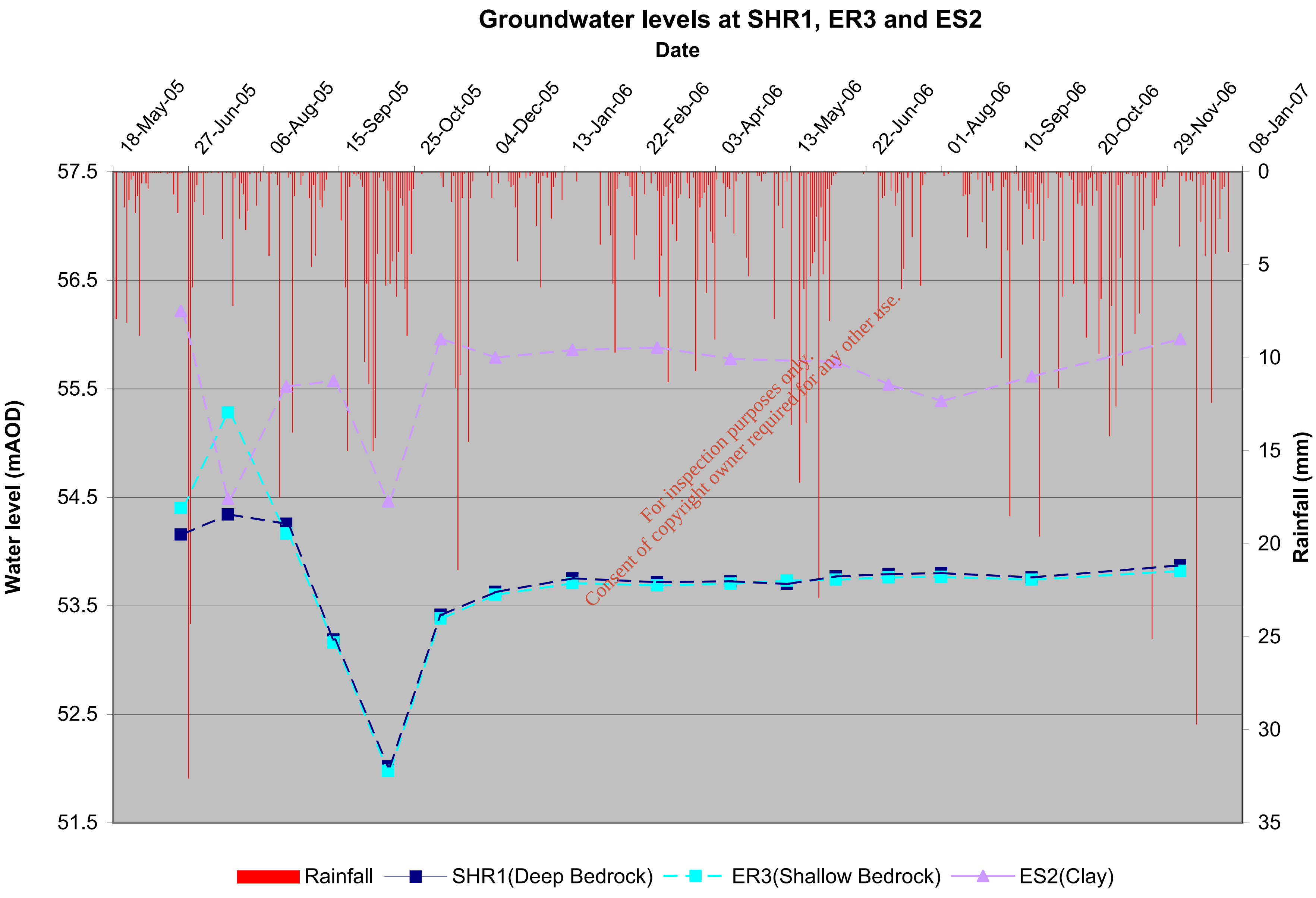


Groundwater levels at ER13



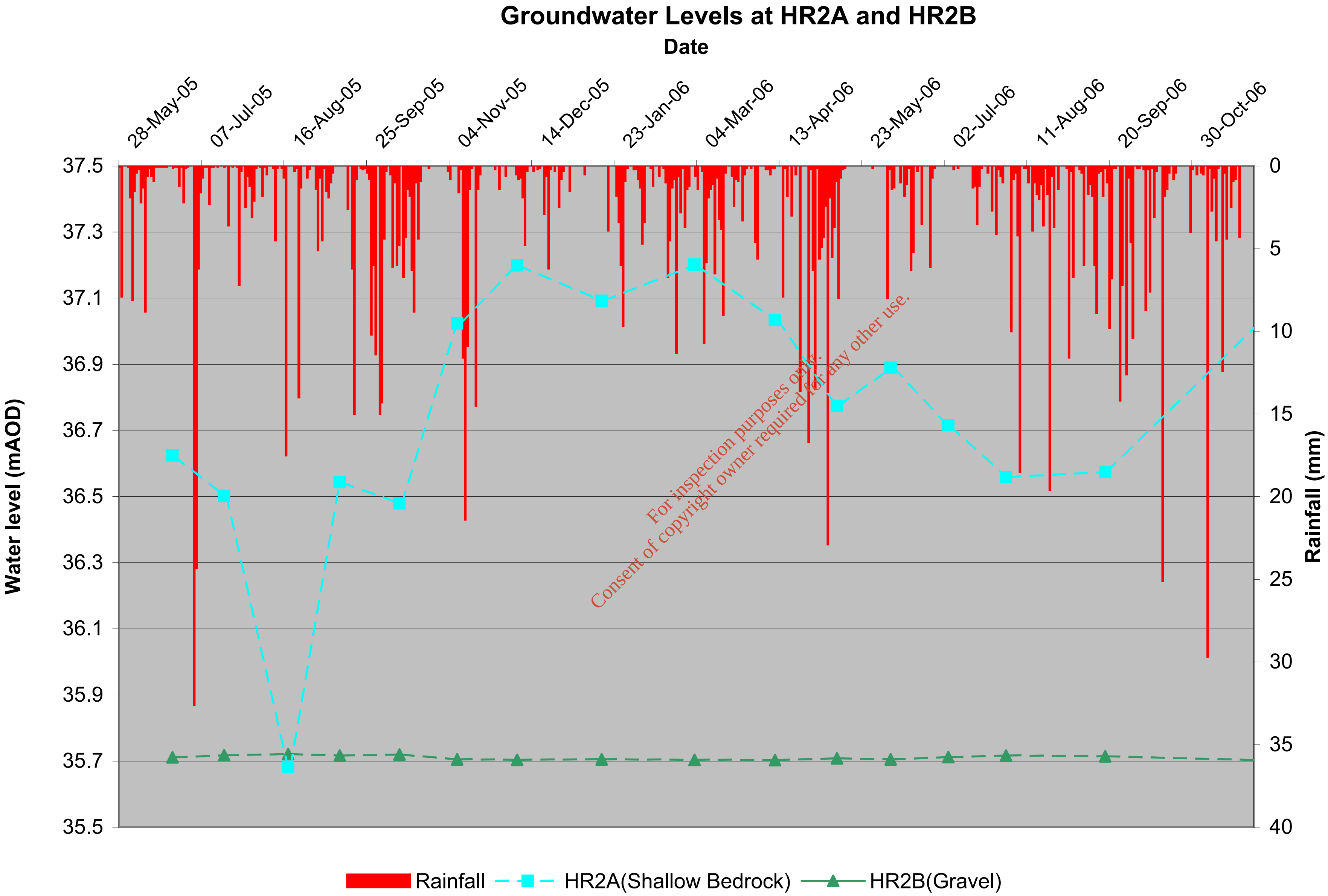
Groundwater levels (ER7, SHR2, ES6)



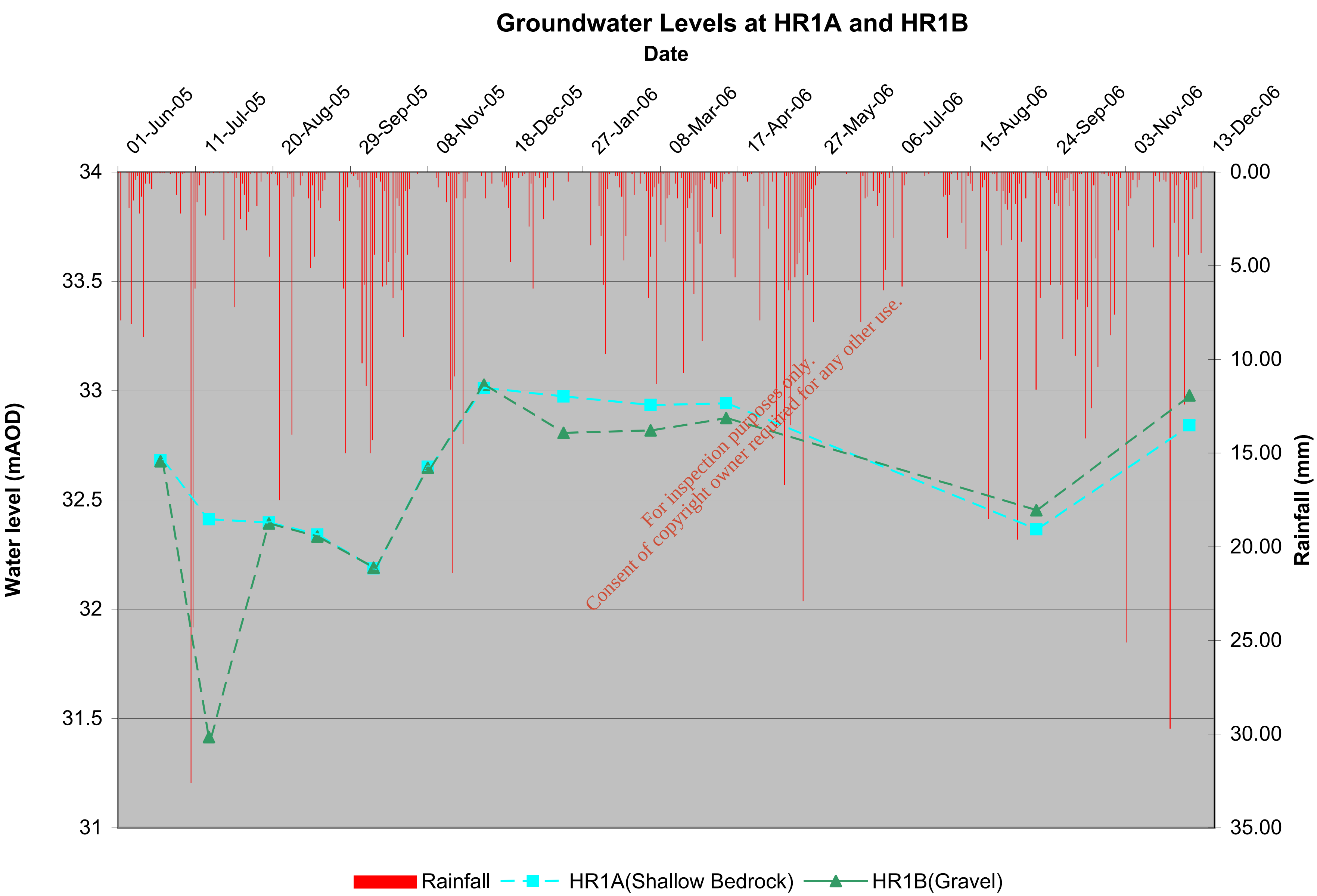


Groundwater levels at SHR1, ER3 and ES2
Date
18-May-05
27-Jun-05
06-Aug-05
15-Sep-05
25-Oct-05
04-Dec-05
13-Jan-06
22-Feb-06
03-Apr-06
13-May-06
22-Jun-06
01-Aug-06
10-Sep-06
20-Oct-06
29-Nov-06
08-Jan-07
Water level (mAOD)
57.5
56.5
55.5
54.5
53.5
52.5
51.5
Rainfall (mm)
0
5
10
15
20
25
30
35
Rainfall
SHR1(Deep Bedrock)
ER3(Shallow Bedrock)
ES2(Clay)

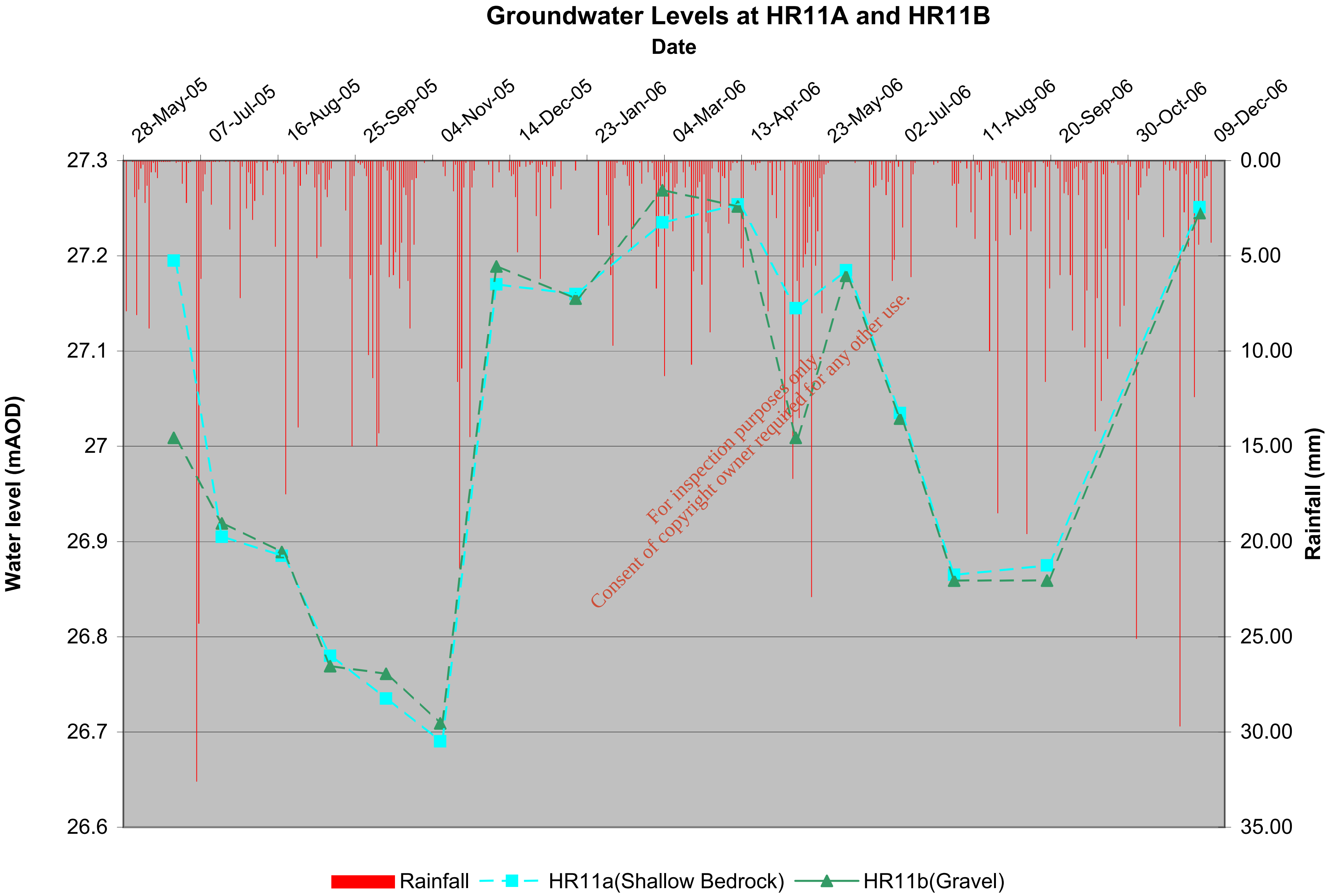
Fingal Landfill



Fingal Landfill



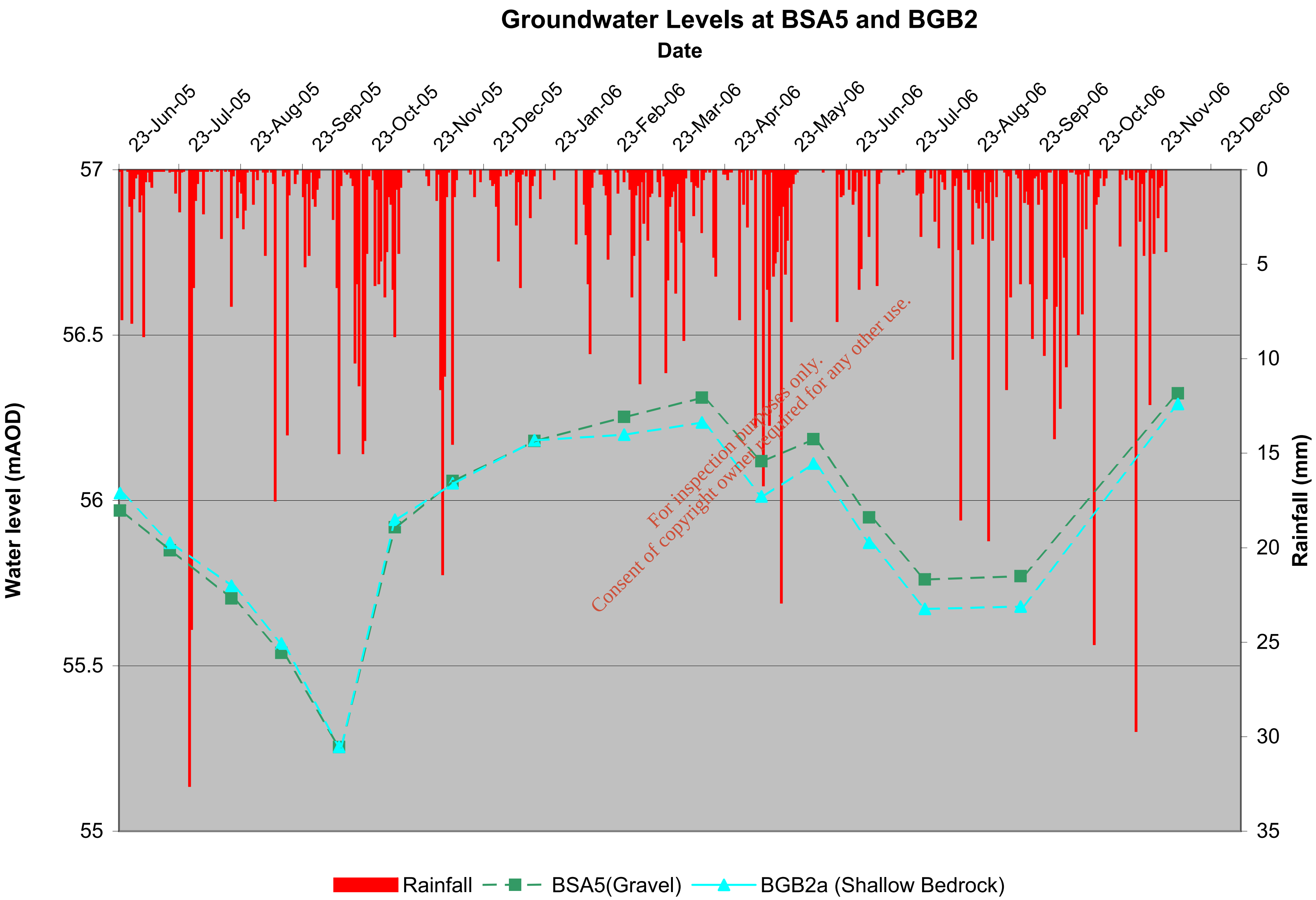
Fingal Landfill



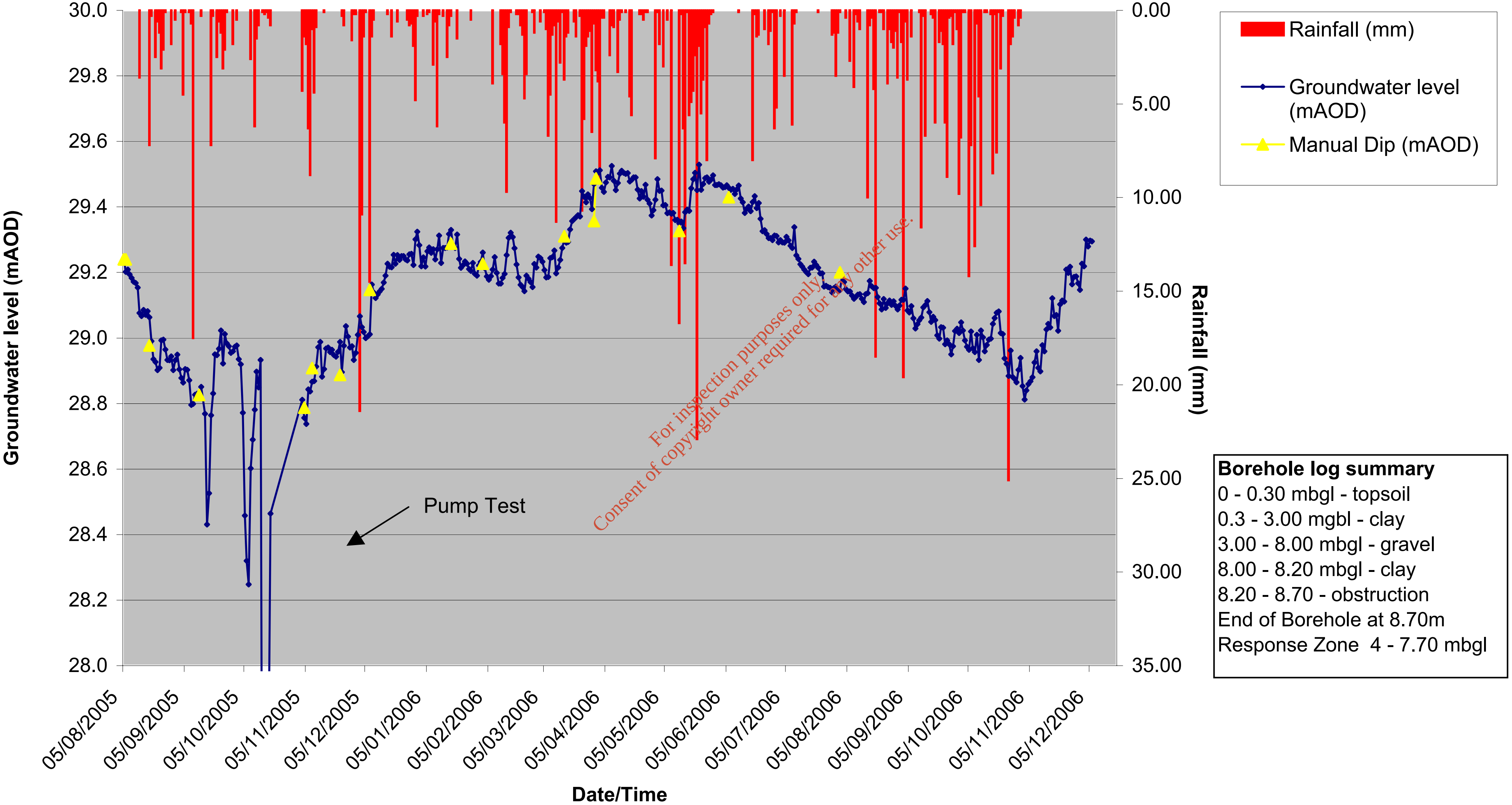
MDR0303

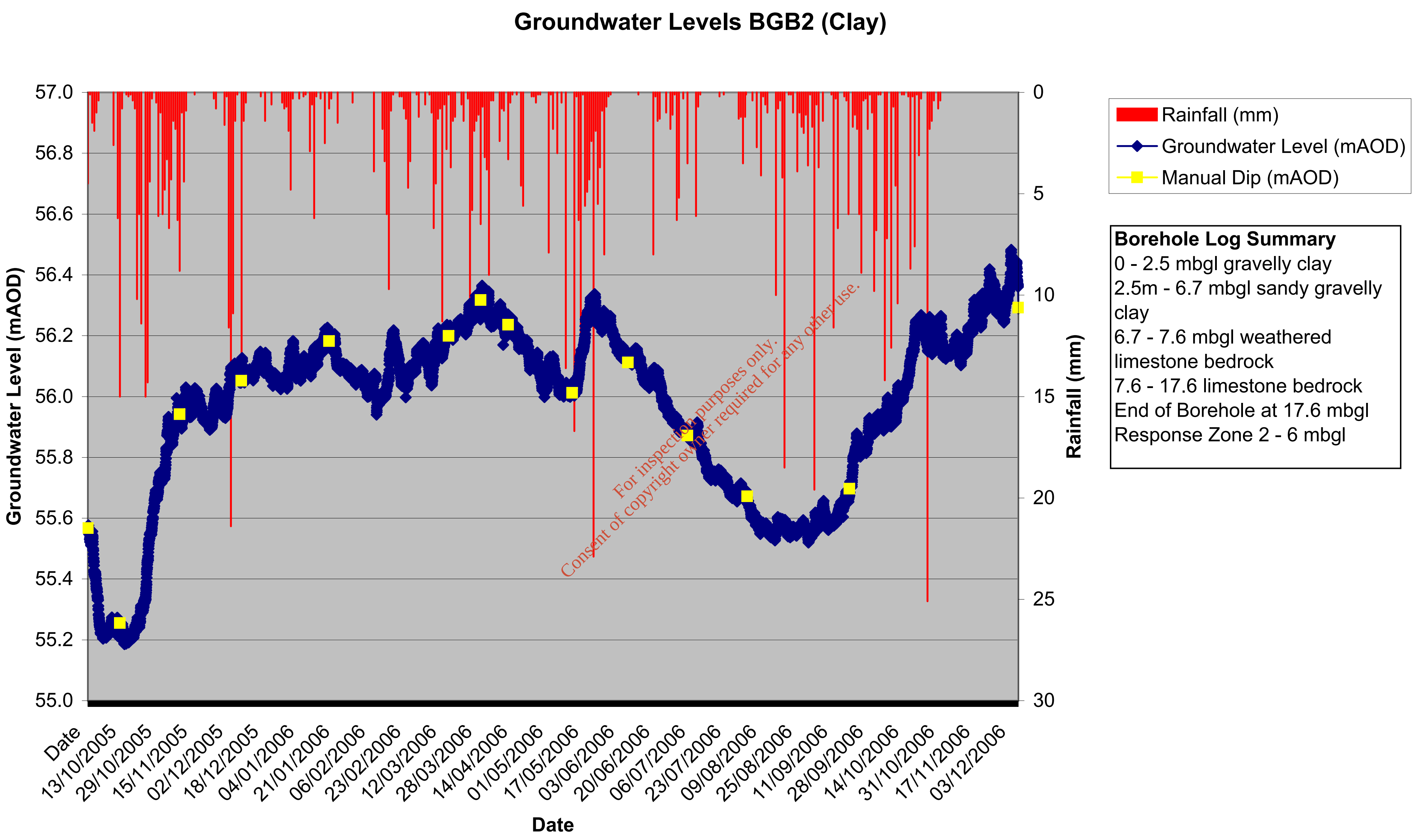
Fingal Landfill Wells Jun04 to present

Fingal Landfill



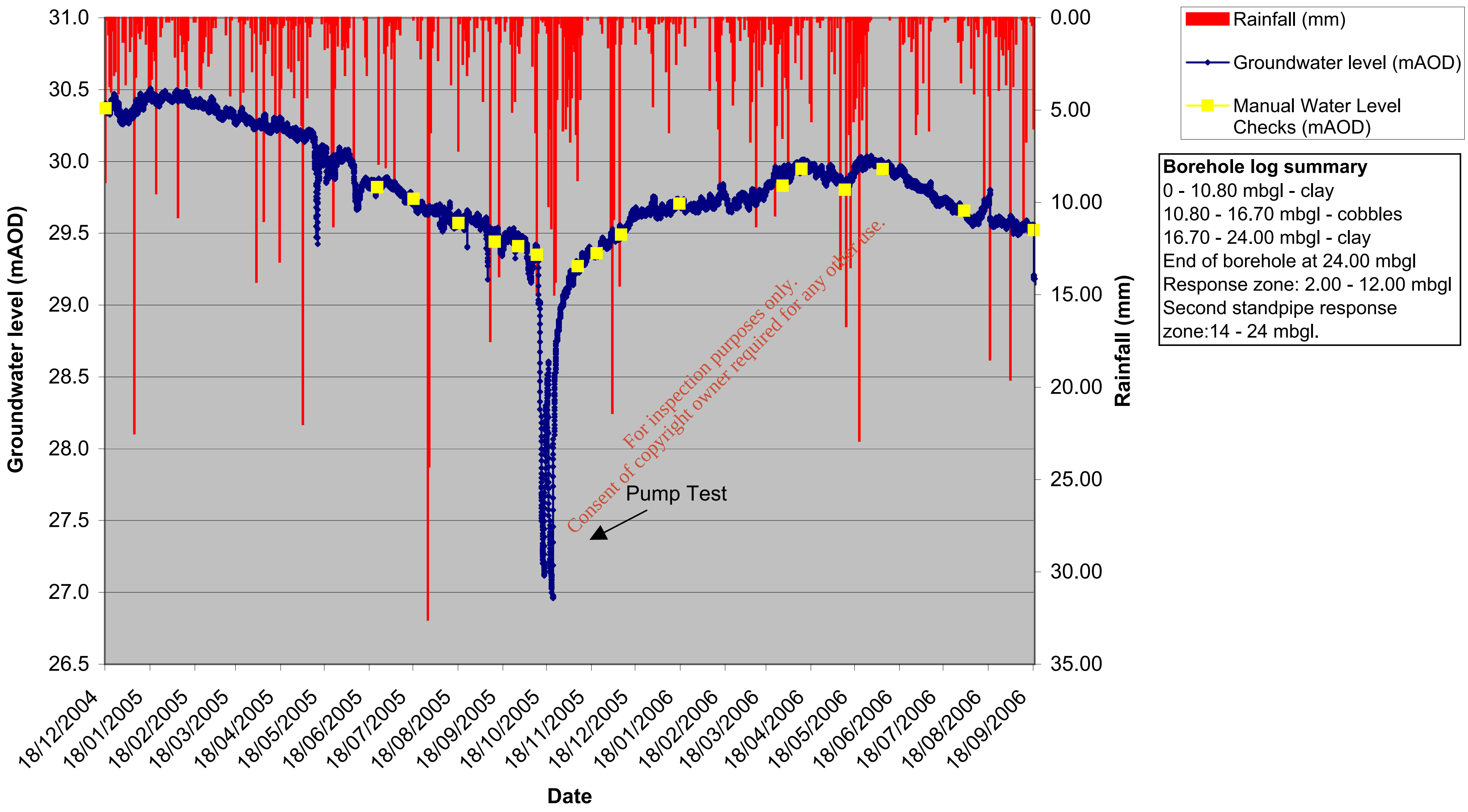
Groundwater levels ASA2 (Gravel)



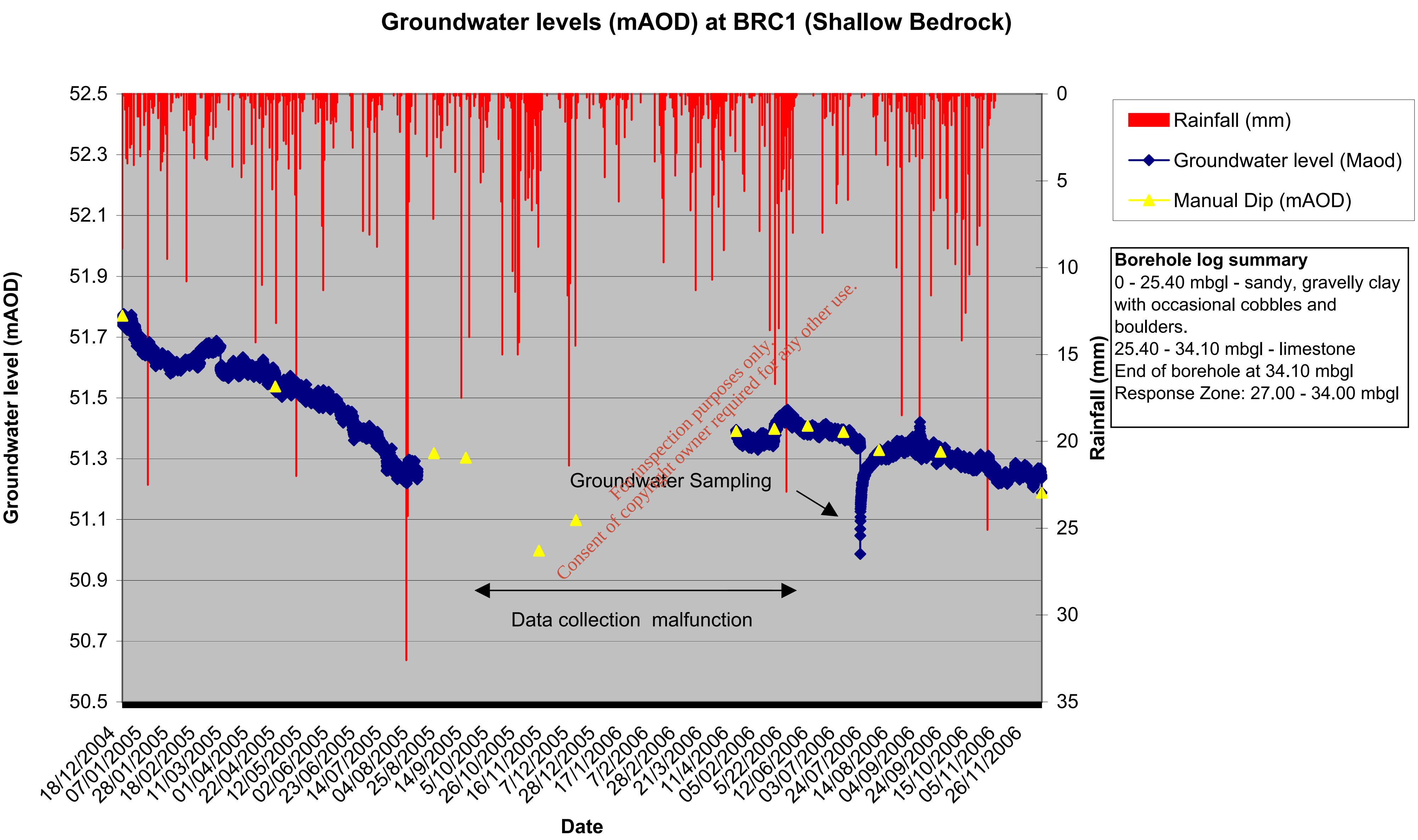


Groundwater Levels BGB2 (Clay)
57.0
56.8
56.6
56.4
56.2
56.0
55.8
55.6
55.4
55.2
55.0
Groundwater Level (mAOD)
0
5
10
15
20
25
30
Rainfall (mm)
Date
13/10/2005
29/10/2005
15/11/2005
02/12/2005
18/12/2005
04/01/2006
21/01/2006
06/02/2006
23/02/2006
12/03/2006
28/03/2006
14/04/2006
01/05/2006
17/05/2006
03/06/2006
20/06/2006
06/07/2006
23/07/2006
09/08/2006
25/08/2006
11/09/2006
28/09/2006
14/10/2006
31/10/2006
17/11/2006
03/12/2006
Date
Rainfall (mm)
Groundwater Level (mAOD)
Manual Dip (mAOD)
Borehole Log Summary
0 - 2.5 mbgl gravelly clay
2.5m - 6.7 mbgl sandy gravelly clay
6.7 - 7.6 mbgl weathered limestone bedrock
7.6 - 17.6 limestone bedrock
End of Borehole at 17.6 mbgl
Response Zone 2 - 6 mbgl

Groundwater Levels at BGB3a (Clay)

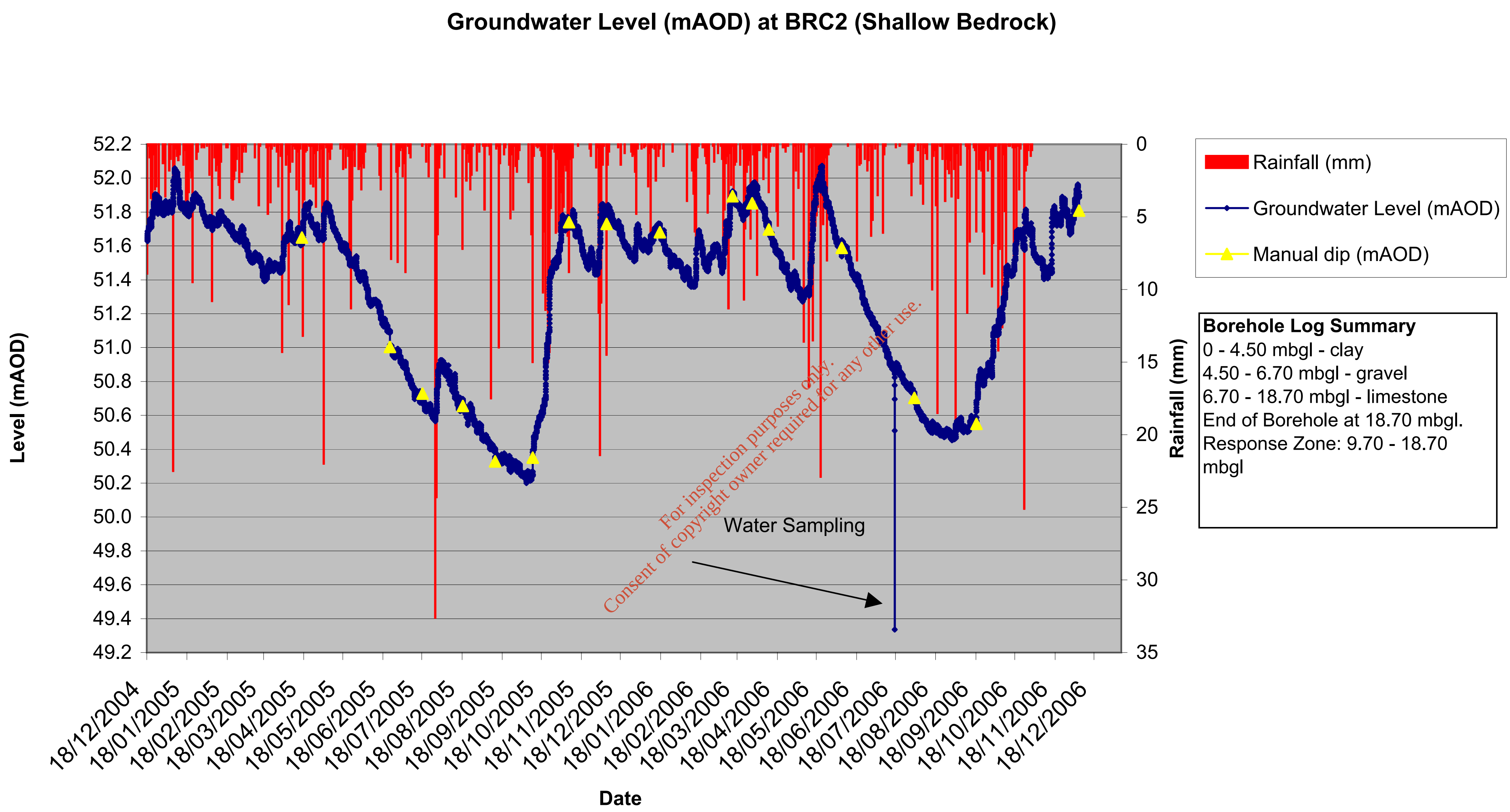


Borehole log summary
0 - 10.80 mbgl - clay
10.80 - 16.70 mbgl - cobbles
16.70 - 24.00 mbgl - clay
End of borehole at 24.00 mbgl
Response zone: 2.00 - 12.00 mbgl
Second standpipe response zone:14 - 24 mbgl.



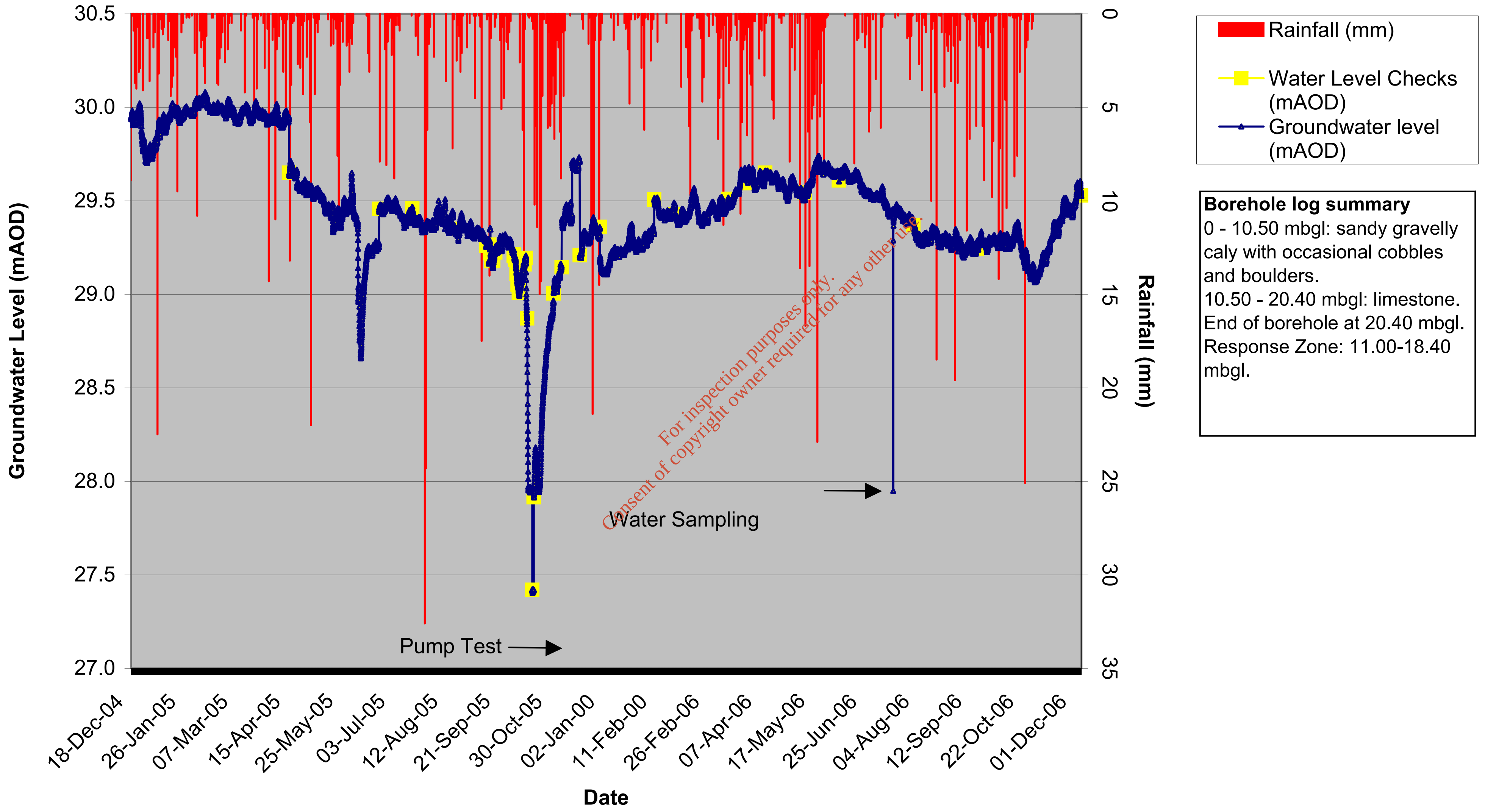
Groundwater levels (mAOD) at BRC1 (Shallow Bedrock)
Groundwater level (mAOD)
Rainfall (mm)
Date
Rainfall (mm)
Groundwater level (Maod)
Manual Dip (mAOD)
Borehole log summary
0 - 25.40 mbgl - sandy, gravelly clay with occasional cobbles and boulders.
25.40 - 34.10 mbgl - limestone
End of borehole at 34.10 mbgl
Response Zone: 27.00 - 34.00 mbgl
Groundwater Sampling
Data collection malfunction
52.5
52.3
52.1
51.9
51.7
51.5
51.3
51.1
50.9
50.7
50.5
0
5
10
15
20
25
30
35
18/12/2004
07/01/2005
28/01/2005
18/02/2005
11/03/2005
01/04/2005
22/04/2005
12/05/2005
02/06/2005
23/06/2005
14/07/2005
04/08/2005
25/8/2005
14/9/2005
5/10/2005
26/10/2005
16/11/2005
7/12/2005
28/12/2005
17/1/2006
7/2/2006
28/2/2006
21/3/2006
11/4/2006
05/02/2006
5/22/2006
12/06/2006
03/07/2006
24/07/2006
14/08/2006
04/09/2006
24/09/2006
15/10/2006
05/11/2006
26/11/2006

Fingal Landfill
BRC2 (Shallow Bedrock) Groundwater Level (mAOD)

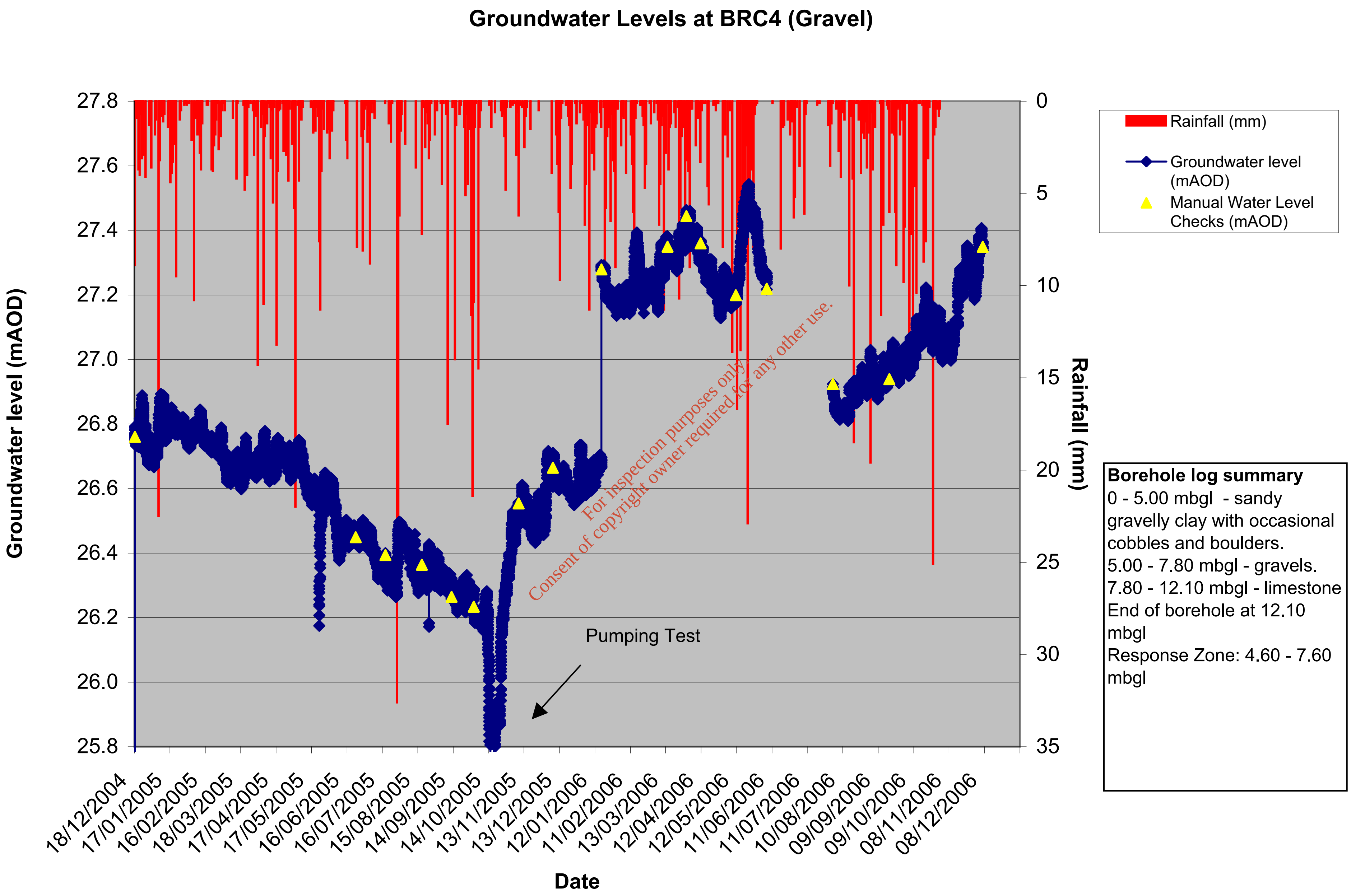


Borehole Log Summary
0 - 4.50 mbgl - clay
4.50 - 6.70 mbgl - gravel
6.70 - 18.70 mbgl - limestone
End of Borehole at 18.70 mbgl.
Response Zone: 9.70 - 18.70 mbgl

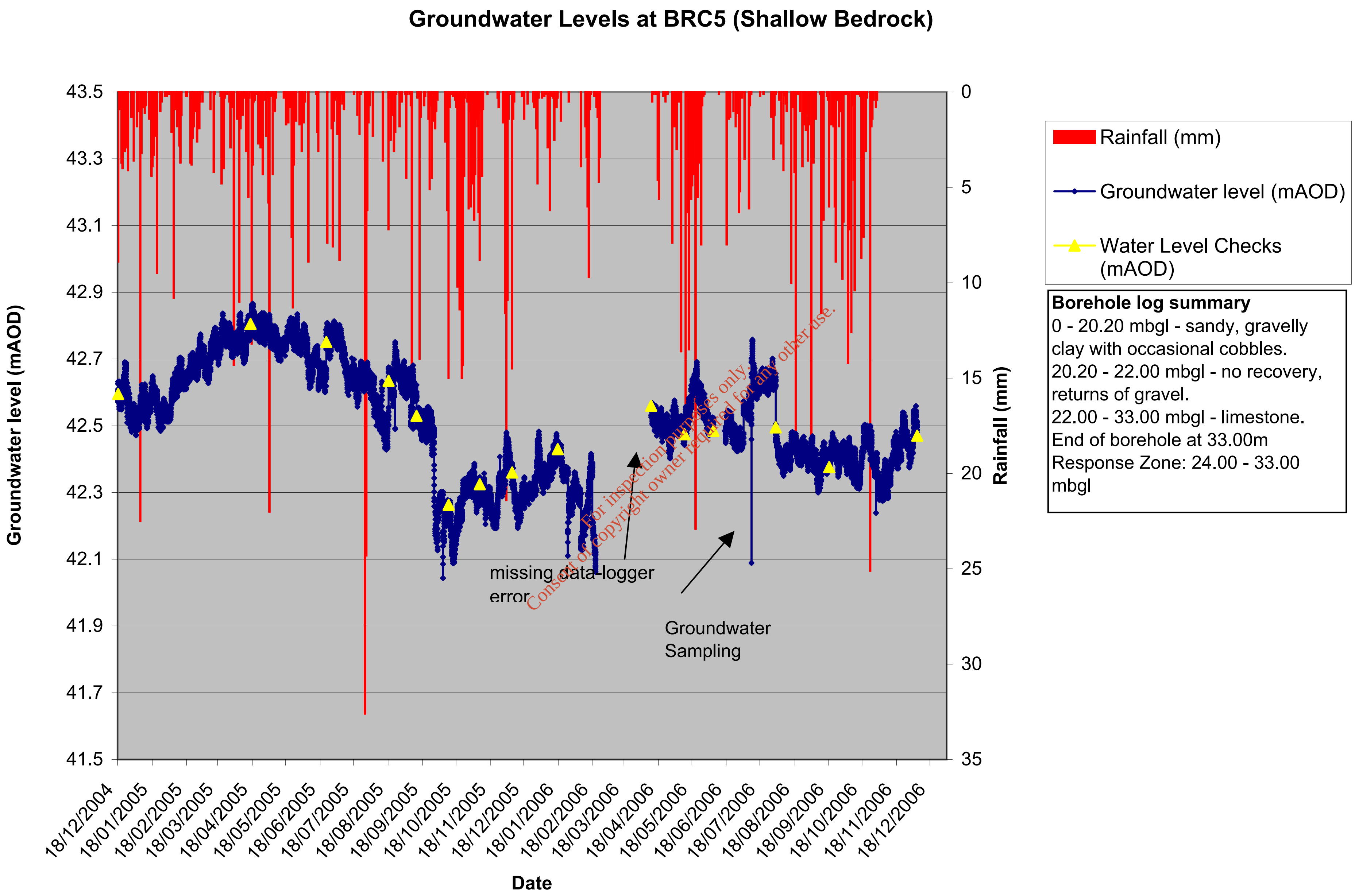
Groundwater levels at BRC3 (Shallow Bedrock)



Borehole log summary
0 - 10.50 mbgl: sandy gravelly caly with occasional cobbles and boulders.
10.50 - 20.40 mbgl: limestone.
End of borehole at 20.40 mbgl.
Response Zone: 11.00-18.40 mbgl.

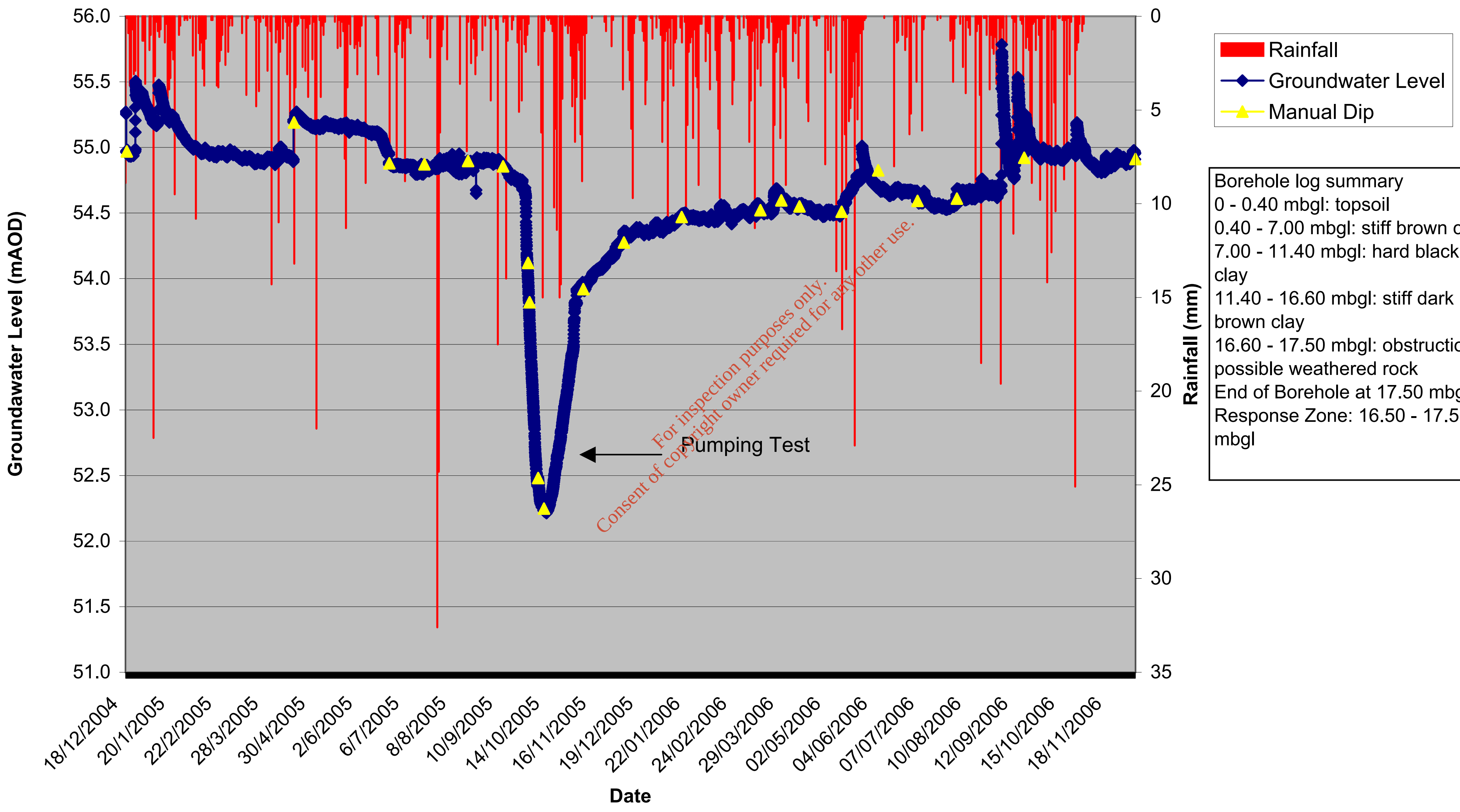


Borehole log summary
0 - 5.00 mbgl - sandy gravelly clay with occasional cobbles and boulders.
5.00 - 7.80 mbgl - gravels.
7.80 - 12.10 mbgl - limestone
End of borehole at 12.10 mbgl
Response Zone: 4.60 - 7.60 mbgl



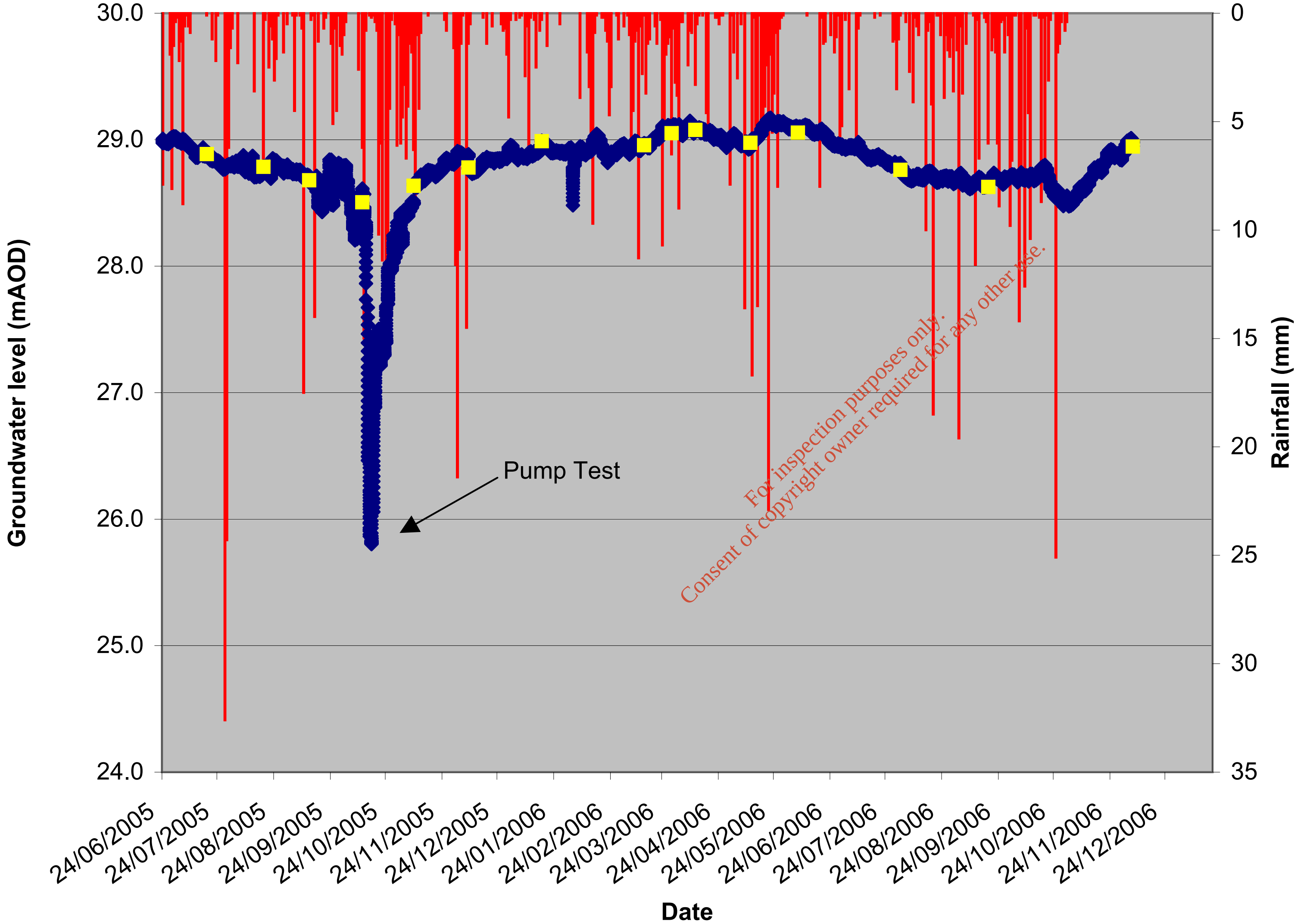
Groundwater Levels at BRC5 (Shallow Bedrock)
Groundwater level (mAOD)
43.5
43.3
43.1
42.9
42.7
42.5
42.3
42.1
41.9
41.7
41.5
Rainfall (mm)
0
5
10
15
20
25
30
35
18/12/2004
18/01/2005
18/02/2005
18/03/2005
18/04/2005
18/05/2005
18/06/2005
18/07/2005
18/08/2005
18/09/2005
18/10/2005
18/11/2005
18/12/2005
18/01/2006
18/02/2006
18/03/2006
18/04/2006
18/05/2006
18/06/2006
18/07/2006
18/08/2006
18/09/2006
18/10/2006
18/11/2006
18/12/2006
Date
missing data-logger error
Groundwater Sampling
Rainfall (mm)
Groundwater level (mAOD)
Water Level Checks (mAOD)
Borehole log summary
0 - 20.20 mbgl - sandy, gravelly clay with occasional cobbles.
20.20 - 22.00 mbgl - no recovery, returns of gravel.
22.00 - 33.00 mbgl - limestone.
End of borehole at 33.00m
Response Zone: 24.00 - 33.00 mbgl

Groundwater Levels (mAOD) BSA1 (Shallow Bedrock)



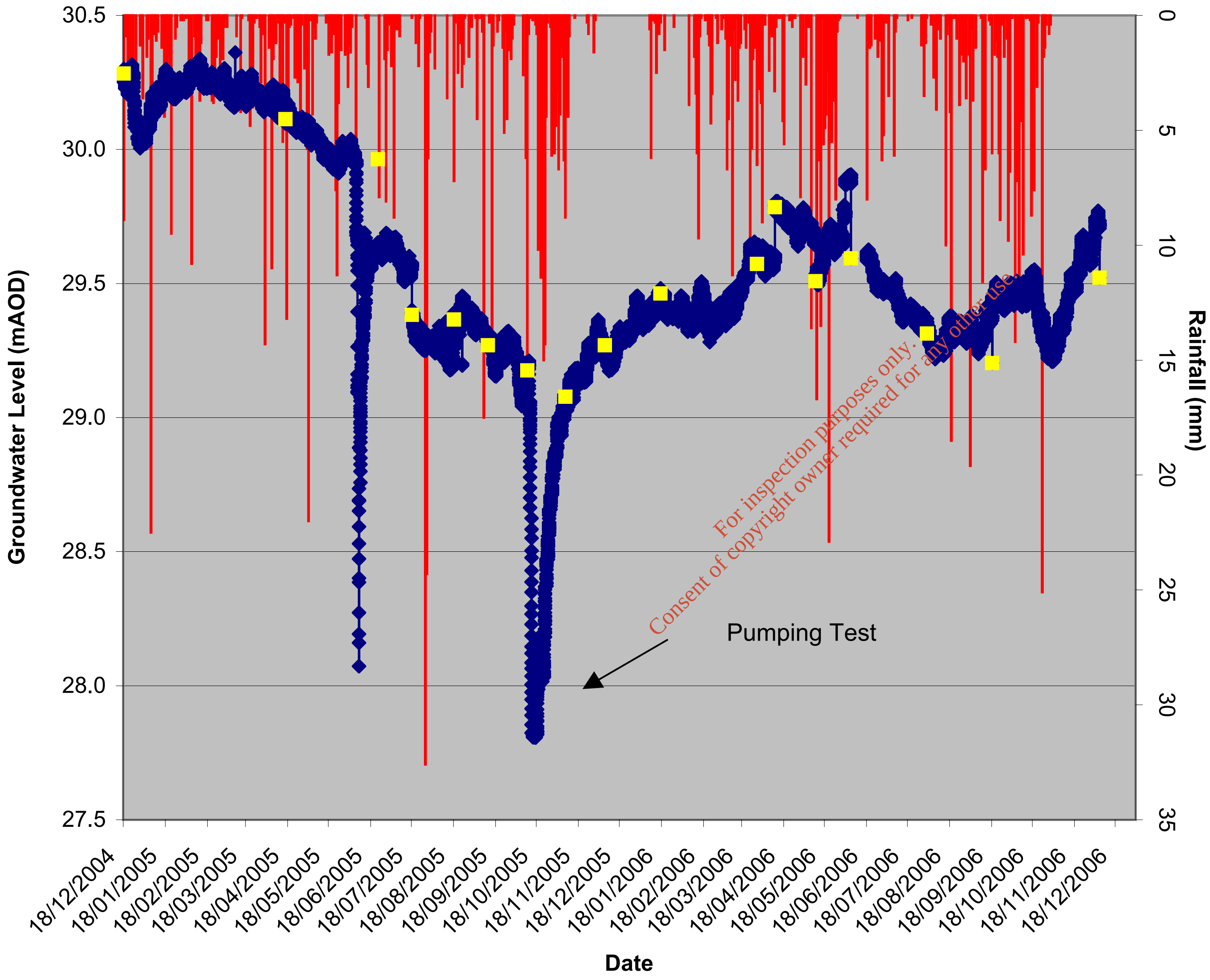
Borehole log summary
0 - 0.40 mbgl: topsoil
0.40 - 7.00 mbgl: stiff brown clay
7.00 - 11.40 mbgl: hard black clay
11.40 - 16.60 mbgl: stiff dark brown clay
16.60 - 17.50 mbgl: obstruction, possible weathered rock
End of Borehole at 17.50 mbgl
Response Zone: 16.50 - 17.50 mbgl

Groundwater levels (mAOD) BSA2 (Clay)

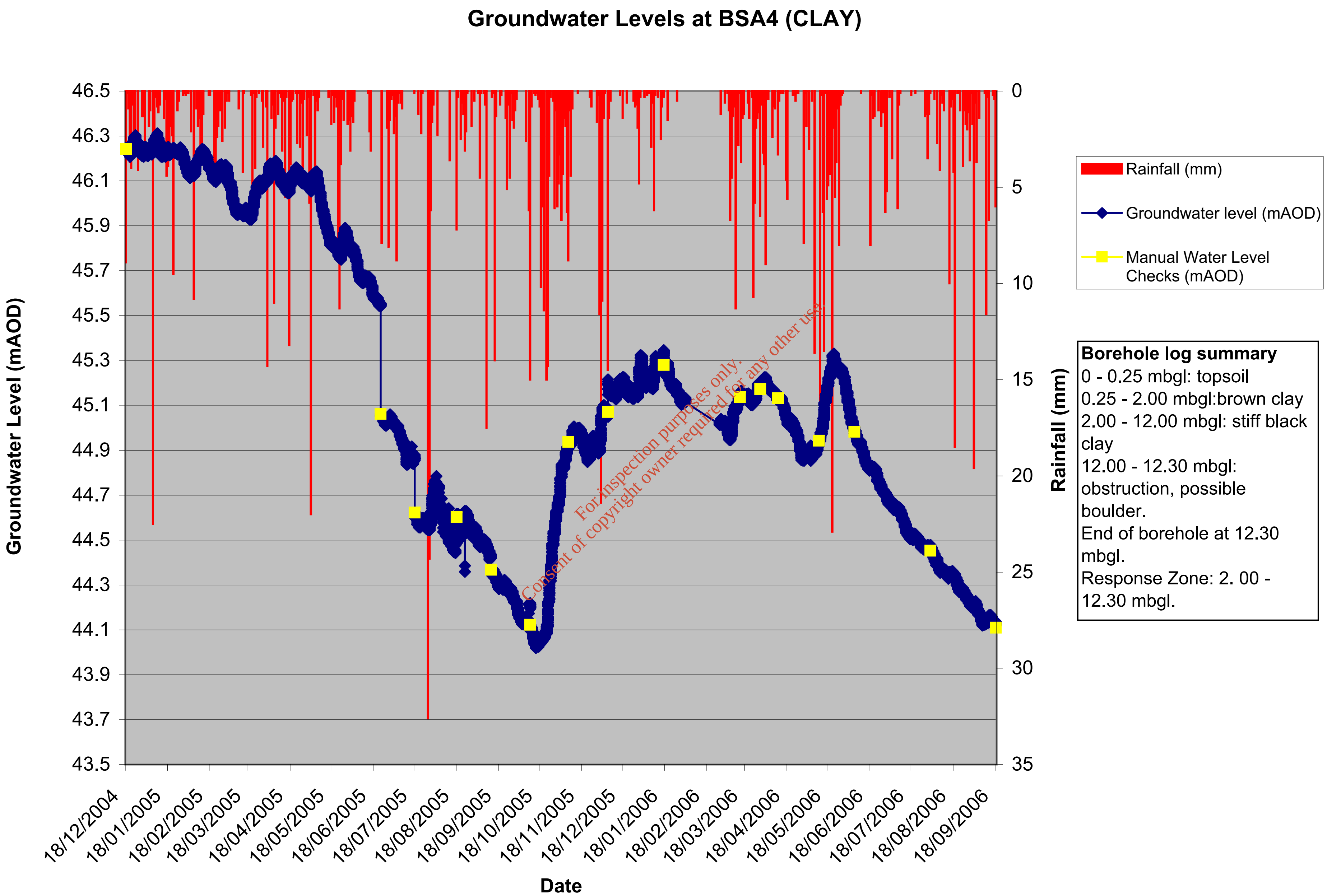


Borehole log summary
0 - 0.30 mbgl: topsoil
0.30 - 0.40 mbgl: grey sandy clay
0.40 - 2.00 mbgl: brown clay
2.00 - 7.00 mbgl: stiff dark brown clay with cobbles and boulders
7.00 - 7.40 mbgl: very stiff grey/black clay with cobbles and boulders.
End of borehole at 7.40 mbgl.
Response Zone: 5.40 - 7.40 mbgl.

Groundwater Levels at BSA3a (Clay)

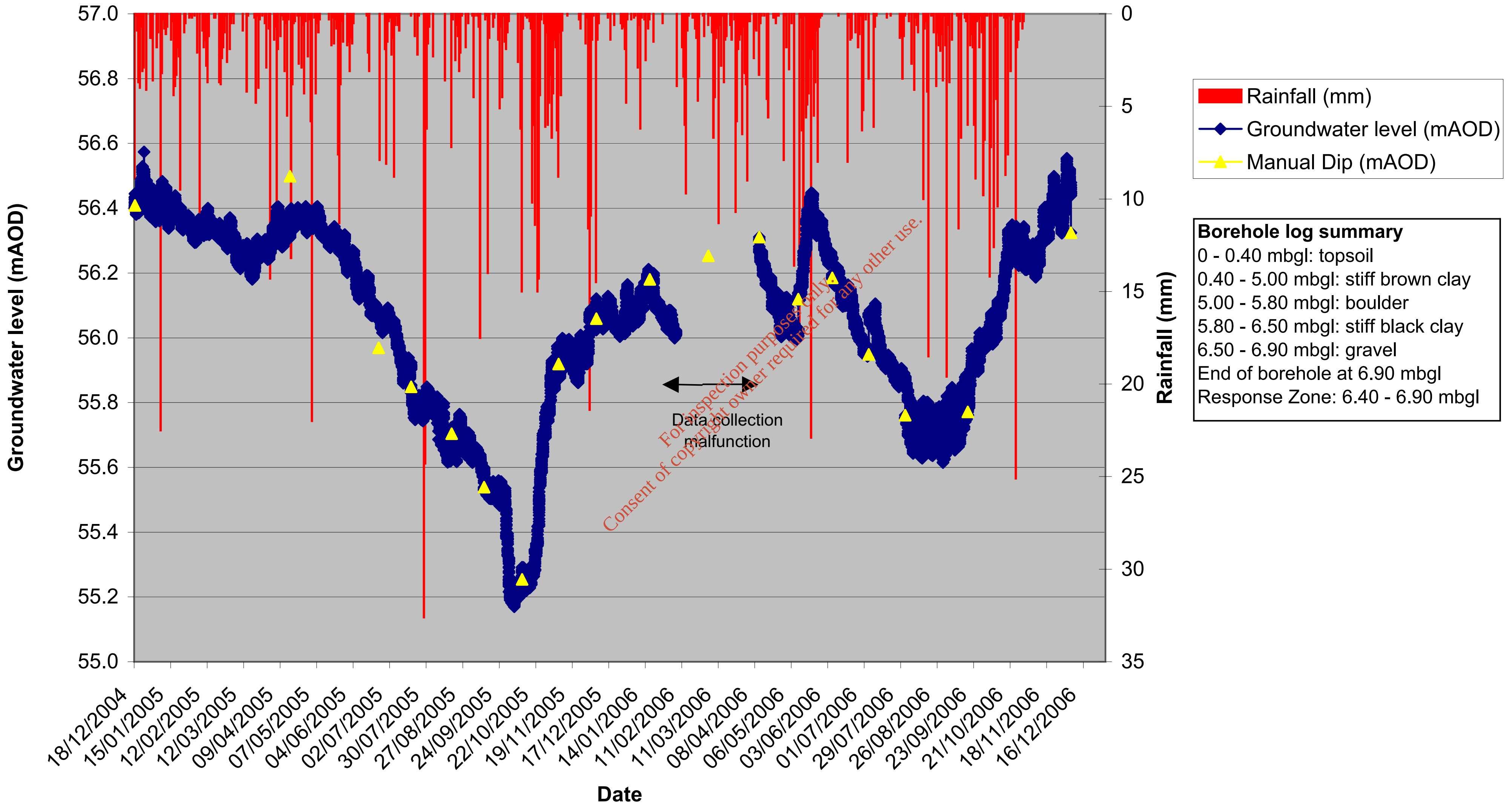


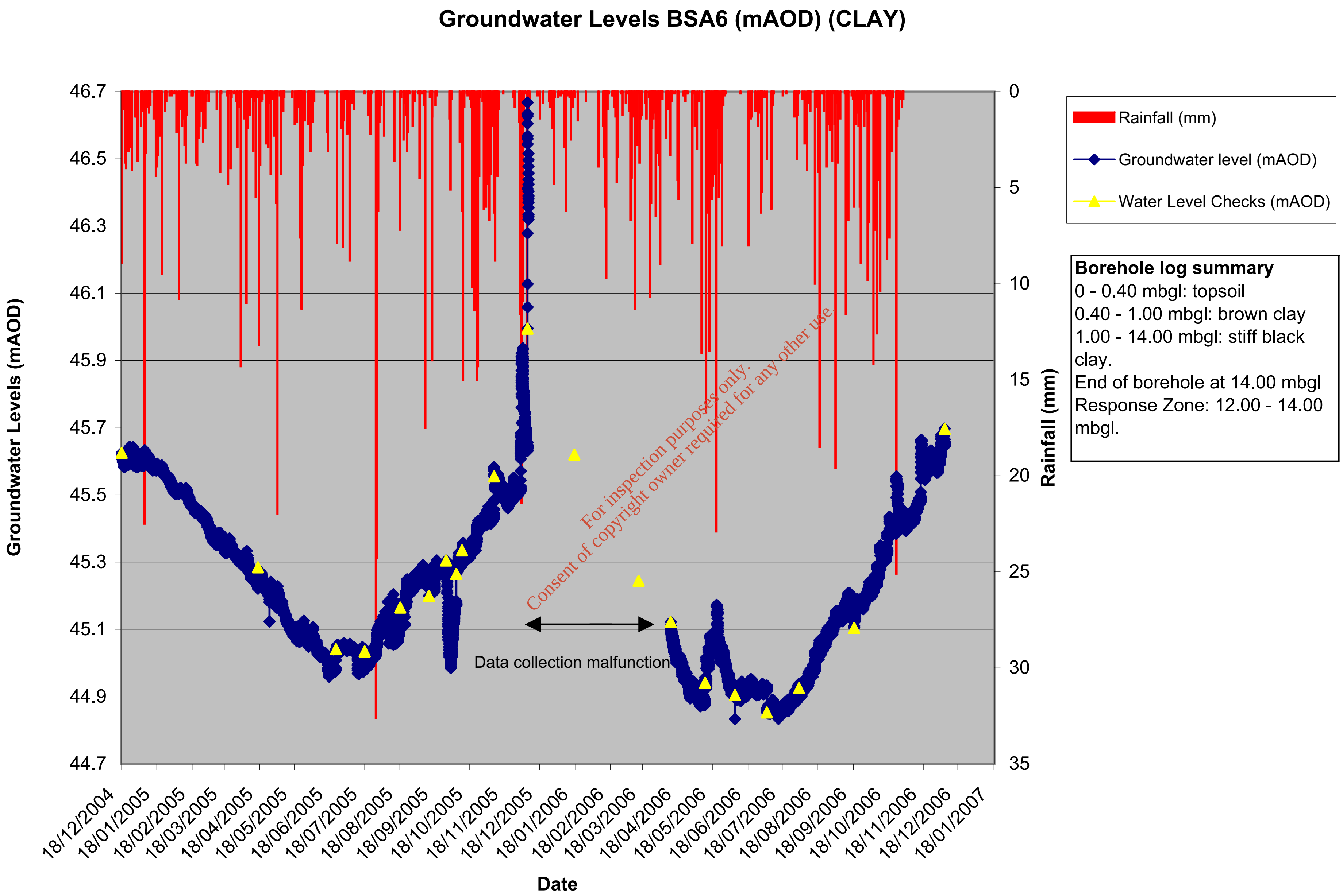
Borehole log summary
0 - 0.40 mbgl: topsoil
0.40 - 2.40 mbgl: brown clay
2.40 - 10.50 mbgl: very stiff black clay
10.50 - 17.00 mbgl: very stiff brown clay
Borehole ends at 17.00 mbgl
Response Zone: 16.00 - 17.00 mbgl.



Groundwater Levels at BSA4 (CLAY)
Groundwater Level (mAOD)
Rainfall (mm)
Date
46.5
46.3
46.1
45.9
45.7
45.5
45.3
45.1
44.9
44.7
44.5
44.3
44.1
43.9
43.7
43.5
0
5
10
15
20
25
30
35
18/12/2004
18/01/2005
18/02/2005
18/03/2005
18/04/2005
18/05/2005
18/06/2005
18/07/2005
18/08/2005
18/09/2005
18/10/2005
18/11/2005
18/12/2005
18/01/2006
18/02/2006
18/03/2006
18/04/2006
18/05/2006
18/06/2006
18/07/2006
18/08/2006
18/09/2006
Rainfall (mm)
Groundwater level (mAOD)
Manual Water Level Checks (mAOD)
Borehole log summary
0 - 0.25 mbgl: topsoil
0.25 - 2.00 mbgl:brown clay
2.00 - 12.00 mbgl: stiff black clay
12.00 - 12.30 mbgl: obstruction, possible boulder.
End of borehole at 12.30 mbgl.
Response Zone: 2. 00 - 12.30 mbgl.

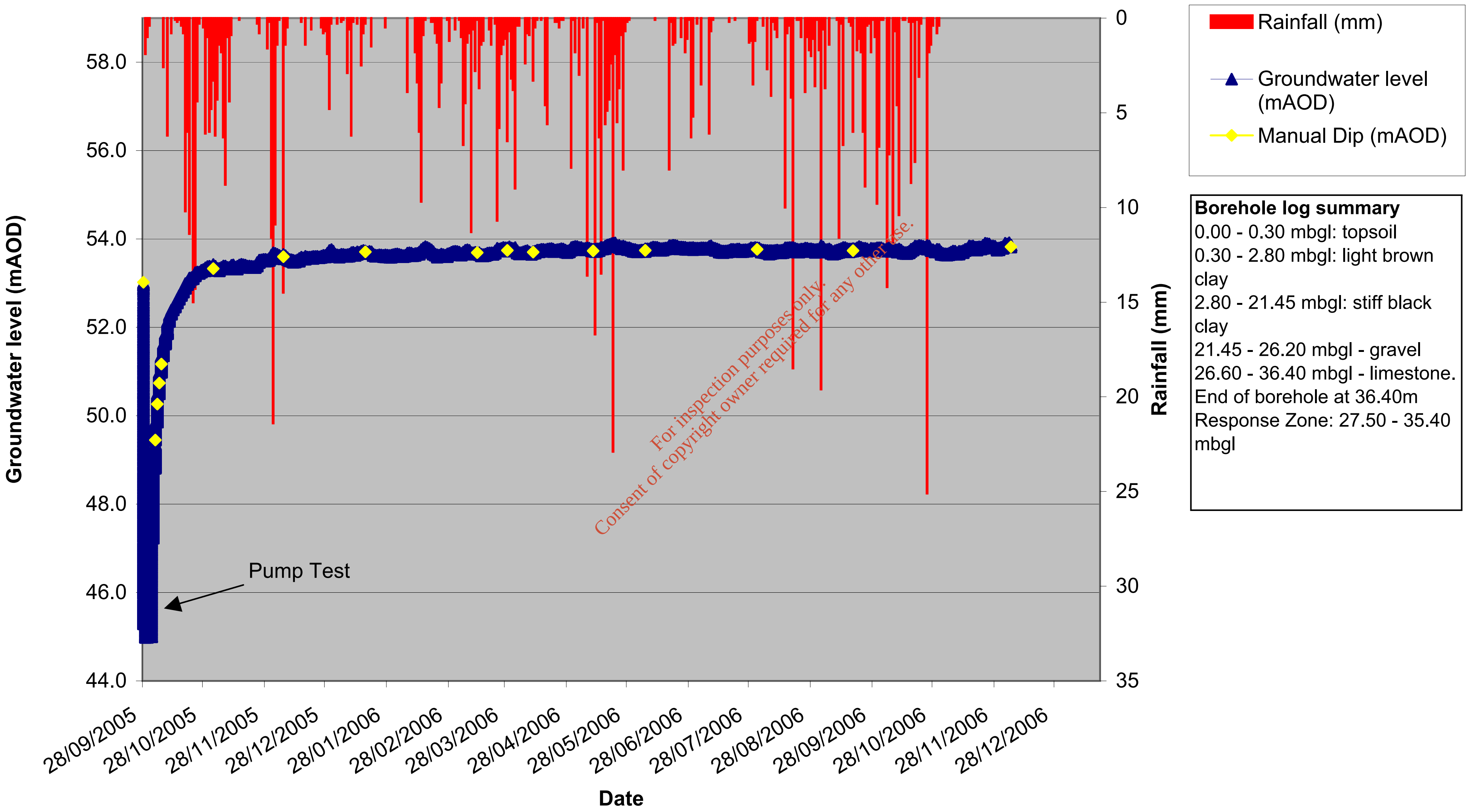
Groundwater levels (mAOD) BSA5 (Gravel)



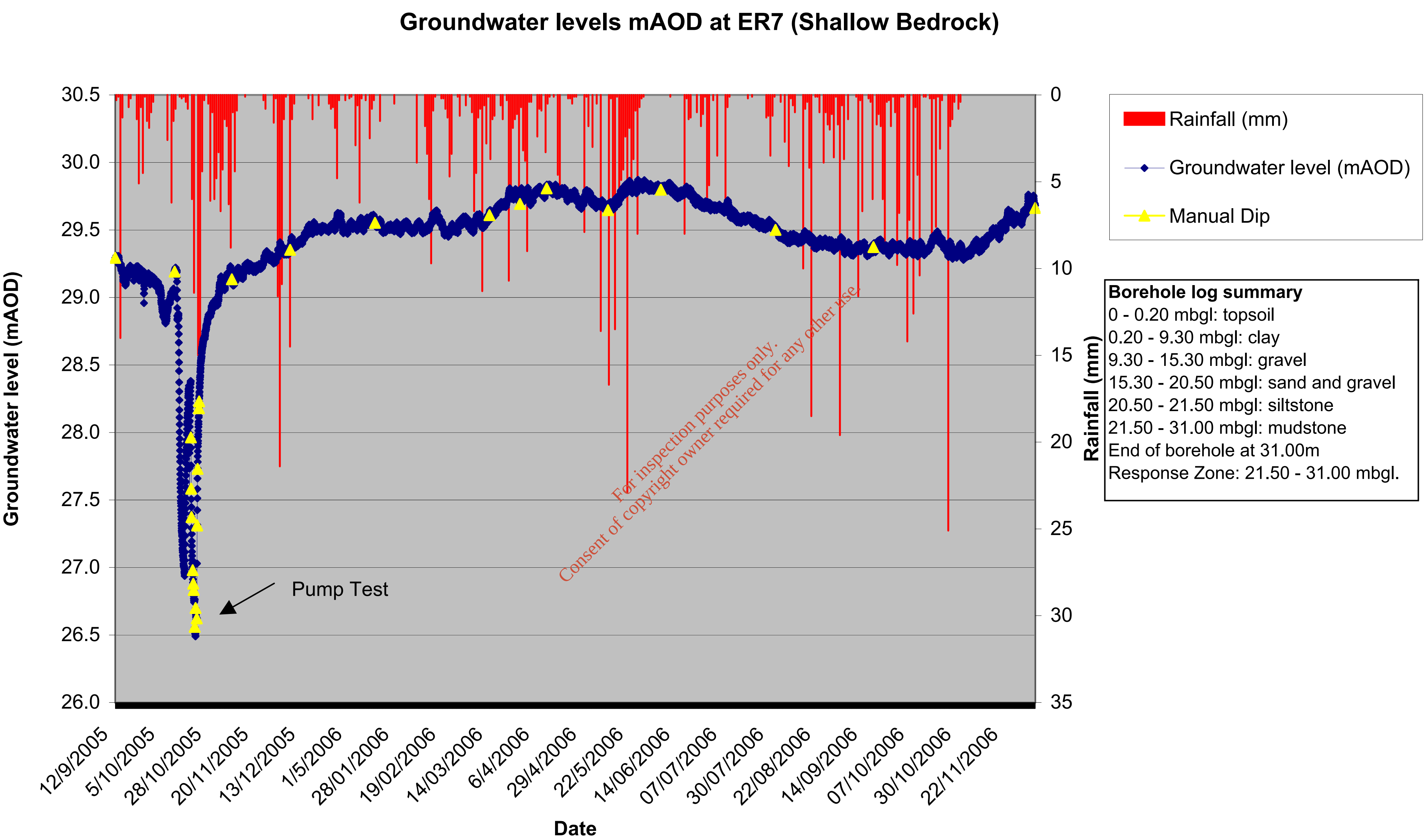


Groundwater Levels BSA6 (mAOD) (CLAY)
Groundwater Levels (mAOD)
46.7
46.5
46.3
46.1
45.9
45.7
45.5
45.3
45.1
44.9
44.7
Rainfall (mm)
0
5
10
15
20
25
30
35
Date
18/12/2004
18/01/2005
18/02/2005
18/03/2005
18/04/2005
18/05/2005
18/06/2005
18/07/2005
18/08/2005
18/09/2005
18/10/2005
18/11/2005
18/12/2005
18/01/2006
18/02/2006
18/03/2006
18/04/2006
18/05/2006
18/06/2006
18/07/2006
18/08/2006
18/09/2006
18/10/2006
18/11/2006
18/12/2006
18/01/2007
Data collection malfunction
Rainfall (mm)
Groundwater level (mAOD)
Water Level Checks (mAOD)
Borehole log summary
0 - 0.40 mbgl: topsoil
0.40 - 1.00 mbgl: brown clay
1.00 - 14.00 mbgl: stiff black clay.
End of borehole at 14.00 mbgl
Response Zone: 12.00 - 14.00 mbgl.

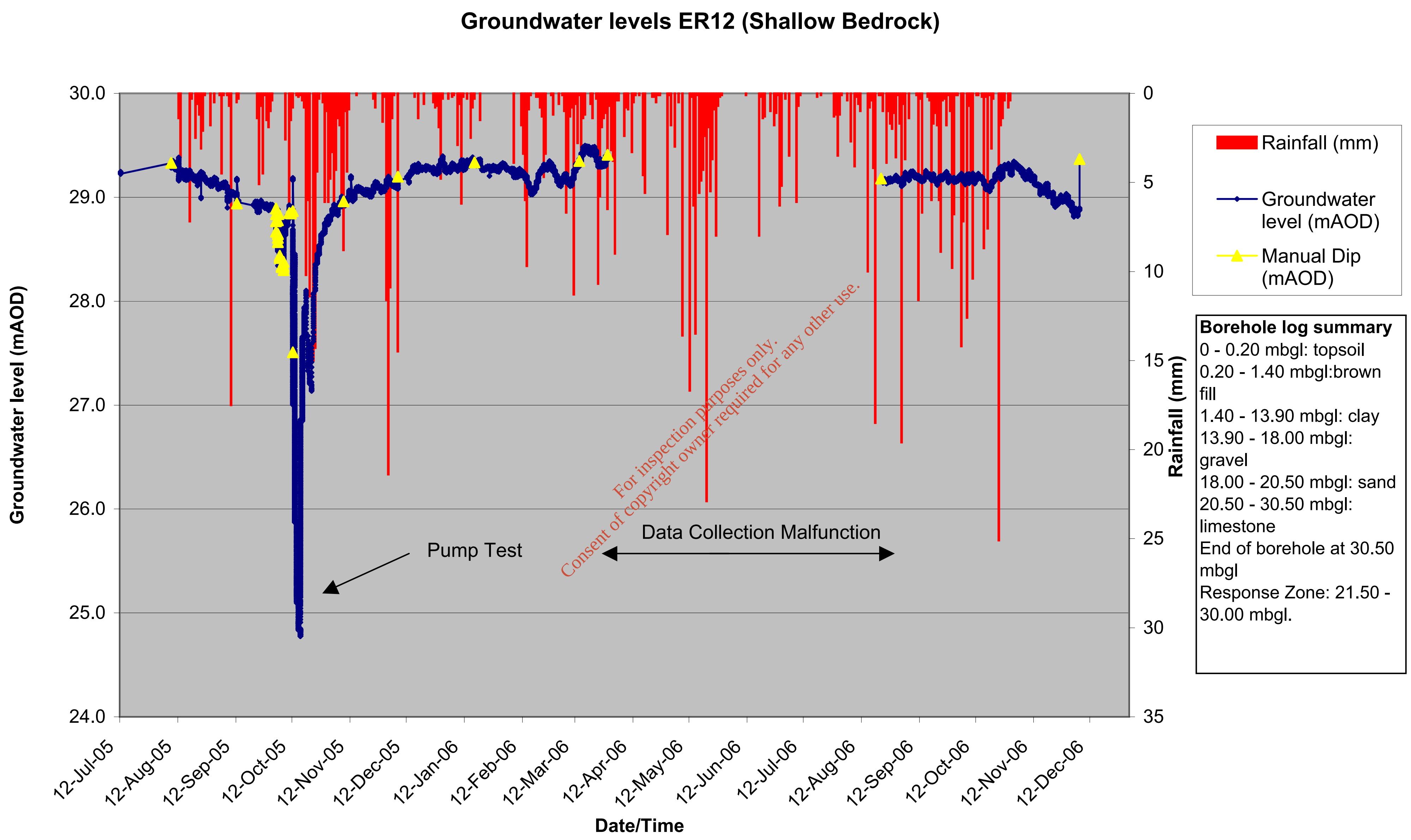
Groundwater level (mAOD) ER3 (Shallow Bedrock)

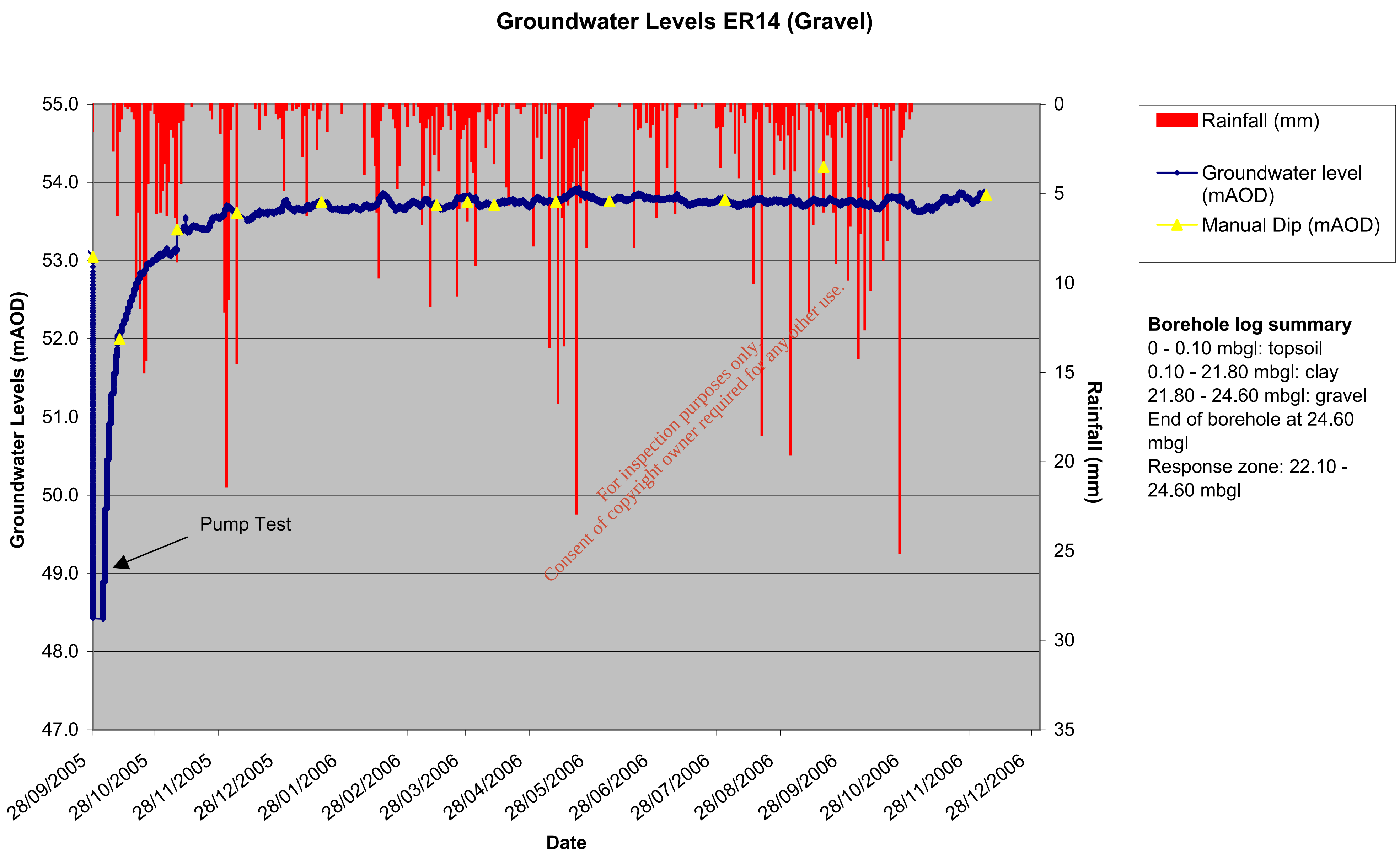


Borehole log summary
0.00 - 0.30 mbgl: topsoil
0.30 - 2.80 mbgl: light brown clay
2.80 - 21.45 mbgl: stiff black clay
21.45 - 26.20 mbgl - gravel
26.60 - 36.40 mbgl - limestone.
End of borehole at 36.40m
Response Zone: 27.50 - 35.40 mbgl

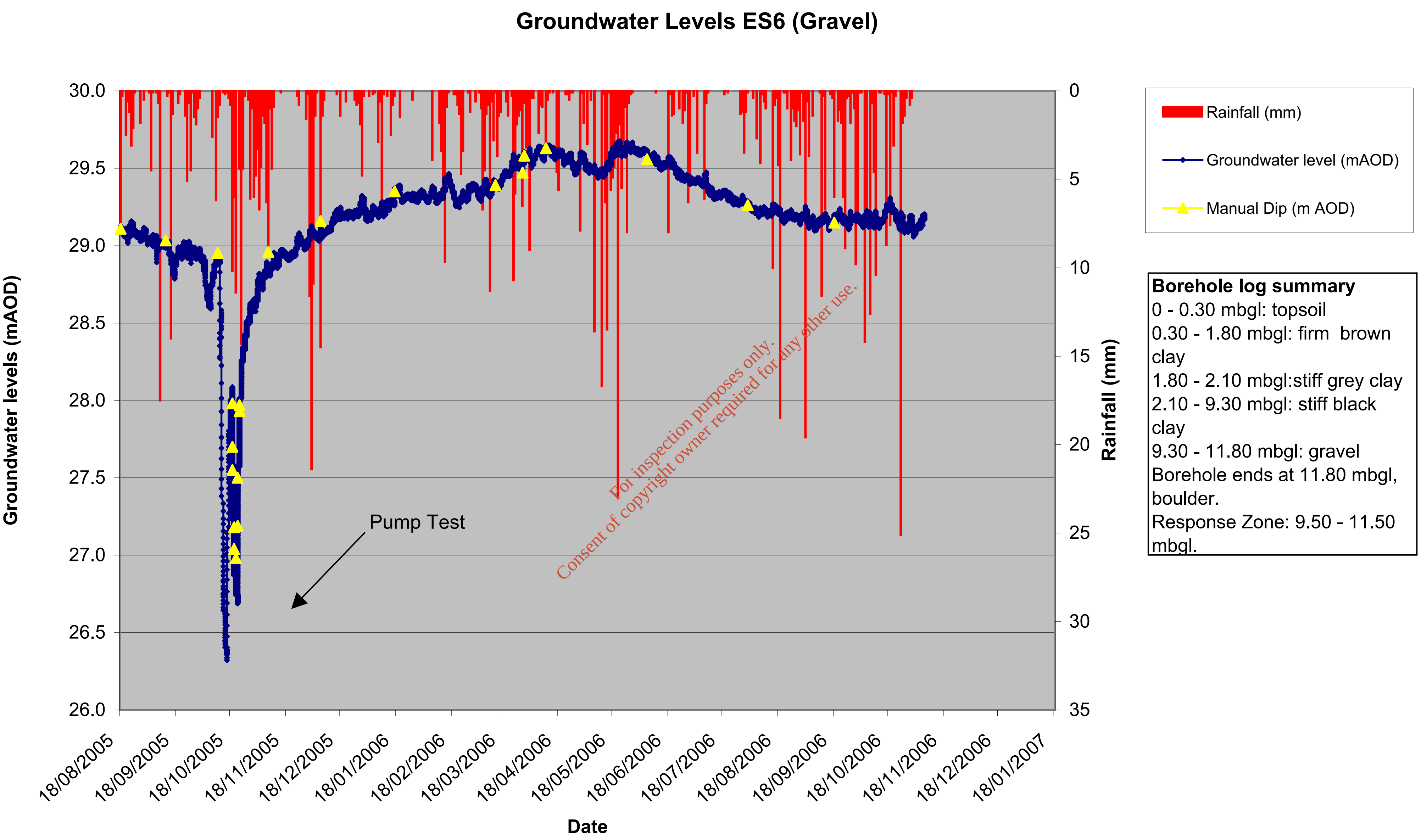


Groundwater levels mAOD at ER7 (Shallow Bedrock)
Groundwater level (mAOD)
30.5
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
Rainfall (mm)
0
5
10
15
20
25
30
35
Pump Test
12/9/2005
5/10/2005
28/10/2005
20/11/2005
13/12/2005
1/5/2006
28/01/2006
19/02/2006
14/03/2006
6/4/2006
29/4/2006
22/5/2006
14/06/2006
07/07/2006
30/07/2006
22/08/2006
14/09/2006
07/10/2006
30/10/2006
22/11/2006
Date
Rainfall (mm)
Groundwater level (mAOD)
Manual Dip
Borehole log summary
0 - 0.20 mbgl: topsoil
0.20 - 9.30 mbgl: clay
9.30 - 15.30 mbgl: gravel
15.30 - 20.50 mbgl: sand and gravel
20.50 - 21.50 mbgl: siltstone
21.50 - 31.00 mbgl: mudstone
End of borehole at 31.00m
Response Zone: 21.50 - 31.00 mbgl.


Groundwater levels ER12 (Shallow Bedrock)
Groundwater level (mAOD)
30.0
29.0
28.0
27.0
26.0
25.0
24.0
Rainfall (mm)
0
5
10
15
20
25
30
35
12-Jul-05
12-Aug-05
12-Sep-05
12-Oct-05
12-Nov-05
12-Dec-05
12-Jan-06
12-Feb-06
12-Mar-06
12-Apr-06
12-May-06
12-Jun-06
12-Jul-06
12-Aug-06
12-Sep-06
12-Oct-06
12-Nov-06
12-Dec-06
Date/Time
Pump Test
Data Collection Malfunction
Rainfall (mm)
Groundwater level (mAOD)
Manual Dip (mAOD)
Borehole log summary
0 - 0.20 mbgl: topsoil
0.20 - 1.40 mbgl:brown fill
1.40 - 13.90 mbgl: clay
13.90 - 18.00 mbgl: gravel
18.00 - 20.50 mbgl: sand
20.50 - 30.50 mbgl: limestone
End of borehole at 30.50 mbgl
Response Zone: 21.50 - 30.00 mbgl.

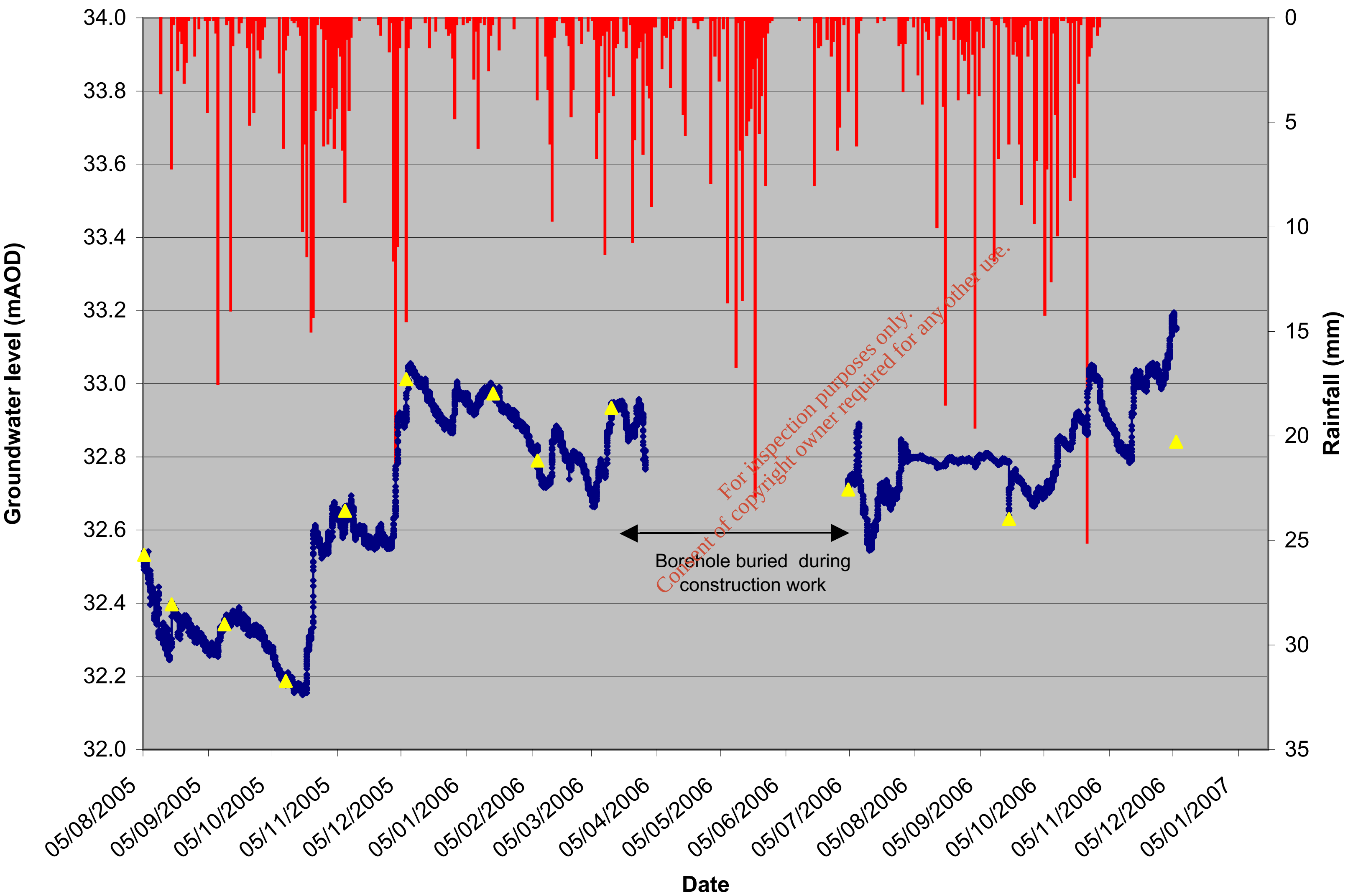


Borehole log summary
0 - 0.10 mbgl: topsoil
0.10 - 21.80 mbgl: clay
21.80 - 24.60 mbgl: gravel
End of borehole at 24.60 mbgl
Response zone: 22.10 - 24.60 mbgl

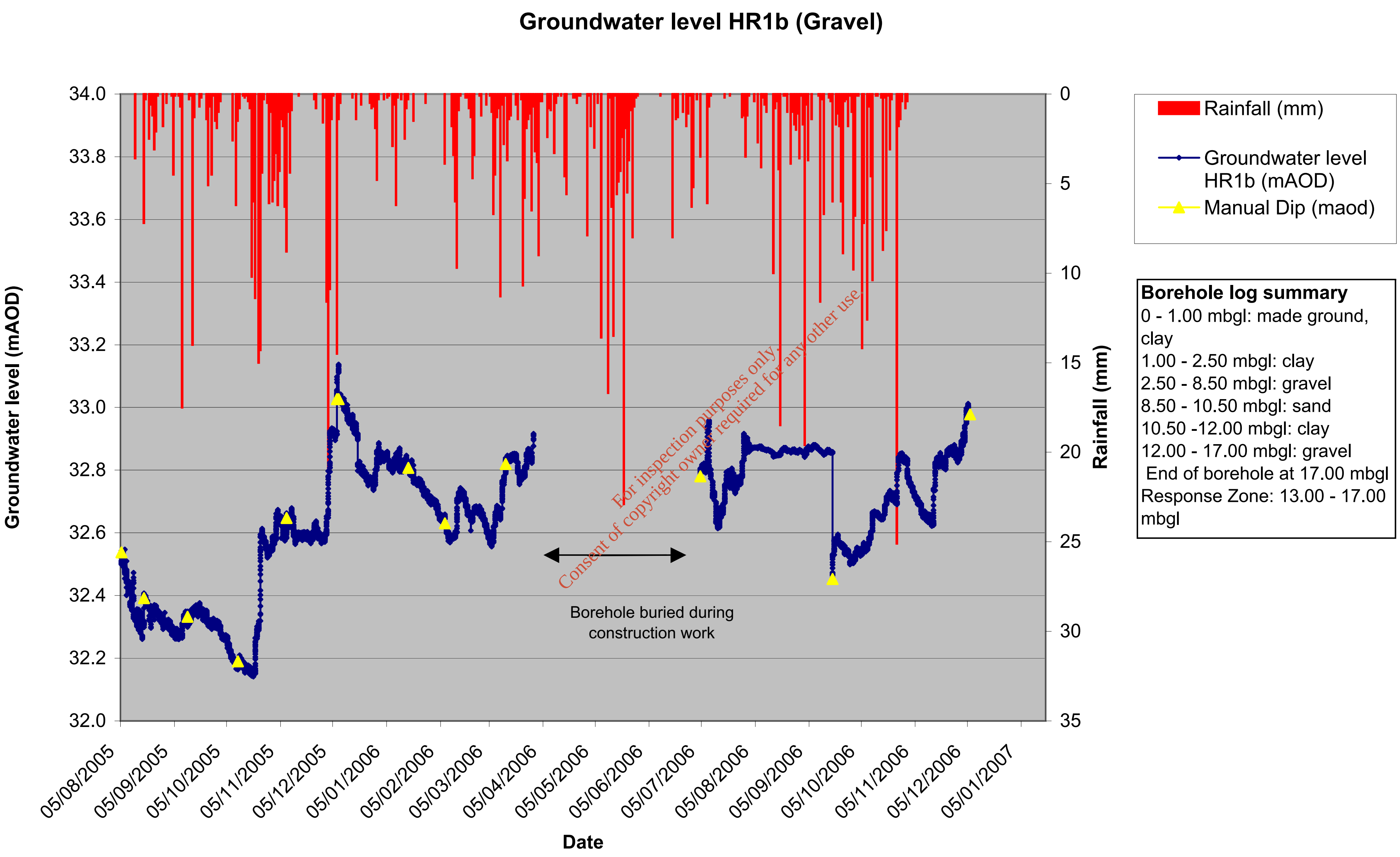


Borehole log summary
0 - 0.30 mbgl: topsoil
0.30 - 1.80 mbgl: firm brown clay
1.80 - 2.10 mbgl:stiff grey clay
2.10 - 9.30 mbgl: stiff black clay
9.30 - 11.80 mbgl: gravel
Borehole ends at 11.80 mbgl, boulder.
Response Zone: 9.50 - 11.50 mbgl.

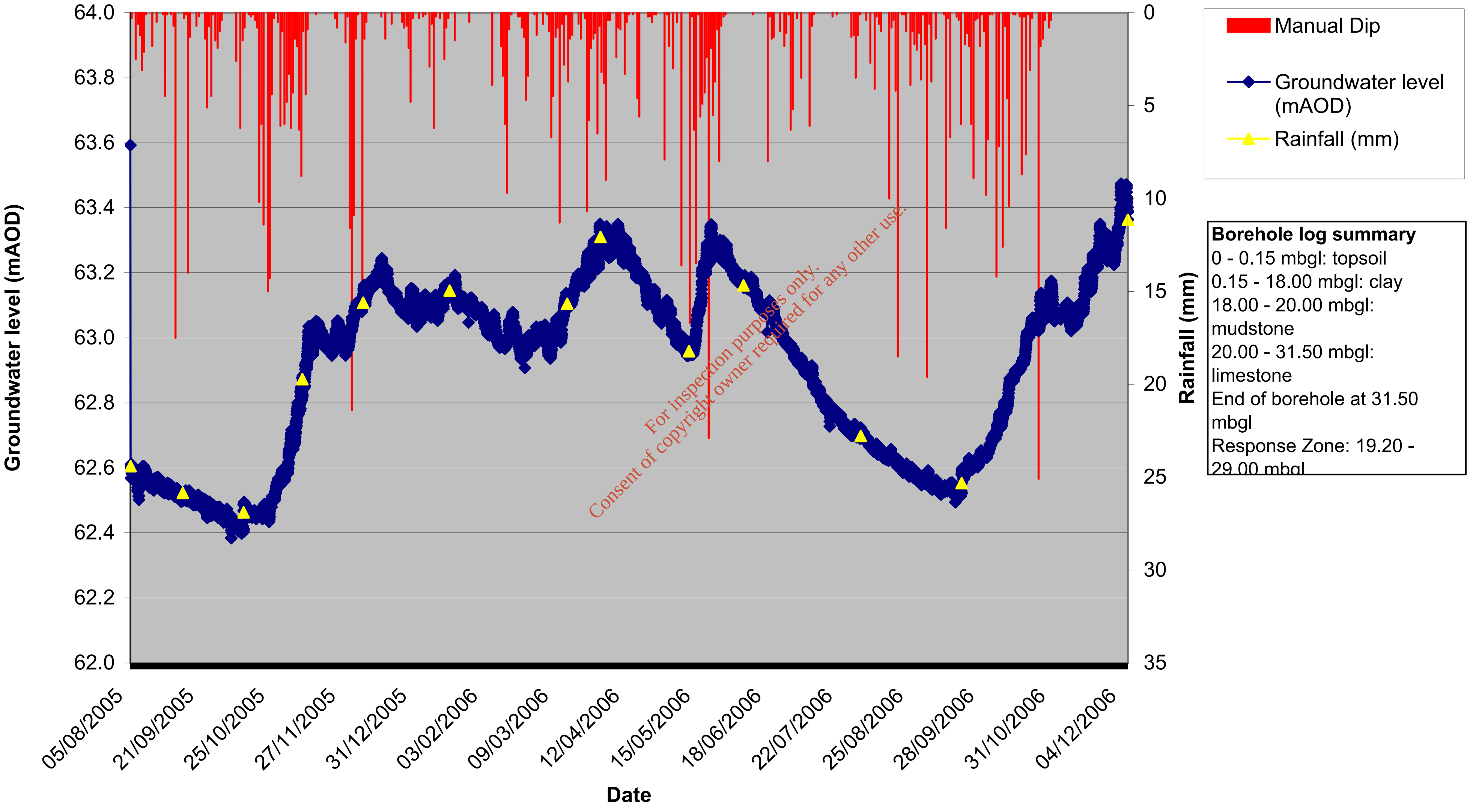
Groundwater Levels HR1a (Shallow Bedrock)

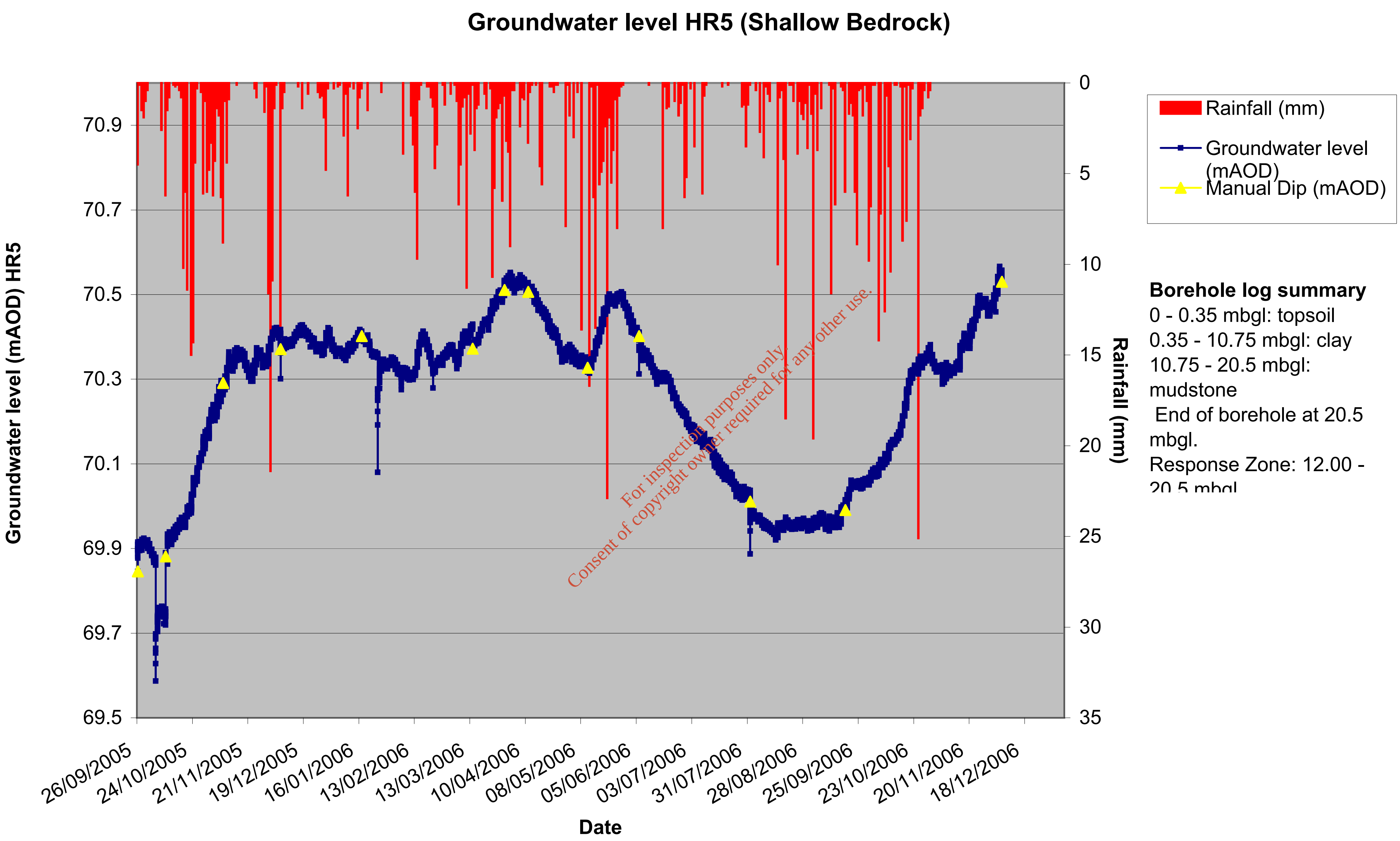


Borehole log summary
0 - 1.00 mbgl: made ground, clay
1.00 - 4.00 mbgl: clay
4.00 - 17.00 mbgl: sandy gravel
17.00 -27.70 mbgl: limestone
End of borehole at 27.7 mbgl.
Response Zone 18.75 - 27.7 mbgl

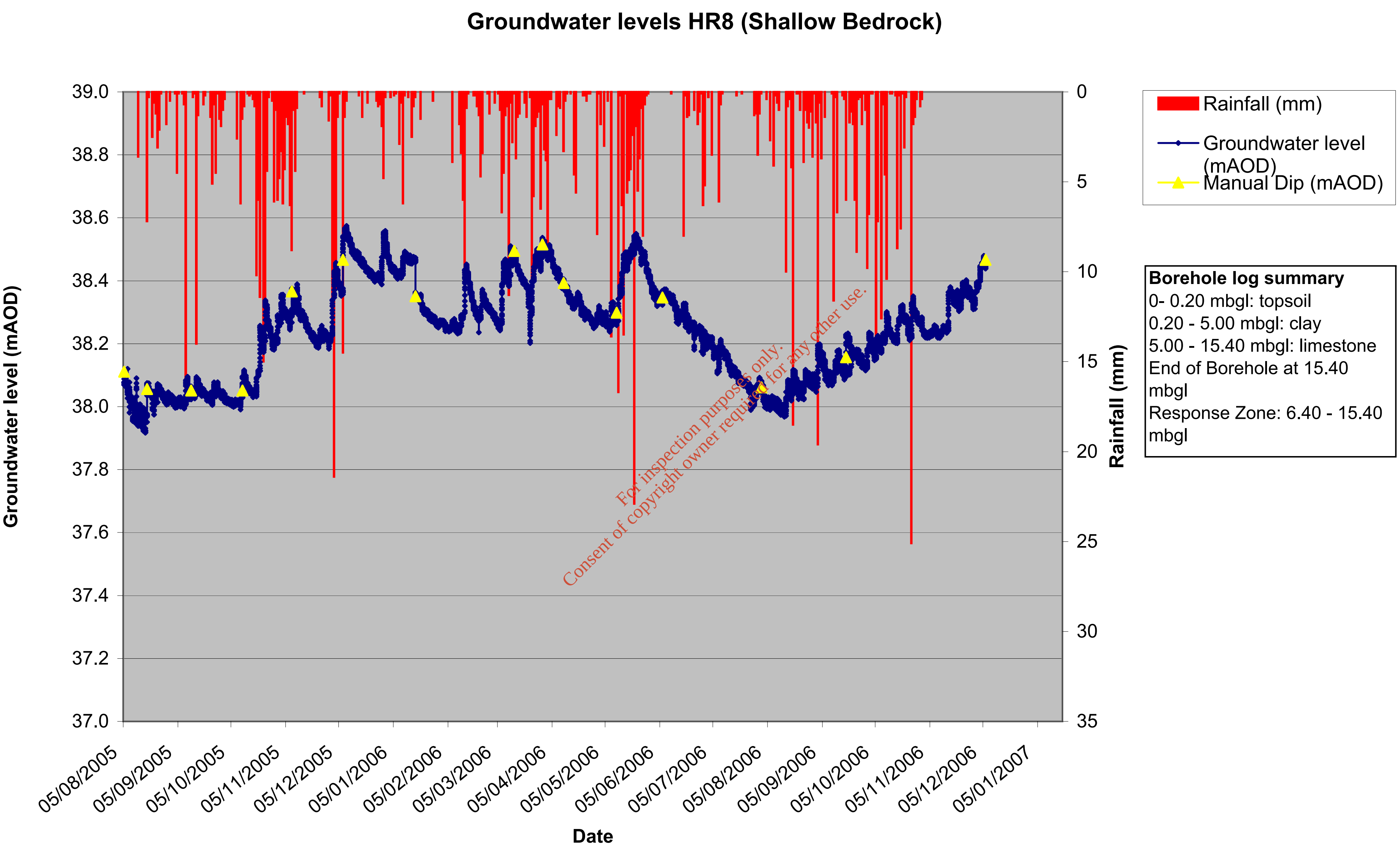

Groundwater level HR1b (Gravel)
Groundwater level (mAOD)
Rainfall (mm)
Date
Borehole buried during construction work
Rainfall (mm)
Groundwater level HR1b (mAOD)
Manual Dip (maod)
Borehole log summary
0 - 1.00 mbgl: made ground, clay
1.00 - 2.50 mbgl: clay
2.50 - 8.50 mbgl: gravel
8.50 - 10.50 mbgl: sand
10.50 -12.00 mbgl: clay
12.00 - 17.00 mbgl: gravel
End of borehole at 17.00 mbgl
Response Zone: 13.00 - 17.00 mbgl
34.0
33.8
33.6
33.4
33.2
33.0
32.8
32.6
32.4
32.2
32.0
0
5
10
15
20
25
30
35
05/08/2005
05/09/2005
05/10/2005
05/11/2005
05/12/2005
05/01/2006
05/02/2006
05/03/2006
05/04/2006
05/05/2006
05/06/2006
05/07/2006
05/08/2006
05/09/2006
05/10/2006
05/11/2006
05/12/2006
05/01/2007

Groundwater levels (mAOD) at HR4 (Shallow Bedrock)

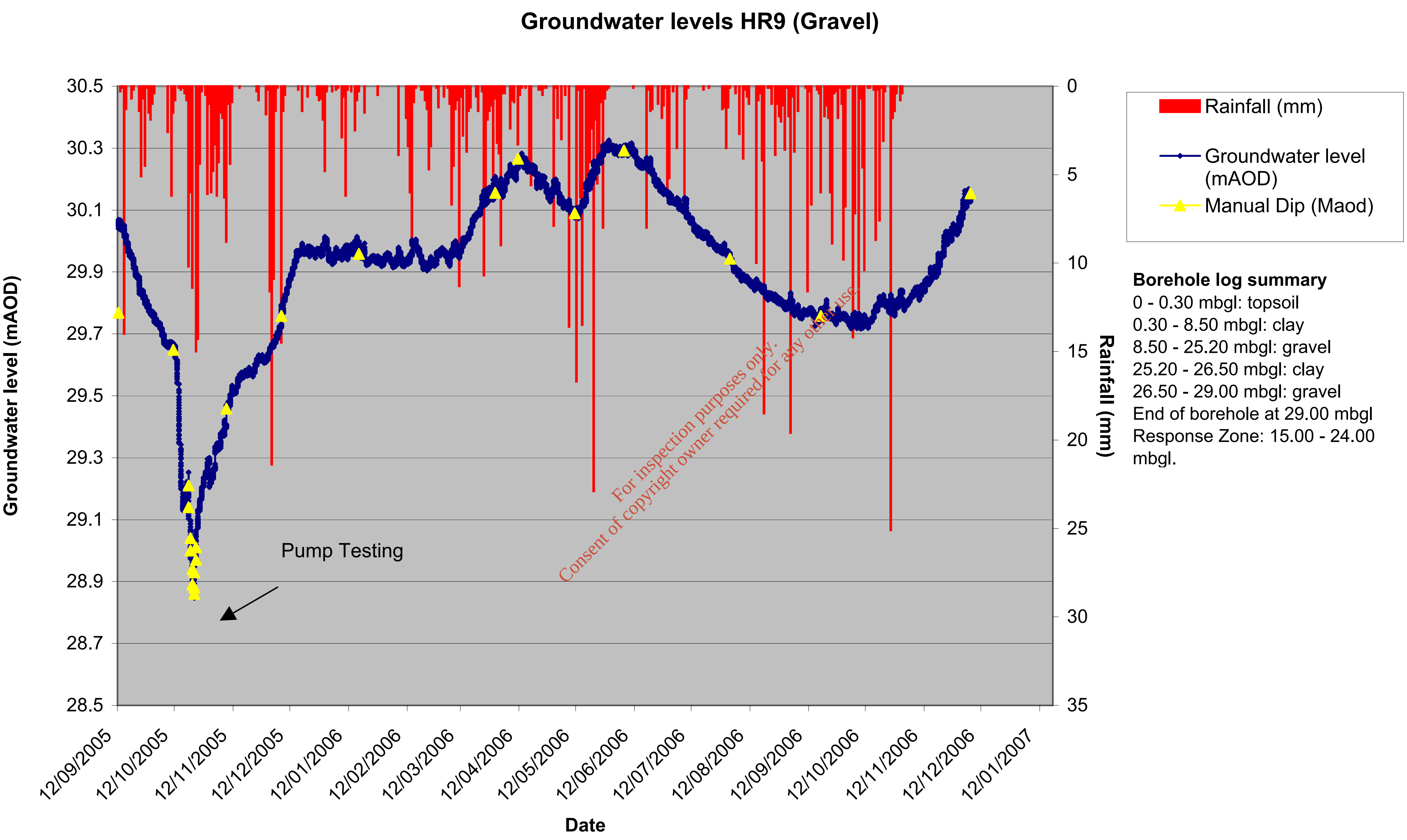




Borehole log summary
0 - 0.35 mbgl: topsoil
0.35 - 10.75 mbgl: clay
10.75 - 20.5 mbgl: mudstone
End of borehole at 20.5 mbgl.
Response Zone: 12.00 - 20.5 mbgl

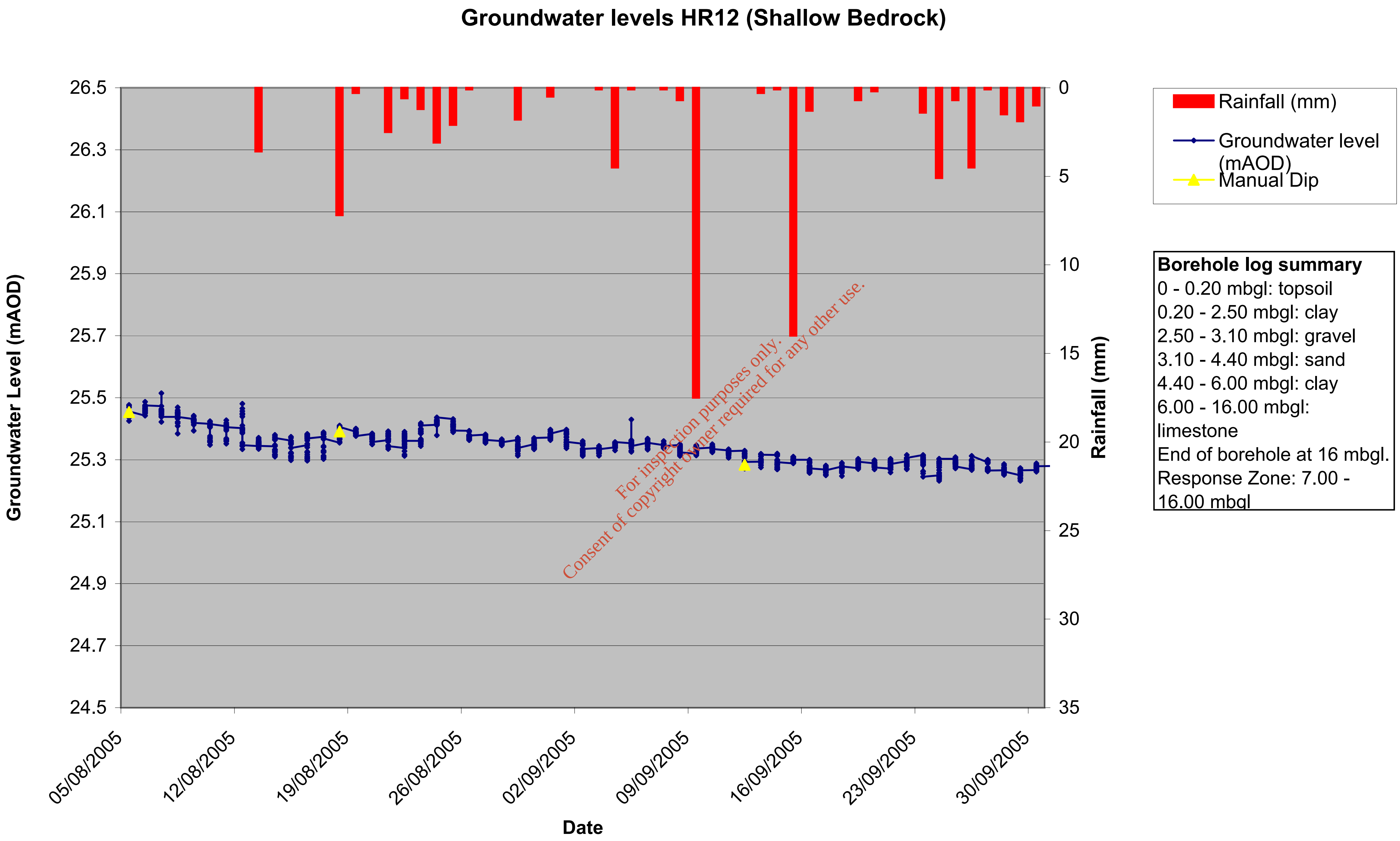


Groundwater levels HR8 (Shallow Bedrock)
Groundwater level (mAOD)
39.0
38.8
38.6
38.4
38.2
38.0
37.8
37.6
37.4
37.2
37.0
Rainfall (mm)
0
5
10
15
20
25
30
35
05/08/2005
05/09/2005
05/10/2005
05/11/2005
05/12/2005
05/01/2006
05/02/2006
05/03/2006
05/04/2006
05/05/2006
05/06/2006
05/07/2006
05/08/2006
05/09/2006
05/10/2006
05/11/2006
05/12/2006
05/01/2007
Date
Rainfall (mm)
Groundwater level (mAOD)
Manual Dip (mAOD)
Borehole log summary
0- 0.20 mbgl: topsoil
0.20 - 5.00 mbgl: clay
5.00 - 15.40 mbgl: limestone
End of Borehole at 15.40 mbgl
Response Zone: 6.40 - 15.40 mbgl

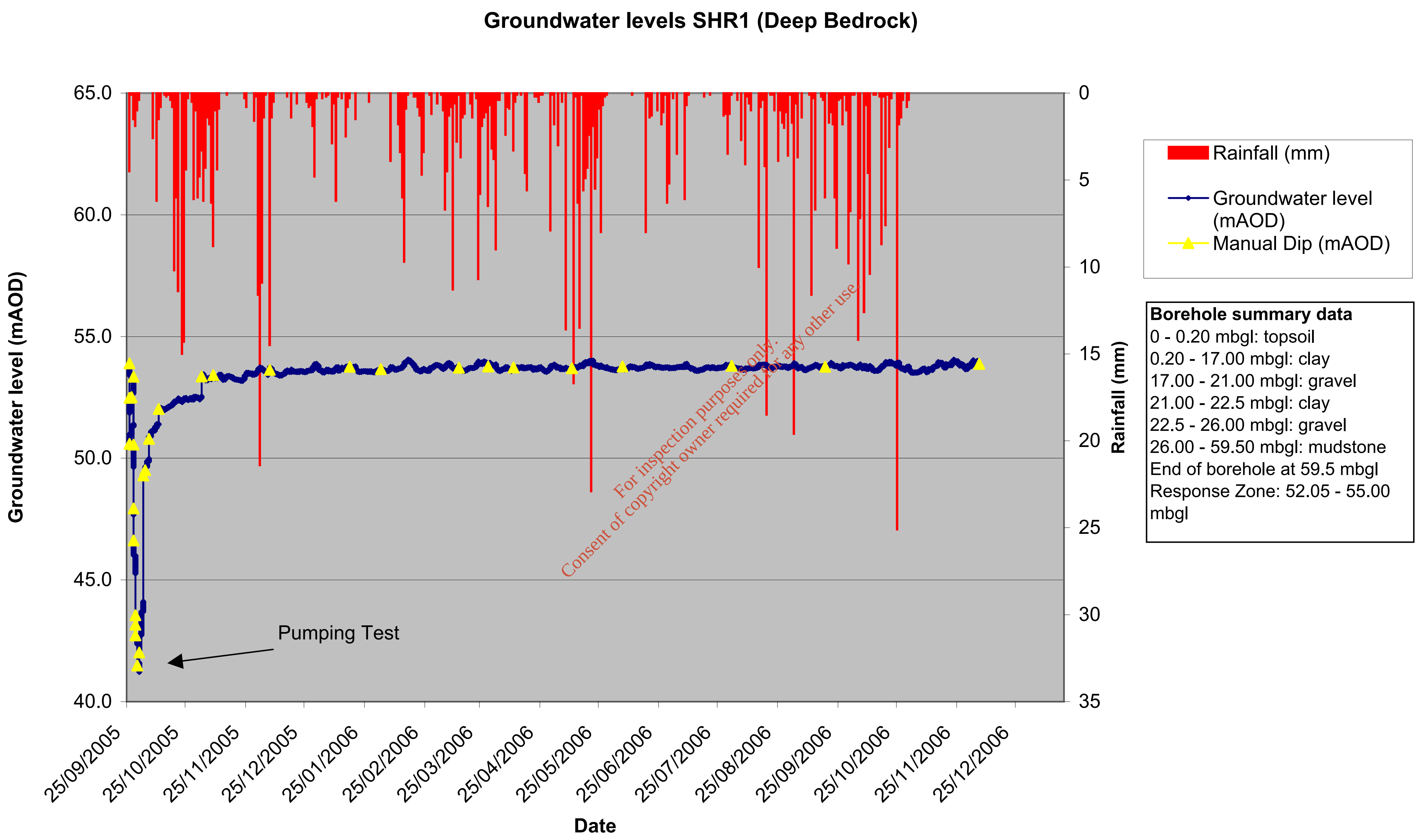


Borehole log summary

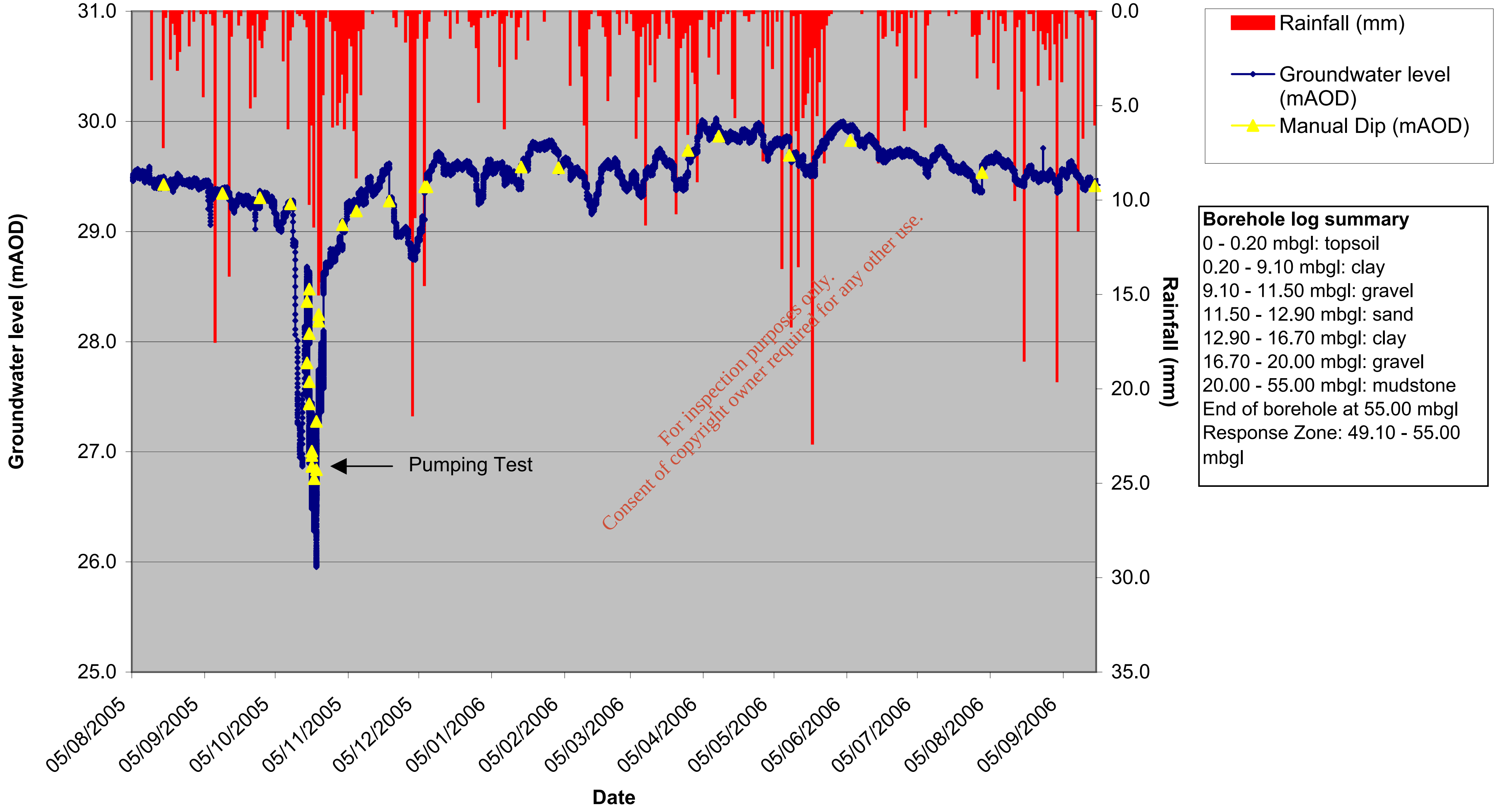
0 - 0.30 mbgl: topsoil
0.30 - 8.50 mbgl: clay
8.50 - 25.20 mbgl: gravel
25.20 - 26.50 mbgl: clay
26.50 - 29.00 mbgl: gravel
End of borehole at 29.00 mbgl
Response Zone: 15.00 - 24.00 mbgl.



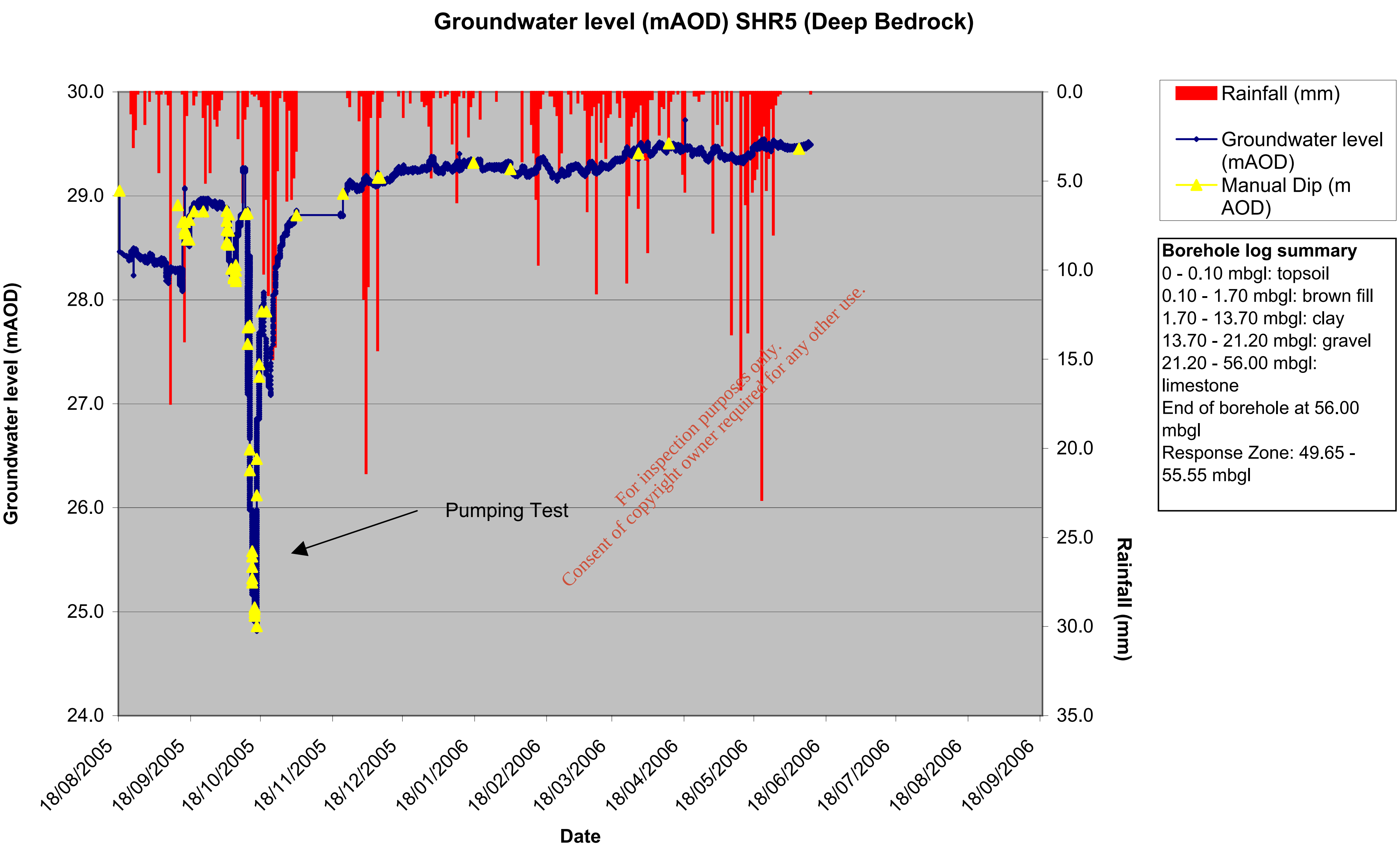
Borehole log summary
0 - 0.20 mbgl: topsoil
0.20 - 2.50 mbgl: clay
2.50 - 3.10 mbgl: gravel
3.10 - 4.40 mbgl: sand
4.40 - 6.00 mbgl: clay
6.00 - 16.00 mbgl: limestone
End of borehole at 16 mbgl.
Response Zone: 7.00 - 16.00 mbgl


Groundwater levels SHR1 (Deep Bedrock)
Groundwater level (mAOD)
65.0
60.0
55.0
50.0
45.0
40.0
Rainfall (mm)
0
5
10
15
20
25
30
35
Pumping Test
25/09/2005
25/10/2005
25/11/2005
25/12/2005
25/01/2006
25/02/2006
25/03/2006
25/04/2006
25/05/2006
25/06/2006
25/07/2006
25/08/2006
25/09/2006
25/10/2006
25/11/2006
25/12/2006
Date
Rainfall (mm)
Groundwater level (mAOD)
Manual Dip (mAOD)
Borehole summary data
0 - 0.20 mbgl: topsoil
0.20 - 17.00 mbgl: clay
17.00 - 21.00 mbgl: gravel
21.00 - 22.5 mbgl: clay
22.5 - 26.00 mbgl: gravel
26.00 - 59.50 mbgl: mudstone
End of borehole at 59.5 mbgl
Response Zone: 52.05 - 55.00 mbgl

Groundwater levels SHR2 (Deep Bedrock)

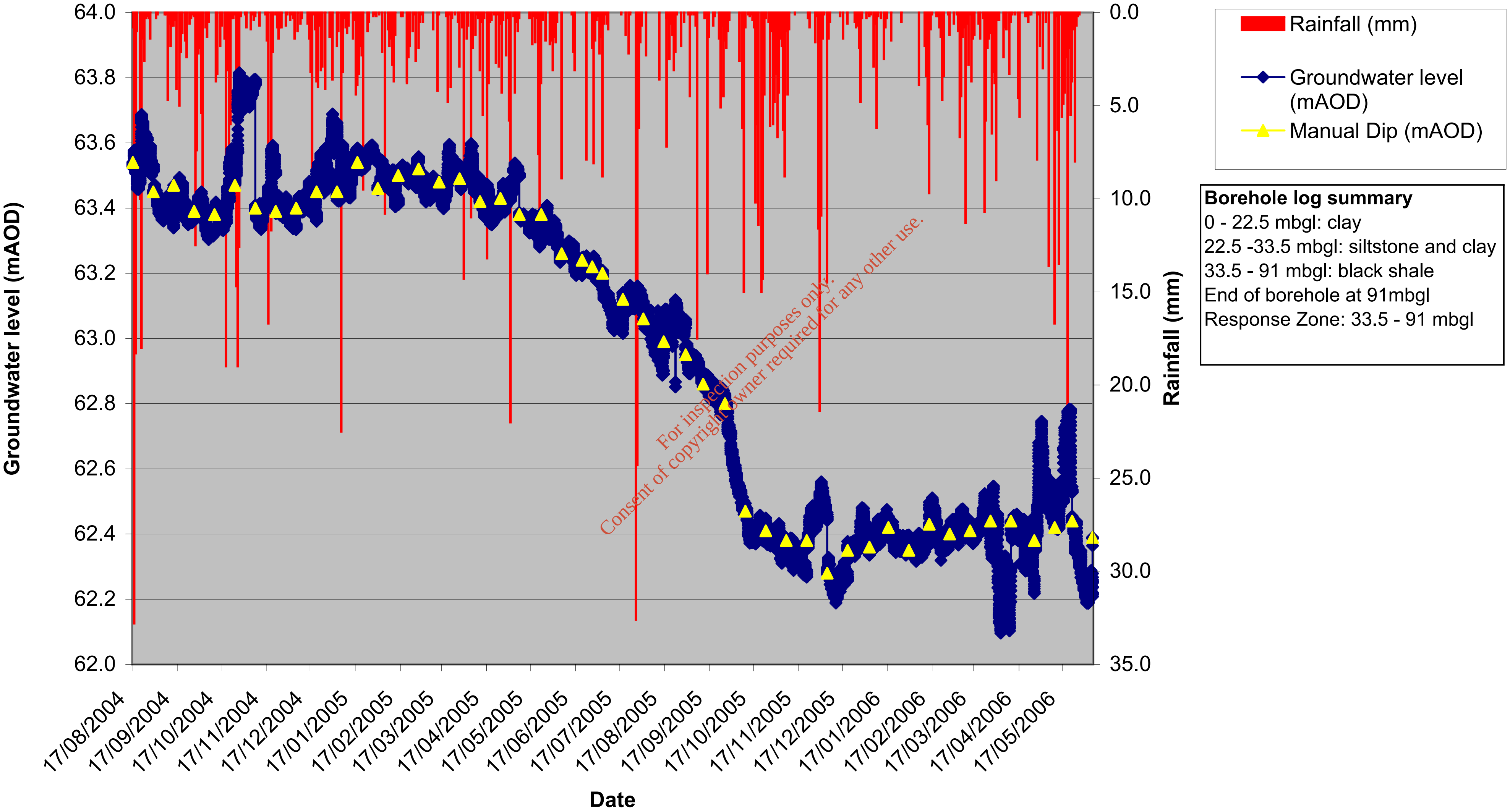


Borehole log summary
0 - 0.20 mbgl: topsoil
0.20 - 9.10 mbgl: clay
9.10 - 11.50 mbgl: gravel
11.50 - 12.90 mbgl: sand
12.90 - 16.70 mbgl: clay
16.70 - 20.00 mbgl: gravel
20.00 - 55.00 mbgl: mudstone
End of borehole at 55.00 mbgl
Response Zone: 49.10 - 55.00 mbgl



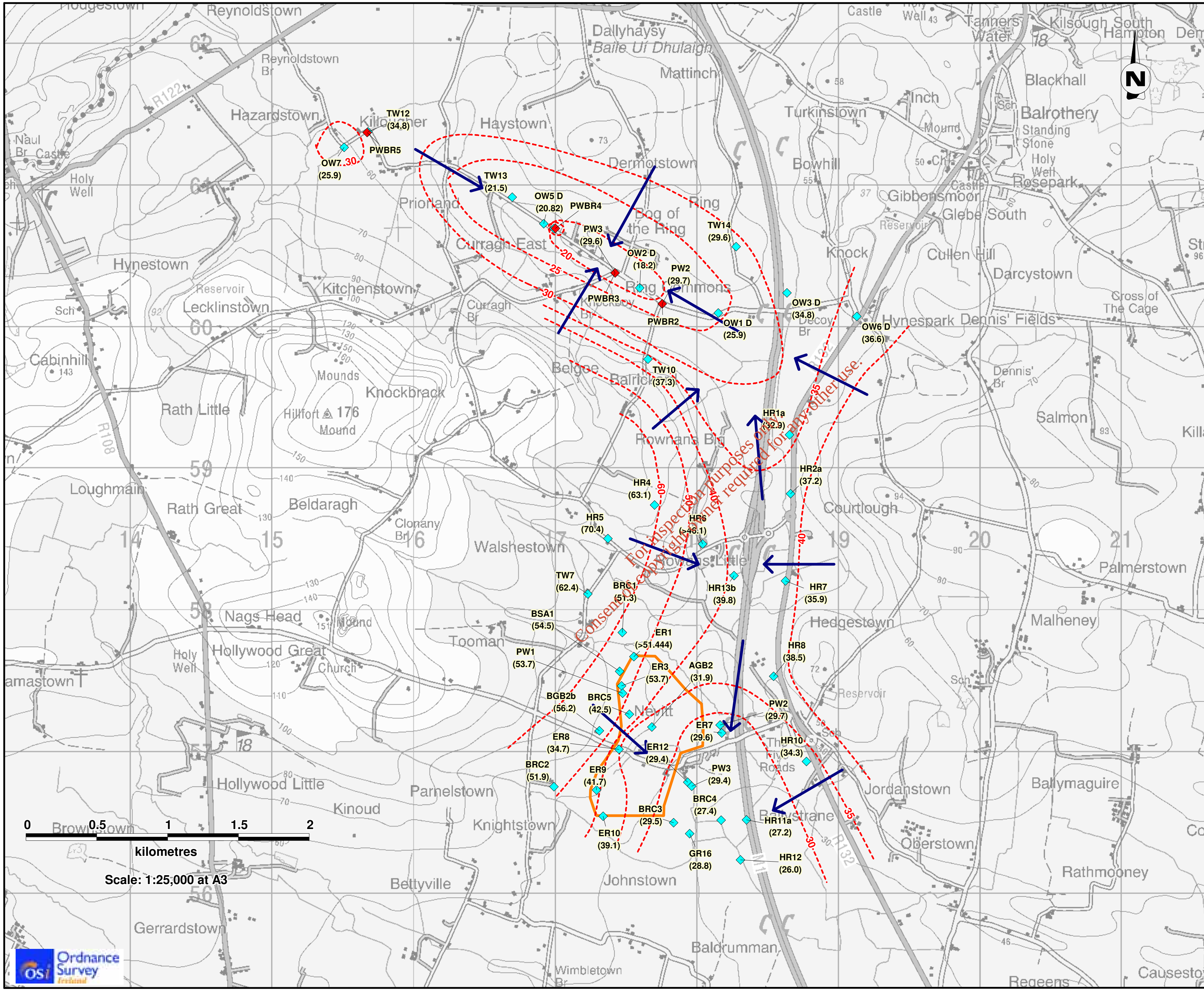
Borehole log summary
0 - 0.10 mbgl: topsoil
0.10 - 1.70 mbgl: brown fill
1.70 - 13.70 mbgl: clay
13.70 - 21.20 mbgl: gravel
21.20 - 56.00 mbgl: limestone
End of borehole at 56.00 mbgl
Response Zone: 49.65 - 55.55 mbgl

Groundwater Levels (mAOD) TW7



APPENDIX 6

GROUNDWATER FLOW MAPS



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

Comhairle Contae Fhine Gall

Project

Fingal Landfill

Title

Groundwater Contours (mAOD)
Bedrock
14th March 2006

APPENDIX A x

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Issue Details

Drawn:	CR/SK/AA	Project No.	MDR0303
Checked:	F. Collins	File Ref.	MDR0303MI0211A02
Approved:	S.Herlihy		
Scale:	1:25000 at A3	Drawing No. MI0211	Rev. A02
Date:	18/01/2007		

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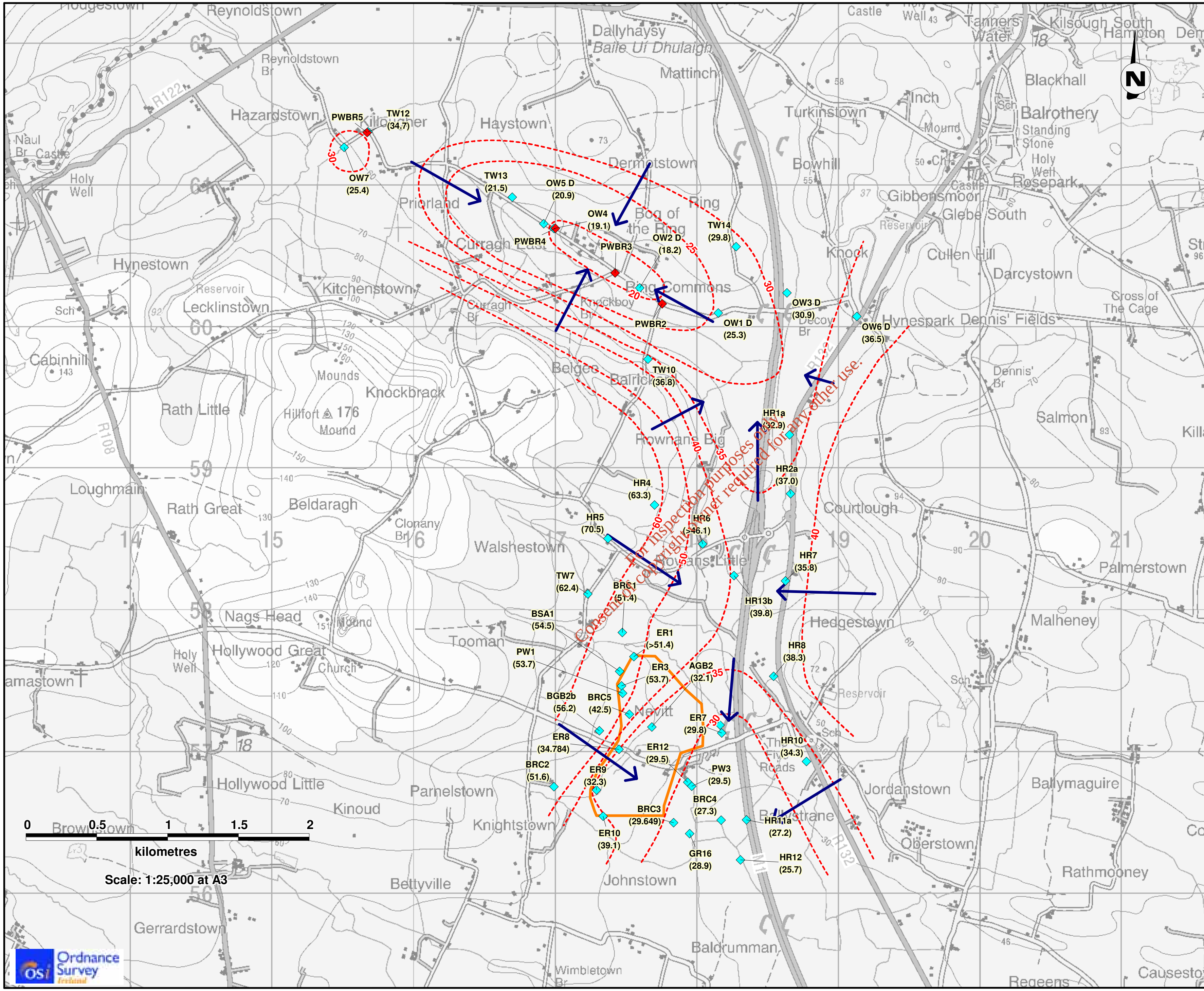
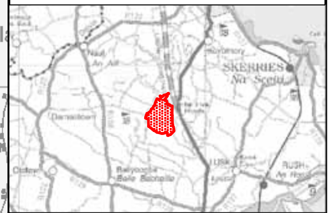


Legend

- 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

Project
Fingal Landfill

Title
Groundwater Contours (mAOD) Bedrock 11th April 2006

APPENDIX A x

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Issue Details

Drawn:	CR/SK/AA	Project No.	MDR0303
Checked:	F. Collins	File Ref.	MDR0303MI0212A02
Approved:	S.Herlihy		
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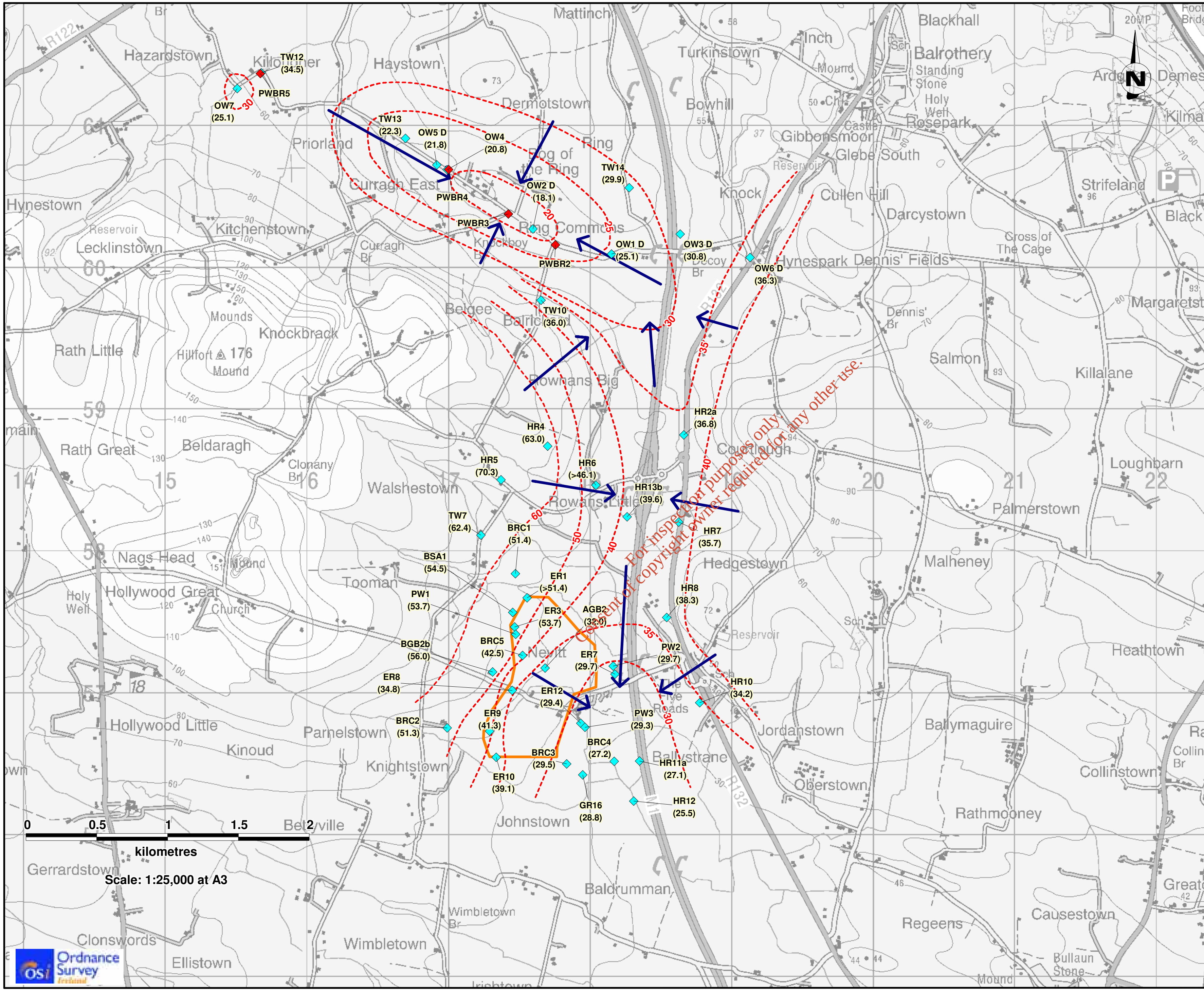

Legend

- 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
Comhairle Contae Fhine Gall

Project

Fingal Landfill

Title

Groundwater Contours (mAOD)
Bedrock
11th May 2006

APPENDIX A x

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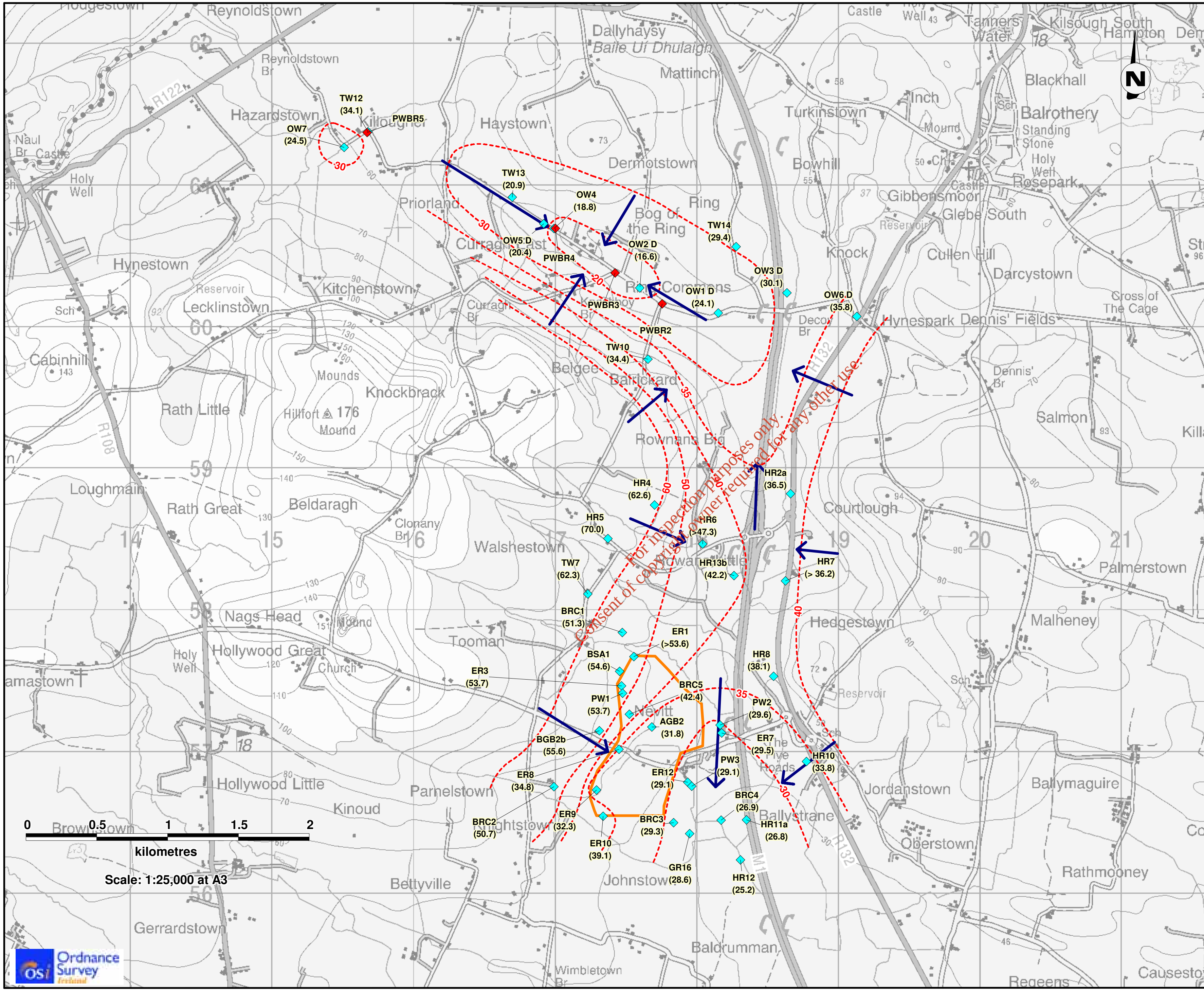

Legend

- 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
Comhairle Contae Fhine Gall

Project
Fingal Landfill

Title
Groundwater Contours (mAOD)
Bedrock
1st August 2006

Figure A.2

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Issue Details

Drawn: SK/AA		Project No. MDR0303	
Checked: F. Collins		File Ref. MDR0303MI0214A02	
Approved: S. Herlihy			
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Date: 18/01/2007			

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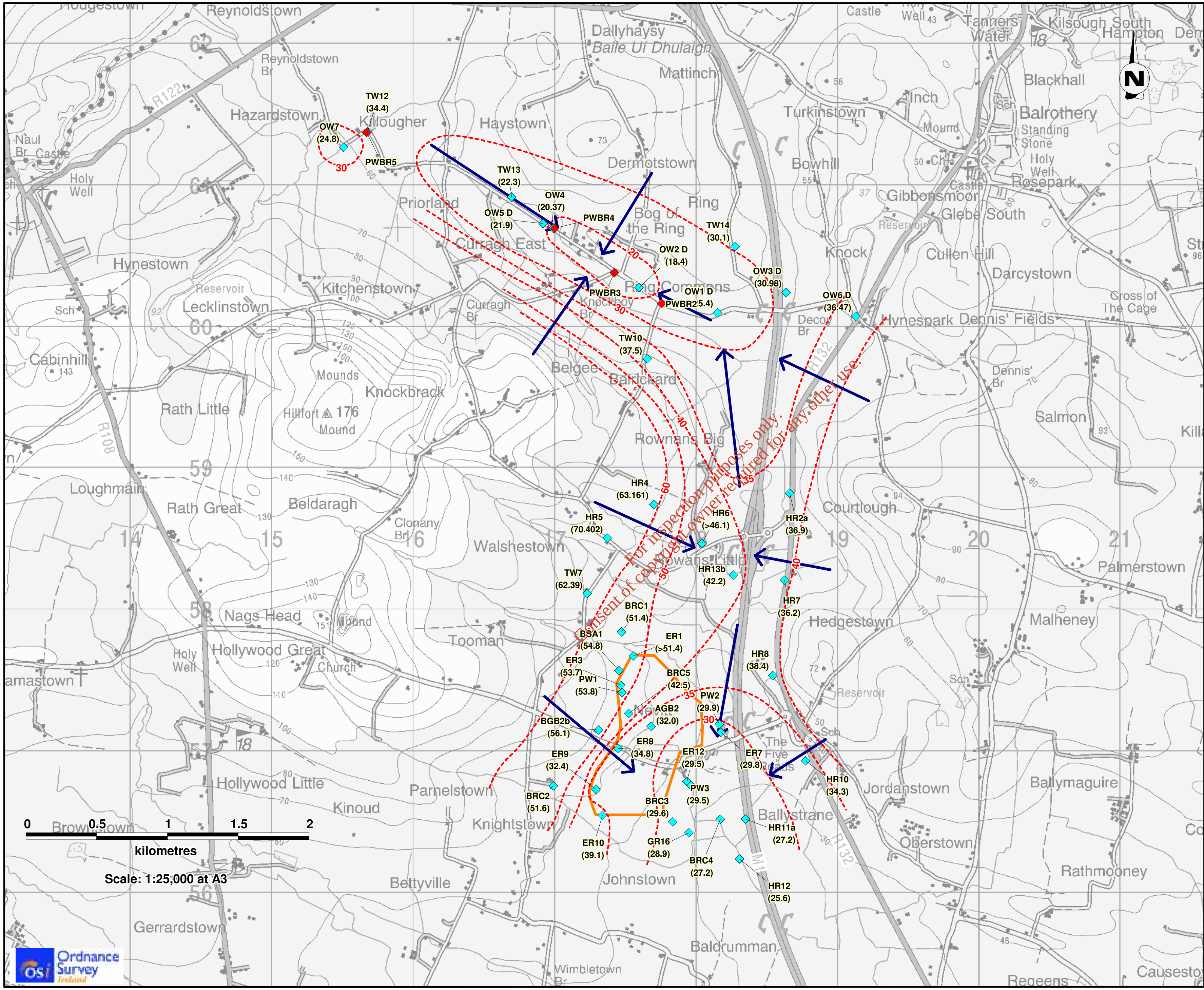

Legend

- 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
Comhairle Contae Fhine Gall

Project
Fingal Landfill

Title
Groundwater Contours (mAOD)
Bedrock
6th June 2006

Figure xxx

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Issue Details

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Checked: FC		**File Ref.** MDR0303MI0215A02	
Approved: S. Herlihy			
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Date: 18/01/2007			

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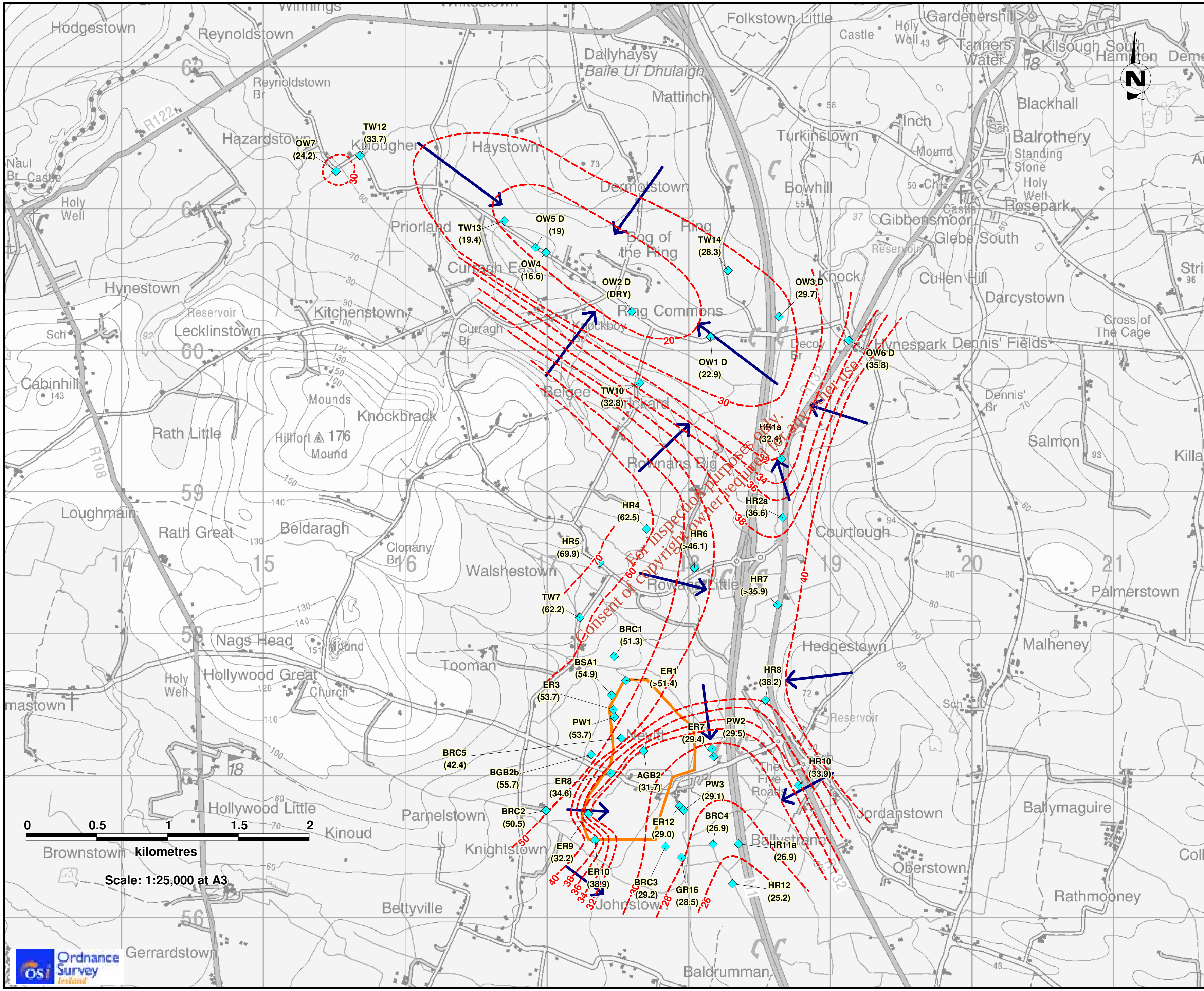

Legend

BRC2 (51.72) Borehole ID (Waterlevel mAOD)

30 Groundwater Contour (mAOD)

Groundwater Flow Direction

Proposed Landfill Footprint

Fingal County Council

Project

Fingal Landfill

Title

Groundwater Contours (mAOD) Bedrock 18th September 2006

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Issue Details

Drawn:	H. Steinberg/SK/AA	Project No.	MDR0303
Checked:	F. Collins	File Ref.	MDR0303MI0235A01
Approved:	S.Herlihy		
Scale:	1:25000 at A3	Drawing No. MI0235	Rev. A01
Date:	08/01/2007		

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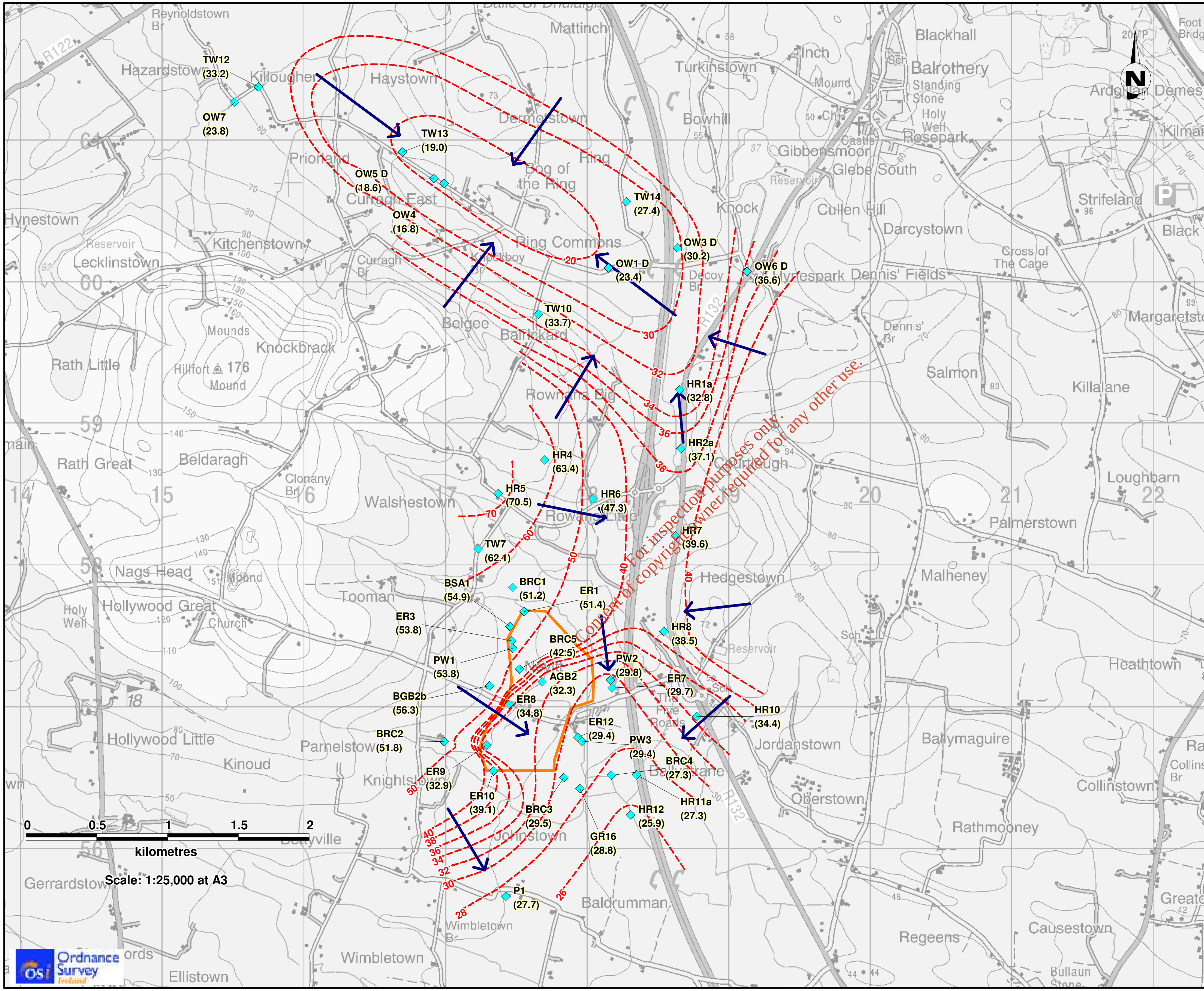

Legend

BRC2 (51.72) Borehole ID (Waterlevel mAOD)

30 Groundwater Contour (mAOD)

Groundwater Flow Direction

Proposed Landfill Footprint

Fingal County Council

Project

Fingal Landfill

Title

Groundwater Contours (mAOD) Bedrock 6th December 2006

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Issue Details

Drawn:	S. Khan	Project No.	MDR0303
Checked:	F. Collins/Y. Cannon	File Ref.	MDR0303MI0239A01
Approved:	S.Herlihy		
Scale:	1:25,000 at A3	Drawing No. MI0239	Rev. A01
Date:	09/01/2007		

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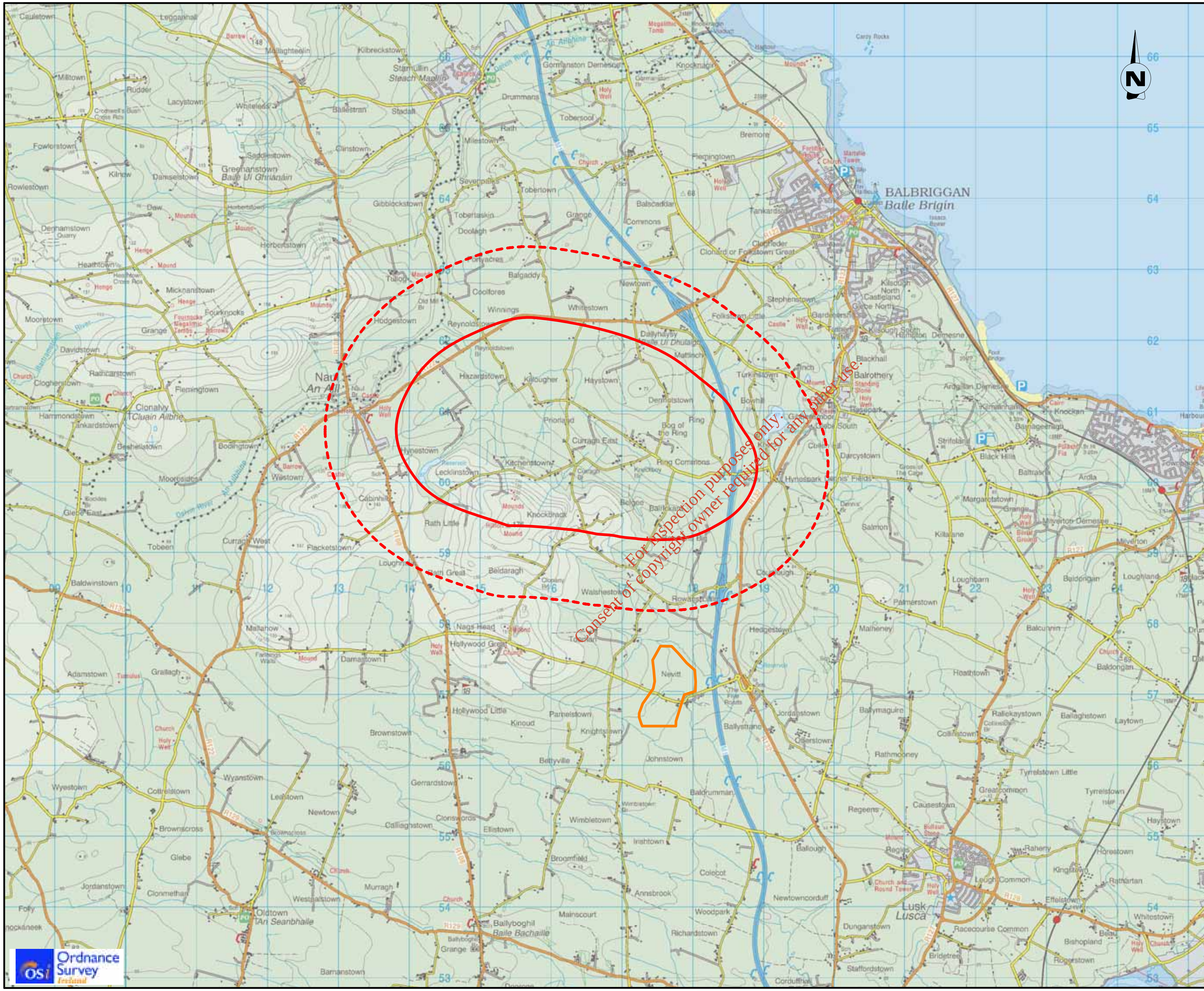
APPENDIX 7

BOG OF THE RING
CONE OF DEPRESSION

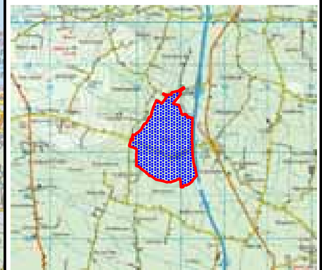


Legend

Cone of Depression (CoD)

100% Expansion of CoD

Proposed Landfill Footprint



Fingal County Council

Comhairle Contae Fhine Gall

Project

Fingal Landfill

Title

Bog Of The Ring Pumping Wells Cone of Depression, 2006

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Issue Details

Drawn:	S. Khan/A.A.	Project No.	MDR0303
Checked:	F. Collins/Y. Cannon	File Ref.	MDR0303MI0242D01
Approved:	S.Herlihy		
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Date:	10/01/2007		

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