(6)

Dr Stephen Barnes BSc MSc PhD FGS (Golder Associates)

Mr David Hall BSc MSC CGeol (Golder Associates)

EPA Oral Hearing, Bracken Court Hotel, Balbriggan – 28 April 2009 (Slide 1)

Re: Fingal Landfill Project

Statement of Evidence

Qualifications of Authors (Slide 2)

Dr Stephen Barnes BSc MSc PhD FGS. I have a BSc (Hons) in Geology, an MSc in Hydrogeology, and a PhD from Queens University Belfast on the hydrogeology of the Chalk and basalt aquifers in Northern Ireland. Following qualification at MSc level, I have gained over 14 years experience in academia (inc. Postdoctoral research), industry and consultancy environments. This has included working as the sole hydrogeologist in the largest waste management company in the UK, and as a member of the Waste and Resource Management Group at Golder Associates (UK) Ltd.

I have specialist understanding of landfill risk assessment and have either managed or completed hydrogeological risk assessments for approximately 100 different landfill sites across the UK and Ireland. These have covered all manner of sites settings, waste types (from inert to hazardous), life cycle stages, engineered designs, and management practices.. The work has contributed to numerous planning applications, and Waste Management Licence (WML) and Pollution Prevention and Control (PPC) permit applications, and has helped to constrain risks, landfill designs and leachate and landfill management protocols within the context of the governing requirements presented within the Landfill Directive and Groundwater Directive.

I am an experienced landfill performance modeller. I have routinely used LandSim for the past ten years and since version 1.0. Since 2003 I have been a LandSim trainer for the regulatory authorities (Environment Agency (England and Wales), Scottish Environment Protection Agency, and the Northern Ireland Environment Agency)), other consultants and clients. I have also been using the Environment Agency's SC0310 Hydraulic Containment Model since its release in 2004.

(Slide 3)

Mr David Hall BSc MSc CGeol. David holds a BSc in Geological Sciences and an MSc in Hydrogeology and Water Resources. David has over 30 years professional experience. He specialises in contaminant migration, the assessment of solid waste disposal sites, and the assessment and modelling of contaminated land. He initiated the development the LandSim risk model and has been its project director from 1994 to date, and project director of the ConSim model since 1999. David has been working within the waste management and environmental fields for over 30 years in research institutes, local government and private sector consulting. He has been involved in the setting of Waste Acceptance Criteria on behalf of the Environment Agency and the UK Government, and has recently completed research in to landfill sustainability and waste related life cycle assessment, as well as assisting clients with site permitting and landfill / waste treatment plant development. He has published extensively on the performance assessment of landfills, groundwater impact assessment, and numerical probabilistic risk assessment.

OH(2) Sub No. 6

Recd From: Greenstar

Date: 28/4/09 11.05am

Nature of Objection

This Statement will demonstrate that the Hydrogeological Risk Assessment upon which this oral hearing is based, is fundamentally flawed. We believe that the outputs are not conservative, the use of LandSim during key stages of the lifecycle is not appropriate, and the overall results are misleading.

The HRA is derived from an inaccurate and incomplete conceptual model, and does not demonstrate that the proposed landfill development can comply with the requirements of the Groundwater Directive throughout its entire lifecycle. The apparent success of the submission, in part relies upon the assumption that List I substances can be discharged to groundwater in the shallow drift. Indeed, essentially the lack of understanding and clarity associated with the behaviour of the shallow groundwater system at the site, and how the development will be managed and interact with this system throughout its lifecycle, is only possible if the escape of listed substances from the site to groundwater in the drift is permitted.

In addition, other uncertainties remain regarding key elements of the conceptual understanding of the site. These relate to how the landfill will be developed and operated, the nature of pathways modelled for contaminants migrating from the site, and the location of the receptors. Notwithstanding the above, the landfill performance modelling presented includes assumptions or omissions which collectively are judged likely to overestimate the landfill's performance and to give grossly over-optimistic results.

On 17 October 2008 the Environmental Protection Agency requested a risk assessment evaluating 'groundwater below the proposed facility'. Section 1.2 of the HRA states that the report objective is to 'evaluate the potential for leakage and migration to groundwater within the aquifer unit beneath the site'. The aquifer unit is defined by the applicant as comprising the bedrock and the overlying gravel. The shallow groundwater is effectively ignored, and consequently the HRA does not deal effectively with the EPA request. This discrepancy is coupled with the omission of other potential pathways and receptors in the vicinity of the proposed landfill and is believed to result in many of the issues identified within our statement.

It is important to recognize that this is the second request for numerical model in relation to this application. An Article 14 Notice by the EPA in November 2006 originally requested a numerical model for the site using MODFLOW or similar software. The applicant advised the EPA, that in their opinion, it was unnecessary. Had that modeling been undertaken as requested, it would have provided an opportunity to fully investigate and understand the site including the conceptual understanding of the development area.

A Conceptual Model

Pathways

The shallow overburden (clay rich drift) has been presented schematically within the Hydrogeological Risk Assessment (HRA), on Figure 006, as having a perched water table. However, lateral flow gradients associated with this water table are not discussed, nor the associated potential for provision of natural baseflow discharging from this unit to streams that exist to the north, south and east of the landfill. In addition, an accurate groundwater contour plot for the shallow drift has not been provided. The possibility for migration of listed substances within the drift to peripheral streams has not, in our opinion, been assessed. It follows that this potential discharge has therefore not been modelled either. In many sedimentary formations, lateral permeability often exceeds vertical permeability by orders of magnitude (i.e. by factors of 10-100 or more). As a consequence, the bulk of groundwater flow within the drift may be occurring laterally as opposed to the vertical direction assumed and modelled in the HRA. We regard formulating an understanding of this shallow groundwater flow to be a prerequisite to understanding the site's conceptual model, itself a prerequisite to modelling the site using LandSim or any other model. (Slide 4)

Although individual groundwater dip readings were not included in the submission, hydrographs (graphs showing water level fluctuations) contained in the submission, allow the estimation of selected groundwater levels in boreholes across the site. It appears that the shallow drift water table in general, approximates the underlying piezometric surface (i.e. water pressure elevation) from the Gravel/Bedrock aquifer (this applies to shallow drift holes (ER13, ES2, HR9, GS6, ASA2, GS2). Given the data available, the only observed exception to this is for monitoring location ES8, where the shallow drift groundwater elevation can be in the order of 10 m above the hydraulic head in the underlying Gravel/Bedrock unit in the vicinity of this hole. This could mean that from these data, only the groundwater elevation at location ES8 may be best described as perched. This suggests that the hydraulic interaction between the shallow drift and underlying Gravel/Bedrock aquifer, and indeed the permeability of the shallow clay rich drift unit as a whole, would be better understood by further comparison of these levels across the site. Such detail is lacking within the HRA submission, but again judged to be of fundamental importance to a landfill risk assessment for this site setting. In our opinion, more information is required across this extensive site footprint (in the order for 57 hectares) to allow for adequate characterisation of groundwater elevations in the shallow drift, than that provided in the submission. We believe that the data provided in evidence yesterday by the applicant at the Oral Hearing (27/04/09) strengthens our view that hydraulic head within the drift approximates, and is strongly influenced by, the aquifer piezometric surface. Both adopt a similar attitude and fall to the southeast across the site. (Slides 5 & 6)

As a minimum, we would have expected to see further analysis of all the shallow drift groundwater elevation data and its behaviour with respect to rainfall, and hydraulic head fluctuation in the Gravel/Bedrock aquifer within the HRA. In addition, several detailed hydrogeological cross–sections produced for the development area highlighting individual sand and gravel bands within the drift in particular would have been beneficial. The potential implications are that the clay rich drift unit could be better interpreted as a leaky confining layer rather than containing a perched water table, or indeed isolated disconnected perched groundwater bodies. The leaky confining model would suggest saturation of the shallow drift is strongly influenced by hydraulic connection with the Gravel/Bedrock system. It is simply not credible to conclude that the saturation state of shallow clay rich drift observed will not be influenced by virtue of the underlying hydraulic pressure within the Gravel/Bedrock (which is in the order of 10m above the base of the shallow drift and Gravel/Bedrock interface), while at the same time modelling vertical downward seepage through this unit driven by a 1m leachate head contained within an engineered HDPE membrane.

Furthermore, the drift's permeability may be greater than that defined by the individual slug and clay sample testing presented. Failure to properly understand the shallow groundwater relationship could lead to a misinterpretation of the 'Groundwater' status as recognised by the Groundwater Directive (see below). (Slide 7)

Receptors

Groundwater within the clay rich drift is viewed by the applicant as a pathway only within the submission and not as a receptor. The Groundwater Directive and Water Framework Directive state that 'Groundwater' means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. The Directive also states that the discharge of List I substances to groundwater is prohibited. We have seen no justification to support the fact that the 'perched' water table as it is described within the drift (Figure 3.18.7 of the EIS and Figure 006 of the HRA) does not meet the above referenced specification, and therefore that List I substances can be legitimately discharged to this water. Concentrations were modelled and reported at the base of 10 m of clay drift and but have not been presented prior to entry into the drift groundwater. We are unaware of any sites in Ireland, or indeed the UK, where the release of List I substances has been authorised, to what is described by the applicant in the EIS, as a groundwater table.

In general, and at the desk study stage, landfill site location policy is linked to aquifer status. However, following site selection, and at the site specific risk assessment stage, a robust demonstration that groundwater quality will be protected is required regardless of the aquifer status. In effect, at this stage all groundwater bodies are considered equal and all worthy of protection. (Slide 8)

Consideration of Landfill Development

There are four conceptual hydrogeological model scenarios presented for the landfill (Figure 5 of the HRA). Two of these apply to the Operational Phase and two to the Post Management Phase. Both Operational Phase scenarios describe the site as being hydraulically contained, which is also referenced on P.20 of the HRA, with respect to the surrounding groundwater levels within the clay. Both of the Post Management Phase models describe leachate levels exceeding those in the surrounding clay following the cessation of leachate head control. The additional variation to both of these themes is described by the potential for either an upward or downward vertical gradient existing beneath the site and between the shallow clay rich drift and the deeper Gravel/Bedrock system.

None of the scenarios deal with the likely consequence of the site design incorporating an under drain (below the liner). If drift boreholes are showing groundwater levels above the proposed liner elevation in the site (described in the HRA Executive Summary), it is fair to assume that a large excavation into the drift to allow for liner emplacement will require dewatering during construction and during early operations and filling at the site. During the early operation of the landfill, any contamination leaking from the site will presumably be drawn out from the under drain. No indication has been observed as to the likely water quantity or quality from the under drain or what plans exist to manage and treat this water. Uncertainty remains regarding whether or not uncharacterised contamination deriving from the current illegal tip on the site will be drawn to this system. It was demonstrated at the previous EPA Oral Hearing in March 2008 that inadequate site investigation was undertaken at what is potentially the largest illegal dump discovered in Ireland to date. The extent of the dump and the nature of the waste contained in the dump remains unknown (Slide 9).

Development of a high permeability under drain layer below the footprint will encourage contaminants to move laterally below the floor of the site and above the underlying less permeable materials. The modelling and assessment undertaken by the applicant has not examined this aspect within the HRA.

When sub-water table landfills become filled and liner stability can be assured, dewatering of groundwater on the outside of the liner is normally relaxed in a phased and controlled manner. Figure 3.18.7 of the EIS submission presents the leachate within the landfill as being hydraulically contained below both a shallow perched water table in the drift and the piezometric surface in the underlying Gravels/Bedrock. However, the Executive Summary of the subsequent HRA is less definitive (as detailed above). A greater understanding of water levels in the shallow drift is essential to demonstrate the definitive nature of the water table in this unit across the site footprint, if the entire landfill will be developed below this water table, and essentially if it will be fully hydraulically contained at any time during the landfill lifecycle. (Slide 10)

Following cessation of leachate management within the landfill, the HRA states in Section 4.2.3 that *'leachate levels would rise over-time and could potentially exceed perched groundwater levels within the clay..... Eventually a hydraulic equilibrium between leachate levels and perched groundwater would be established such that there would be no net hydraulic flux between the two and the main transport mechanism would be diffusion'*. This text differs from the actual Post Management scenarios presented on Figure 5 and Figure 006, where leachate is reported to occur by advective flow at this time.

We would expect that the leachate level within the site (post active leachate management) would be predominantly influenced by the hydraulics of the landfill including the relative performance of the cap to allow for infiltration and the liner to release leachate. In our experience of modern membrane lined landfill hydraulics, and in particular due to the fact that this site appears to be at least partially hydraulically contained with a relatively shallow waste mass, leachate levels would be expected to accumulate following termination of control until they exceed the surrounding groundwater elevation. Thereafter, breakout via the cap is anticipated, perhaps to a surface water course. As such, diffusion would not be expected to be the main mechanism driving contamination from the site at this time, but rather advective flow down a hydraulic gradient across the liner or break out flows through the restored landfill surface into perimeter surface water drains. To assume that the leachate and shallow drift water levels will remain in equilibrium is fanciful at best. (Slide 11)

Summary Comments on Conceptual Model

In particular, uncertainty remains regarding groundwater present within the drift. This includes its status (as per the Groundwater Directive), its interaction with surface water courses, the degree of hydraulic interaction or continuity it has with the underlying deeper bedrock aquifer unit, and how it will be progressively managed throughout the lifecycle of the landfill. These are fundamental issues that support the conceptual model upon which the computer simulations should be based. These issues need to be resolved before the modelling that has been carried out to date can be considered relevant and applicable to this landfill proposal. Indeed the modelling carried and out thus far and described below may not be relevant or applicable, and could be seriously misleading.

B Modelling

The models that have been run include a LandSim model and an Environment Agency Diffusion model (SC0310 Hydraulic Containment Model). There are some discrepancies between the two simulations undertaken and the four scenarios presented.

<u>LandSim</u>

Lifecycle phases

The LandSim model presented has been used to predict concentrations at the base of a 10 m clay drift column as a result of a 1 m leachate head acting on the basal liner driving leakage out of the site by advective flow. The clay rich drift has been selected to modelled by the applicant as a vertical saturated pathway within LandSim, which allows for vertical seepage migration rates below the landfill based not on natural vertical gradients, but on liner leakage rates driving full moisture displacement within this pathway. The 1 m leachate head is maintained in the model for 60 years following initial waste disposal (30 years following expected closure). Thereafter, LandSim has been used to determine the leachate level within the site based on its transient water balance capabilities and varying infiltration rates and leakage rates as a result of the assumed gradual degradation of the geomembrane in the cap and base liner over time and varying leachate heads. It is not obvious how this transient LandSim model simulates any or several of the four conceptual model scenarios presented in the HRA on Figure 006, which describes the site as being hydraulically contained during the Operational Phase and leaking on the basis of an outward differential head across the liner in the Post Management Phase. No explanation is provided to connect the conceptual model understanding presented to how this is adequately represented by various elements of the model. (Slide 12)

LandSim has not been designed for a sub-water table setting. The model determines leakage rate based on leachate head and liner properties, and no account is taken of any hydraulic head on the outside of the liner. Notwithstanding the above, it is unclear when and for what duration within the landfill lifecycle the above set of simulated conditions will occur and how they have been incorporated within the simulations undertaken. Clearly at some points during the life cycle, any under drain pumps and the leachate pumps in each cell will be turned off. The impact of having and not having these engineering controls has not been fully considered in the modelling, or reported.

Within the context of the limitations highlighted in the HRA to this point, the success of the LandSim model as presented is expected to be linked to several items which require further clarification or justification.

Landfill hydraulics
Given the cap's expected performance (a design infiltration of 58.4 mm per annum) and the liner specification (geomembrane composite), following termination of leachate head control, leachate is expected to accumulate within the site until breakout at the surface occurs. The potential for surface breakout has not been reported within the HRA. Access to the electronic files would be required to confirm this and whether contaminant mass is being removed from the model to surface water, and indeed to the environment in this manner. (Slide 13)

Leachate treatment
The model developed by the applicant assumes that leachate is being abstracted, treated to clean water, and re circulated back into the landfill at rates up to in the order of $100m^3$/day, such that it essentially operates as a flushing bio-reactor. This is a fairly novel approach for a landfill in Ireland; the approach promotes flushing of the waste mass and subsequently more rapid contaminant removal from the waste mass. No mention has been made of this process within the text of the HRA, nor in the leachate treatment element of the EIS and the Waste Licence Application Form, where disposal of treated leachate to sewer is discussed. Further details are necessary demonstrating how this approach will operate, if any examples exist of its successful operation elsewhere, and if the 'conventional' leachate drainage system on the floor of the landfill will have the capability of dealing with this additional re-circulated leachate over and above that generated by infiltration, throughout the lifecycle of the landfill. Usually, where recirculation of leachate occurs, a very robust leachate drainage system is needed and a robust assessment of its performance (including examination of the effects of clogging of the drainage system) is needed. We have not seen this within the submissions.

Contaminant transport
Ammonium has been simulated to biodegrade within both the clay rich drift (vertical pathway) and the underlying fractured Bedrock aquifer with a half-life of 5 to 10 years. This is expected to occur presumably due to oxidation to nitrogen (nitrification). A reference is quoted to justify the half-life selection. This reference states that site-specific data collection is expected where the output from an assessment of pollution risks is sensitive to ammonium attenuation parameters. Indeed, with regard to ammonium biodegradation rates it states that *'extreme caution is recommended in the application of the values provided.....'*. Since the Fingal Landfill is a proposed site and site-specific evidence of actual degradation will not be available, it will be necessary to remove this assumption from the model to determine output sensitivity in this respect. Thereafter, if applicable further justification is required as to the ammonium degradation mechanism, how this will apply at the Fingal site, and if oxidation is the key mechanism, how will this be active within the centre of a likely anoxic leachate plume where the peak concentrations will exist. We see this as a major flaw in the risk assessment (beyond the fact that there appears to be major conceptual model errors). Oxygenation of the clay rich drift will be difficult or impossible to achieve and hence biodegradation unlikely in our view, at least until leachate has entered the groundwater, by which time highly elevated levels of ammonium could cause groundwater pollution.

Contaminant retardation is modelled within the aquifer module of LandSim, which predominantly represents the fractured limestone Bedrock. The fraction of organic carbon applied in the aquifer, and on occasion the partition co-efficient values used, are greater than those used in the overlying clays. This would certainly be unexpected and the retardation factor (deriving from these numbers for individual contaminants) in hard fractured rock or gravel should be much less or negligible in relation to clay rich strata. Justification of these unusual numbers is required for the output results to be credible.

Aquifer dilution
The most likely value used for the hydraulic conductivity and regional gradient for the Gravel/Bedrock aquifer system in the model is 1.5E-4m/s and 0.032 respectively. The aquifer mixing zone thickness is quoted as 10m, and the site width has been estimated by us at approximately 1km. Using Darcy's Law, these data provide for an effective aquifer underflow of $0.05m^3/s$ (approximately $1,500,000m^3$/annum). Assuming aquifer recharge at 100mm per annum, which is considered very optimistic in this part of the aquifer due to the drift cover, this amount of natural underflow in the aquifer would require a recharge area of more than 15 square km's. This is considered unrealistically high given the proximity to the groundwater divide no more than 2km to the northwest of the site which allows for flow to the Bog of the Ring abstraction well field. If the groundwater flow volume is overestimated to a large extent, then the concentrations reported at the receptor in the aquifer, 100m downstream of the site, would be expected to be underestimated and higher levels of contamination will likely result.

The maximum source concentration reported for chloride in the HRA and utilised in the model is 9850mg/l. The peak concentration for this parameter at the aquifer receptor considered is provided at 165mg/l (after 300 years) – see Table 6.3. This reduction in concentration from source to receptor of this conservative and unretarded parameter will predominantly reflect the dilution available in the system. A dilution reduction by a factor of 60 is implied. Applying this factor to the peak ammonium source concentration modelled (3590.5mg/l), provides for a predicted ammonium concentration in the aquifer of approximately 60mg/l, or more than 150 times the Drinking Water Standard for this parameter. This value is many thousands of times the ammonium concentration actually reported by LandSim. Since retardation will have a relatively insignificant impact on peak concentration and effectively slows the contaminant migration velocity only, the discrepancy between the reported ammonium concentration at the receptor and that derived here, demonstrates the importance of the unsubstantiated use of ammonium degradation to the apparent success of the model. In addition, we report that the model already utilises unrealistically high dilution rates.

SC0310 Hydraulic Containment Model

Not all of the anticipated inputs required for the hydraulic containment model nor the actual print out from the model spreadsheets were observed in the submission for review (e.g. the hydraulic containment scenario selected). Some of the input selection issues discussed regarding LandSim above also apply to this simulation. In both cases electronic copies of all models are necessary for further detailed comment, in particular since this model is reported to have been modified from the Environment Agency endorsed and distributed version.

Although not clarified in the submission, it is expected that hydraulic containment (where groundwater elevations exceed leachate elevations) could likely only apply during a restricted time period from nearing the end of the Operational Phase (i.e. following termination of active groundwater control requirements during filling) and during active pumping of the leachate collection underdrain which will continue for 30 years following filling)). At this time, and on the basis of the information presented, it is considered more probable that bulk contaminant transport would migrate laterally by advective flow in the liner under drain down the hydraulic gradient presented and towards a perimeter stream, than diffusion through 10m of clay as modelled and reported. Lateral flow would be favoured by the much higher permeability values of the under drain, which would be expected to more than counteract any areas where comparatively steep downward vertical hydraulic gradients are reported. Certainly the logs for two of the seven identified shallow installations at the site (ASA2 and HR09) report sand and/or gravel layers within the clay and within 15m of the surface. Such occurrences have not been investigated or reported in a systematic fashion in the submission and would serve to undermine the conceptual model presented. Output from this model again is reported at the compliance point taken as the base of the drift which requires justification.

Summary Comments on Modelling

It is unclear exactly when within the anticipated landfill lifecycle, the conditions will exist to match the fixed conceptual model provided by the LandSim simulation in the HRA. LandSim was developed and is marketed as a landfill performance package for site settings above the water table.

In addition, if as expected, an active under drain is required to control groundwater pressures to avoid hydraulic rupture of the liner (as speculated in Section 3.2.2 of the HRA) during the Operational Phase, hydraulic containment during this time would not be expected. As a result, diffusion would not be the main contaminant transport mechanism during this time as stated by the applicant. The modelling needs to take into account the engineering controls that will be applied during the lifecycle of each cell. Until this is done, it can only be concluded that the modelling is inadequate and inappropriate and granting of permission to develop Fingal Landfill is premature as there is a real danger that the results are misleading at best, and more likely overtly optimistic.

Key inputs selected and utilised by both models require clarification that must come from site specific data and design as opposed to literature values and assumptions. In particular, those related to the manner in which leachate will be managed and controlled within the landfill (including leachate treatment technology and the duration of head control) need clarification. Furthermore, selected contaminant degradation and retardation rates in certain pathways seem to have been sourced from reference material rather than using site specific information. We would, as a minimum, expect to see laboratory derived Kd values for the List I metals and consider the inclusion of biodegradation of ammonium (which requires oxygenated conditions) to be grossly optimistic. Clarification is required if LandSim predicts cap breakout following termination of leachate head control, what the breakout rates and concentrations will be at the time, and if appropriate, what consideration has been given to this pathway such that surface water will be protected. Aquifer flow and thus dilution rates require revision or justification.

Conclusions (Slide 14)

- The baseline hydrogeological conditions in relation to groundwater in the drift and its interaction with perimeter streams and the underlying aquifer in particular appear to be poorly understood;

- The only receptor modelled is groundwater within the underlying Gravel/Bedrock aquifer. No consideration has been given to identified potential pathways to perimeter streams, or to the release of contaminants to the groundwater table presented in the drift. Justification is needed as to why this groundwater in the drift should not be protected as specified in the Groundwater Directive;

- The conceptual understanding presented of how the landfill will operate throughout its entire lifetime is considered inaccurate, inadequate, and has been poorly transposed and therefore represented in the software selected;

- Key contaminant attenuation parameters are considered grossly optimistic and inaccurate. Site specific justification has not been provided for identified selections. The models are certainly not considered to be conservative as reported;

- The dilution potential being generated by the model from the input information is considered to be unrealistically high. This would benefit from a proper assessment;

- The leachate treatment technology approach used in the LandSim model is considered significant in relation to the output results. Only scant details of the leachate treatment technology, its operation and integration into the management plan for the site are included in the submission, and not in sufficient detail to allow its adequacy to be determined;

- A demonstration that the development can comply with the requirements of the Groundwater Directive throughout its entire lifecycle has not been provided.

Wrap Up (Slide 15)

This Statement has demonstrated that the hydrogeological risk assessment is fundamentally flawed. The conceptual understanding upon which the modelling is based is inaccurate, and inadequate. We believe that the outputs are not conservative, the use of LandSim during key stages of the lifecycle is not appropriate, and the overall results are misleading.

Groundwater Presentation 2009

Fingal Landfill Project

Dr Stephen Barnes

Golder Associates

Qualifications of Authors

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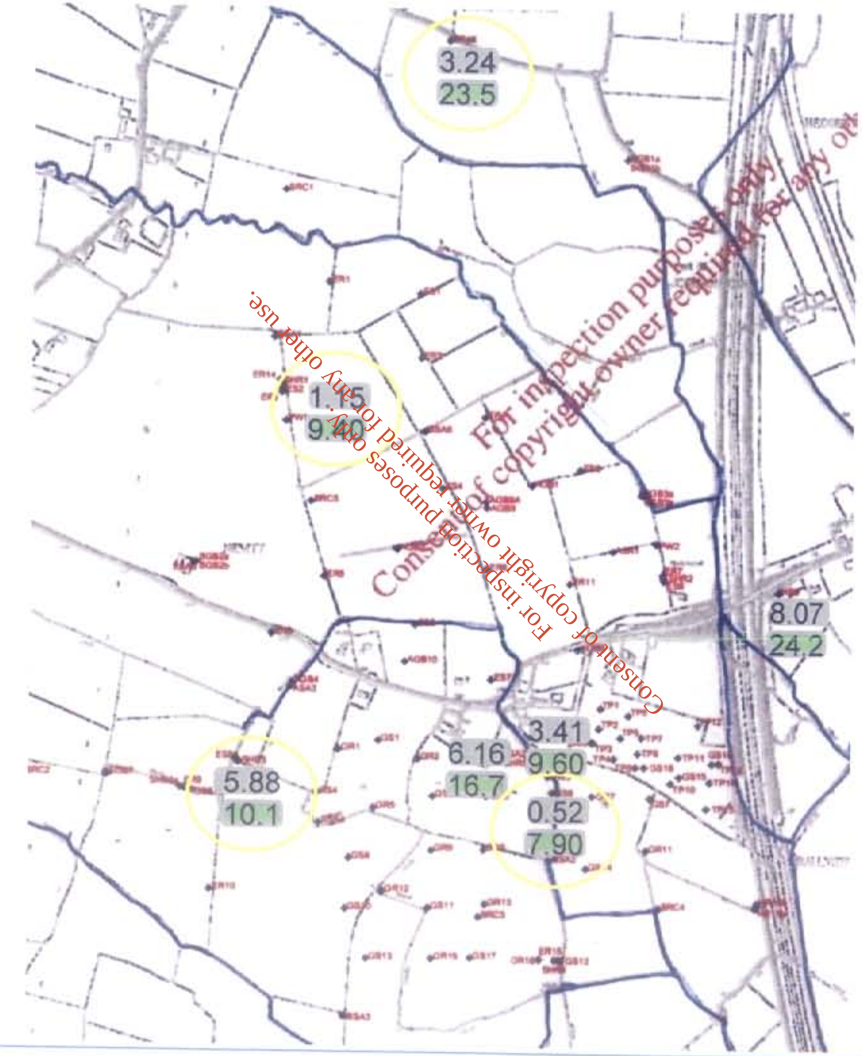
Golder Associates

Pathways – Groundwater in shallow drift



Streams

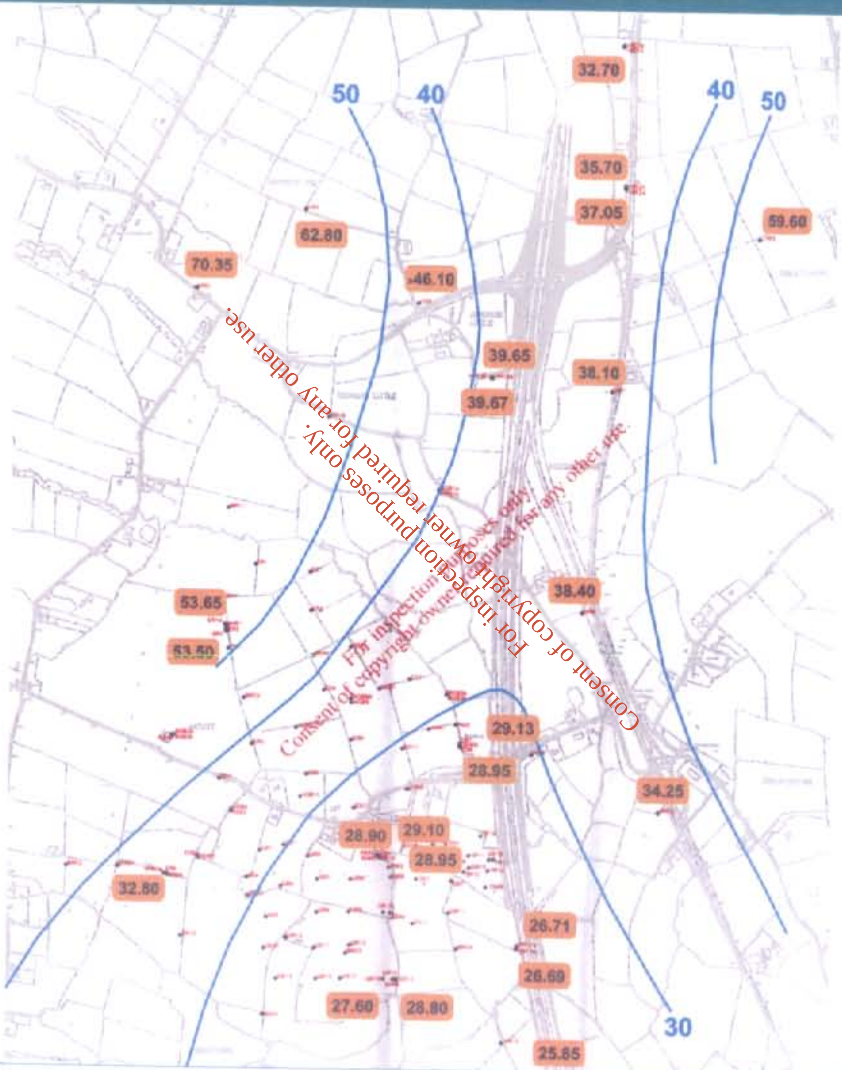
3.24 Dip to Water (November 2005) (m)

23.5 Depth to base of installation (m)

No water strikes recorded at time of drilling

Golder Associates

Pathways - Groundwater Head Contour Plot



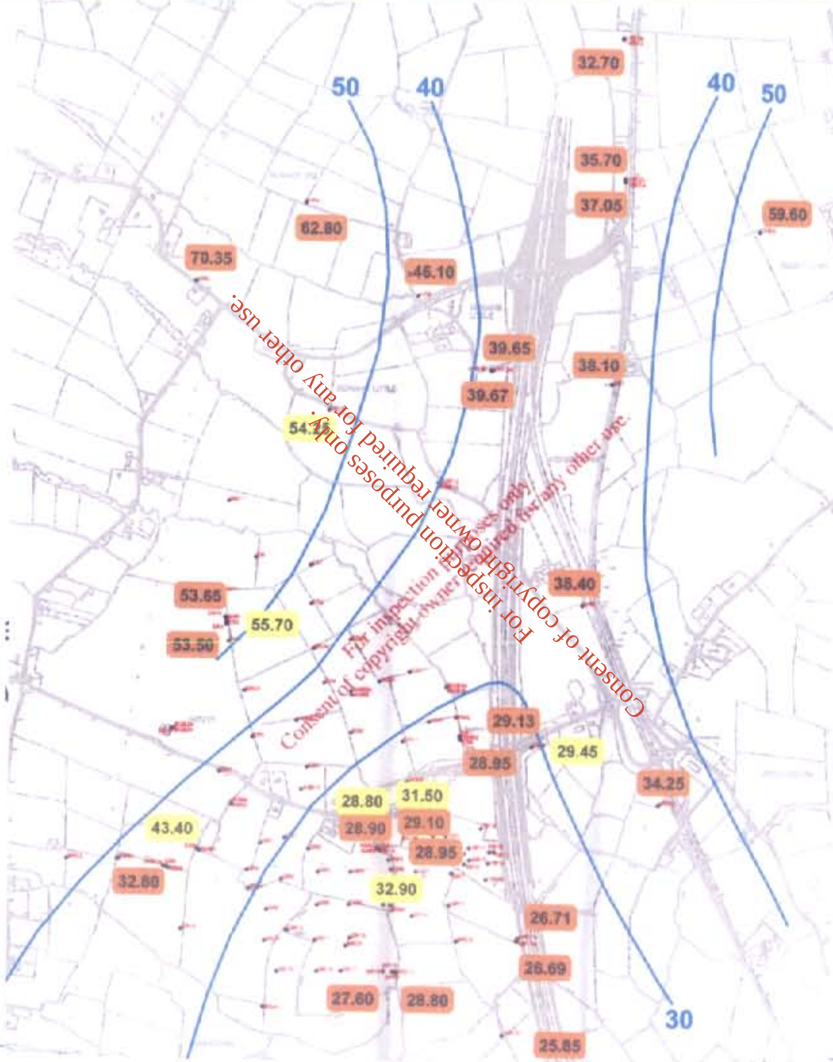
LEGEND

Hand drawn groundwater head contour (Gravel/Bedrock aquifer) (mAOD)

59.60 Point observation from Gravel/Bedrock (November 2005) (mAOD)

Golder Associates

Pathways - Groundwater Head Contour Plot (inc. shallow drift)



54.25 Point observation from shallow drift (mAOD) (November 2005)

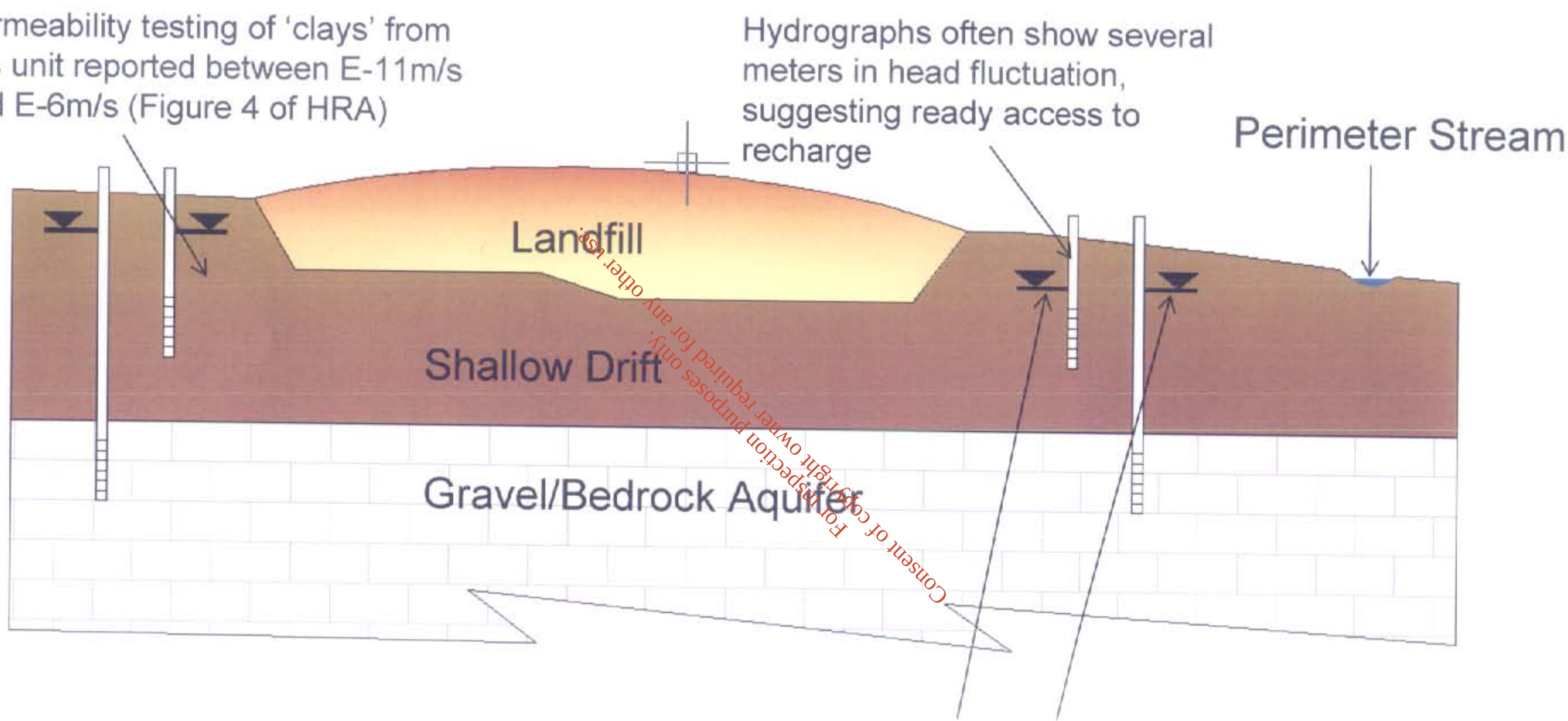
LEGEND

Hand drawn groundwater head contour (mAOD) (Gravel/Bedrock aquifer)

59.60 Point observation from Gravel/Bedrock (November 2005)

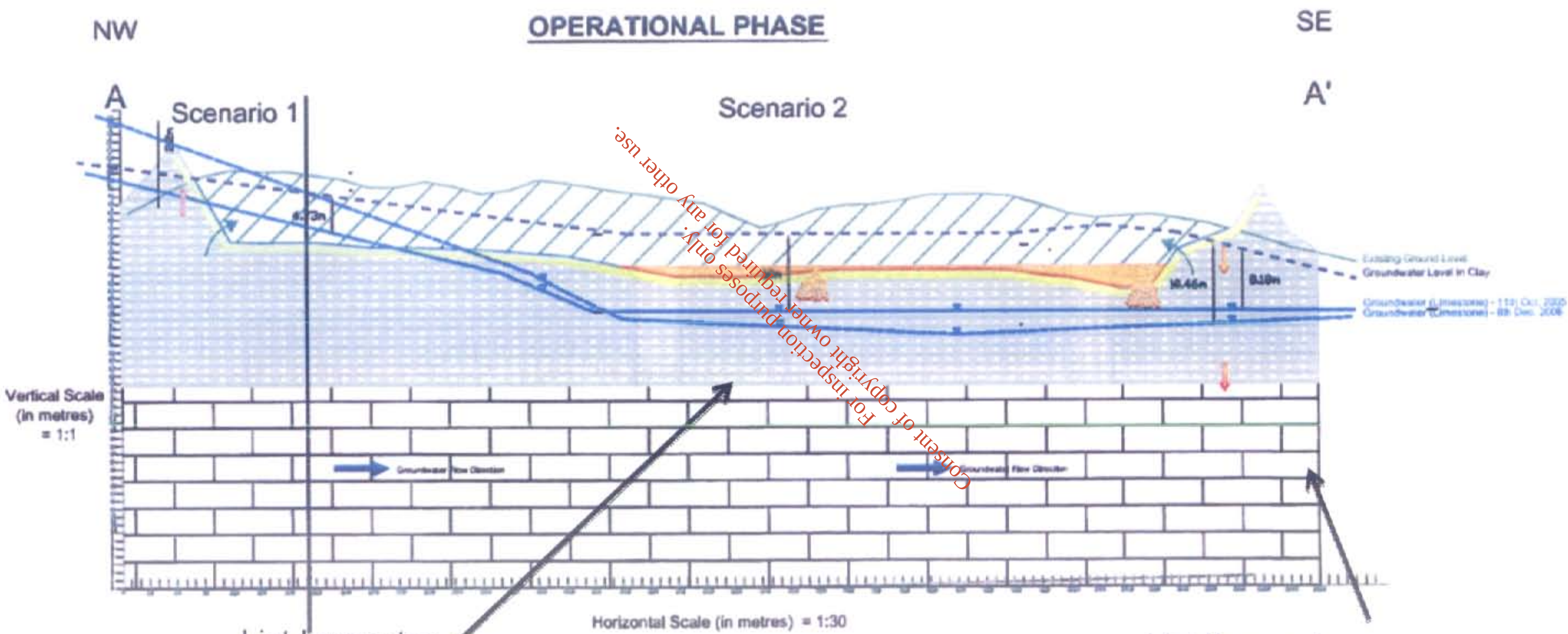
Golder Associates

Pathways – Schematic section of shallow and deep



Similar groundwater elevations in neighbouring boreholes suggests shallow drift is expected to be saturated by virtue of the hydraulic head in the Gravel/Bedrock aquifer – some variations to the levels in both being expected to be driven by recharge events, strata heterogeneity, and 'delayed drainage' in the less permeable shallow system to the perhaps more rapid fluctuations in the deep system

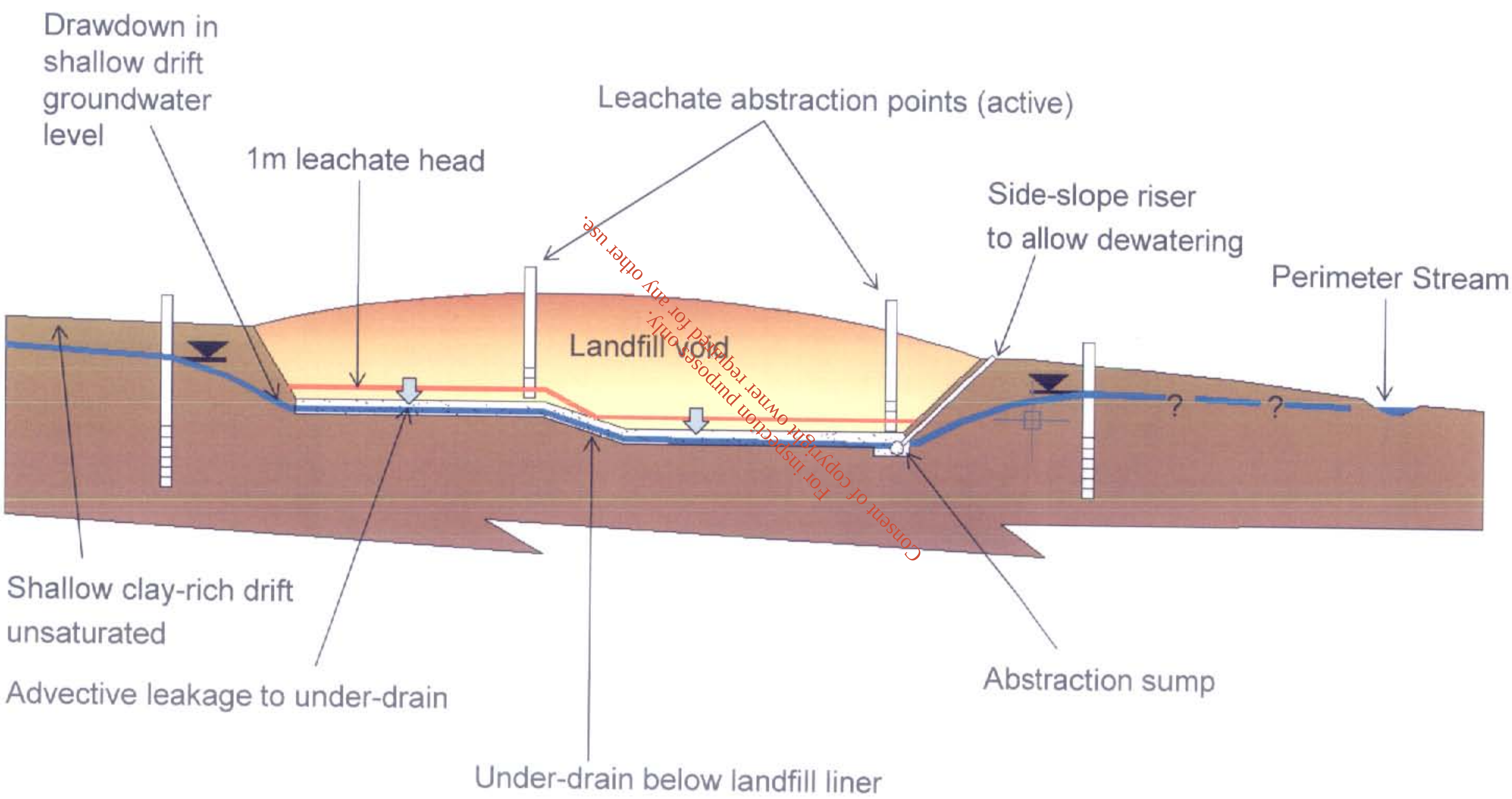
Receptors – those considered include



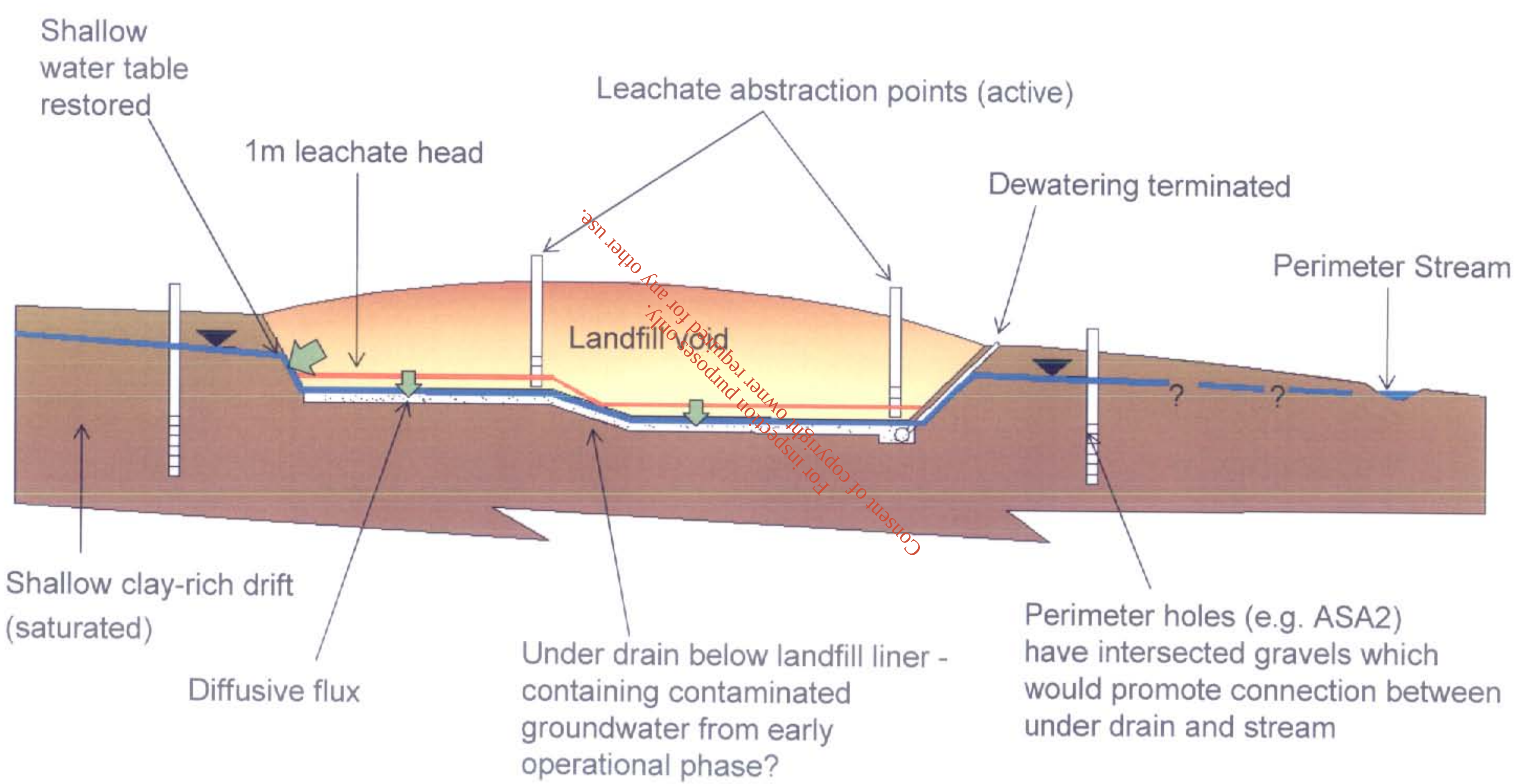
List I receptor
(base of clay rich drift)
-Essentially authorises List I discharge to shallow groundwater in the drift

List II receptor
(100m downstream of landfill boundary)

Consideration of landfill development – early Operational Phase



Consideration of landfill development – late Operational Phase



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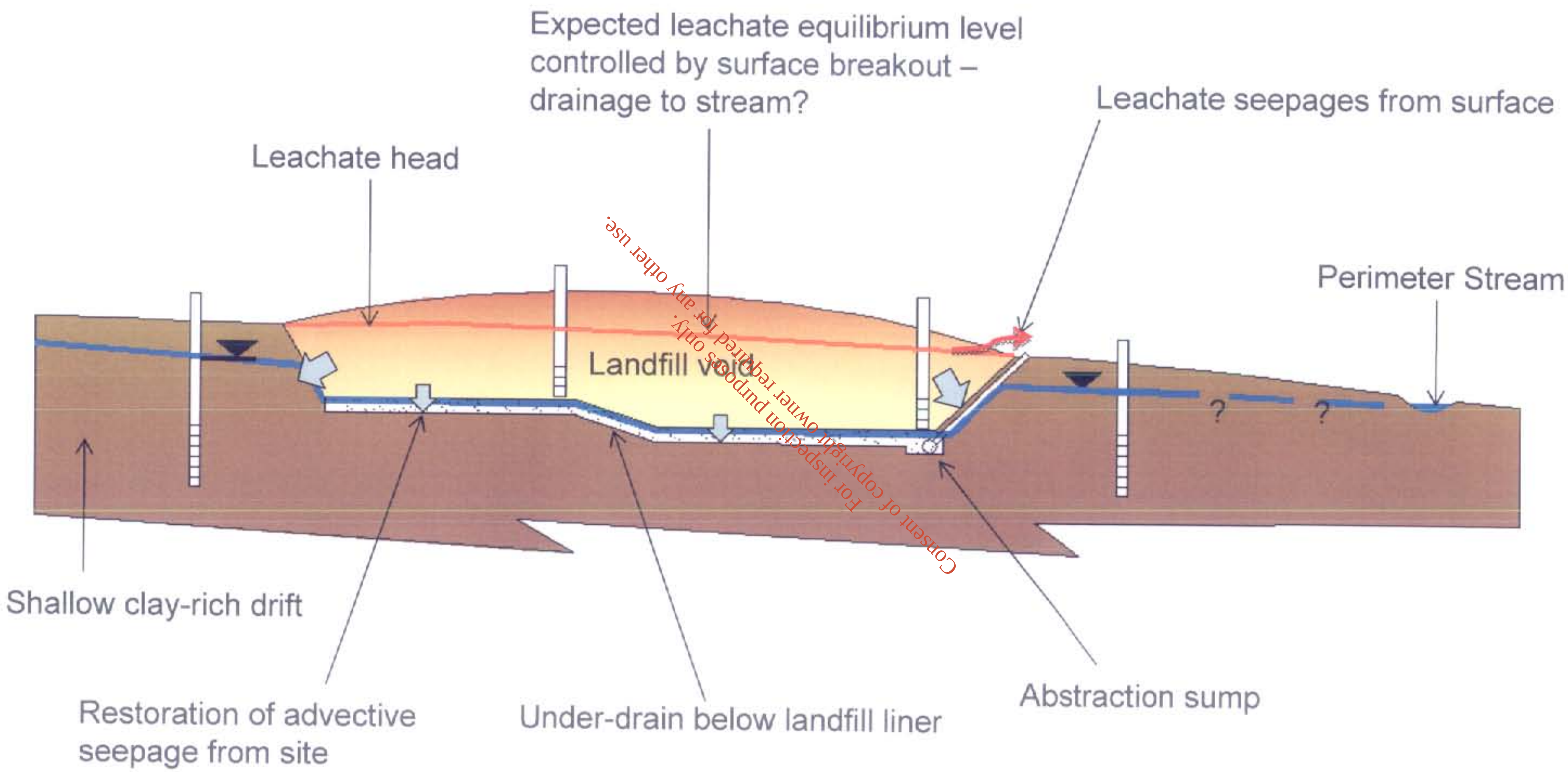
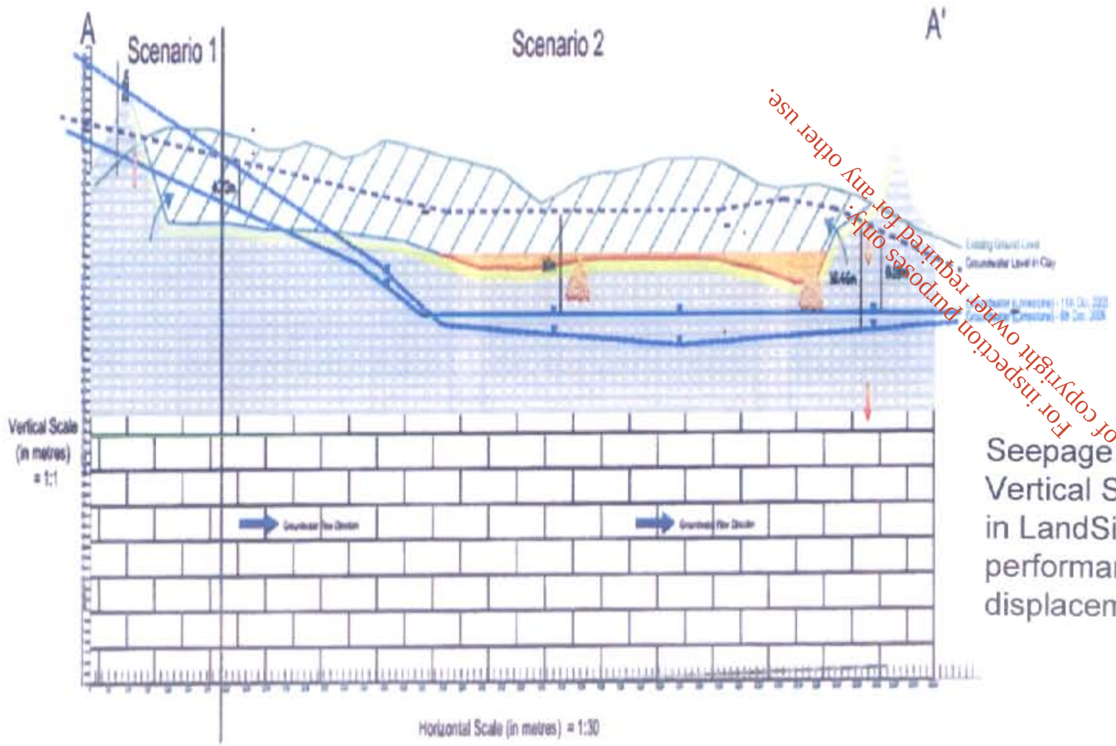
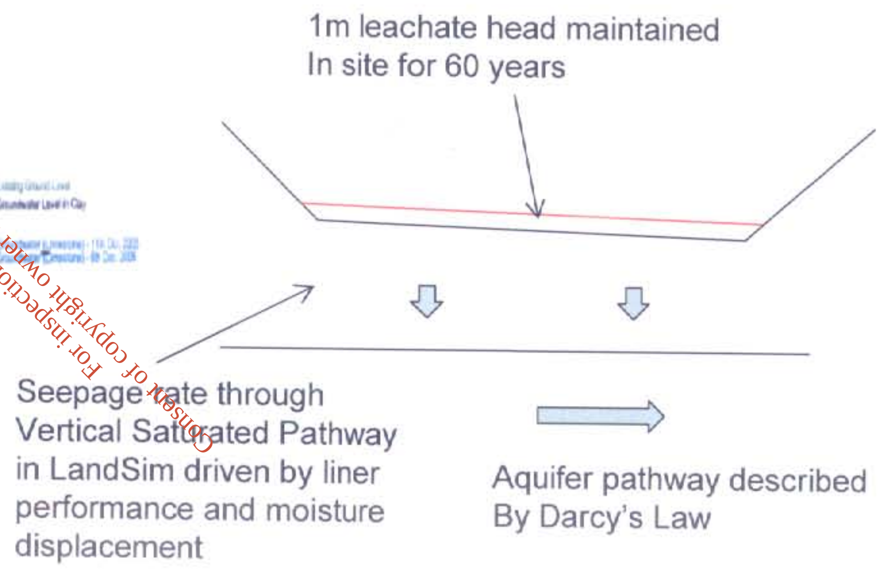
Consideration of landfill development – Post Management



Consideration of landfill development - Operational Phase



LandSim Operational Phase



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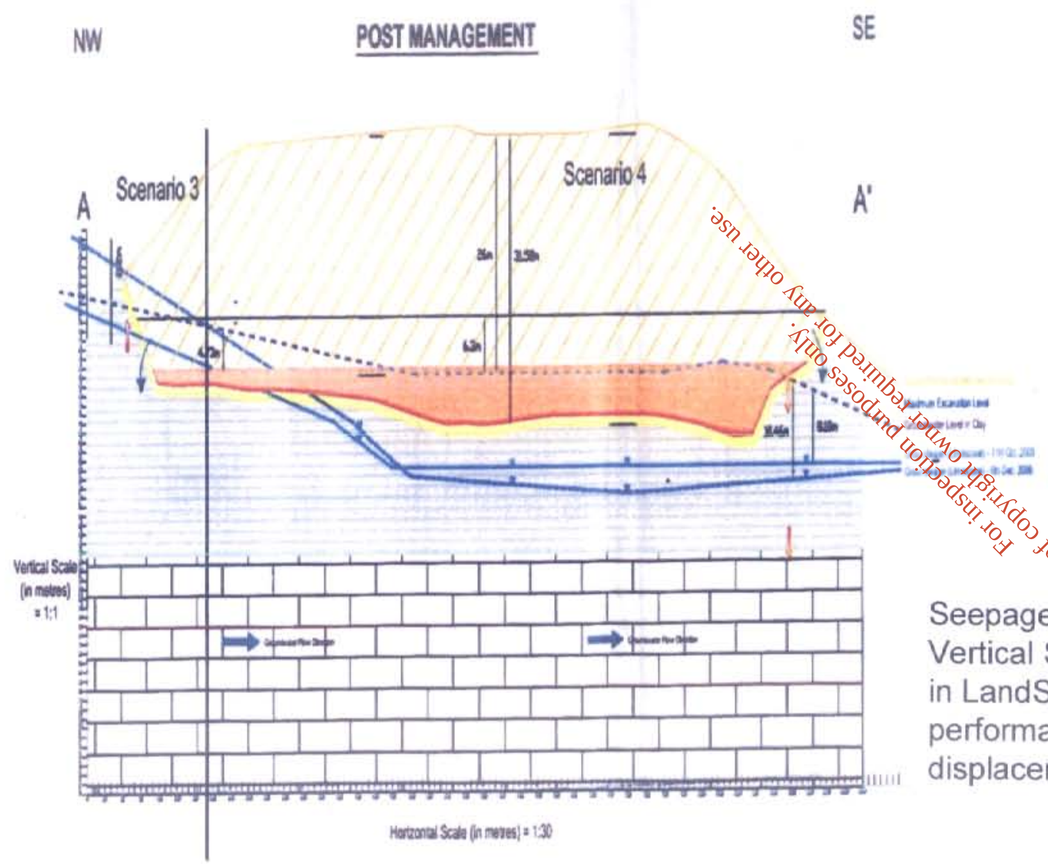
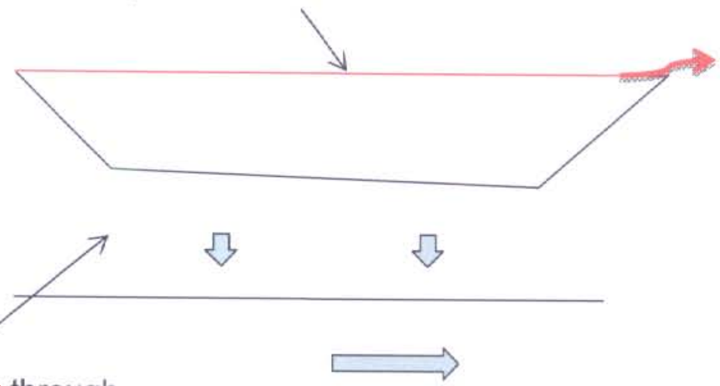
Consideration of landfill development – Post Management



LandSim Post Management

Leachate head control terminated after 60 years, and accumulates to breakout



Seepage rate through Vertical Saturated Pathway in LandSim driven by liner performance and moisture displacement

Aquifer pathway described By Darcy's Law

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Conclusions

- The baseline hydrogeological conditions in relation to groundwater in the drift and its interaction with perimeter streams and the underlying aquifer in particular appear to be poorly understood;
- The only receptor modelled is groundwater within the underlying Gravel/Bedrock aquifer. No consideration has been given to identified potential pathways to perimeter streams, or to the release of contaminants to the groundwater table presented in the drift. Justification is needed as to why this groundwater in the drift should not be protected as specified in the Groundwater Directive;
- The conceptual understanding presented of how the landfill will operate throughout its entire lifetime is considered inaccurate, inadequate, and has been poorly transposed and therefore represented in the software selected;
- Key contaminant attenuation parameters are considered grossly optimistic and inaccurate. Site specific justification has not been provided for identified selections. The models are certainly not considered to be conservative as reported;
- The dilution potential being generated by the model from the input information is considered to be unrealistically high. This would benefit from a proper assessment;
- The leachate treatment technology approach used in the LandSim model is considered significant in relation to the output results. Only scant details of the leachate treatment technology, its operation and integration into the management plan for the site are included in the submission, and not in sufficient detail to allow its adequacy to be determined;
- A demonstration that the development can comply with the requirements of the Groundwater Directive throughout its entire lifecycle has not been provided.

Wrap up

This Statement has demonstrated that the hydrogeological risk assessment is fundamentally flawed. The conceptual understanding upon which the modelling is based is inaccurate, and inadequate. We believe that the outputs are not conservative, the use of LandSim during key stages of the lifecycle is not appropriate, and the overall results are misleading.

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