Witcham Meadlands Landfill Site

784-B070447

Hydrogeological Risk Assessment

Mick George Limited

February 2026

Document prepared on behalf of Tetra Tech Limited

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Document:	Hydrogeological Risk Assessment
Project:	Mepal Landfill
Client:	Mick George Limited
Project number:	784-B070447
File origin:	*\\lds-dc-vm-101\Data\Projects\784-B070447_Mepal_SNRHW_2024\60_Output\61_WIP*

Revision:	1	**Prepared by:**	Gemma Allan
Date:	September 2025	**Checked by:**	
Status:	Draft	**Approved by:**	Michael Jones
Description of revision:			

Revision:	**2**	**Prepared by:**	Gemma Allan
Date:	February 2026	**Checked by:**	Peter Murphy
Status:	Draft	**Approved by:**	Michael Jones
Description of revision:			

Revision:		**Prepared by:**	
Date:		**Checked by:**	
Status:		**Approved by:**	
Description of revision:			

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1.0 Introduction

1.1.1 This Environmental Permit application has been prepared on behalf of the operator; Mick George Limited (Mick George) by Tetra Tech Limited as part of the environmental permit variation application.

1.1.2 The Witcham Meadlands Landfill site is currently regulated under a bespoke Environmental Permit (EPR/LP3996ND) to allow the importation of non-hazardous waste and stable non-reactive hazardous wastes including gypsum and asbestos within an engineered cell (Phase 9). The Environmental Permit also allowed for the importation of inert waste within separate areas to the engineered cell (Phases 1-8).

1.1.3 Mick George are now seeking to vary the environmental permit to apply a number of changes which are summarised in the Non-Technical Summary but the changes that affect this report are as follows:-

- Change the annual throughput.
- Extend Phase 9 southwards.
- Amend the sulphate compliance levels that are currently set in Table S3.3 of the environmental permit as shown in the HRA.
- Allow the importation of Air Pollution Control (APC) wastes.
- Addition of a number of waste codes to the Phase 9 area.

1.1.4 Pre-application discussions have been held with the Environment Agency in order to confirm the scope of the application. A copy of the Environment Agency's pre-application advice is provided as Appendix B of this application.

1.1.5 The changes to the permit above are addressed within the document below but the basic premise, calculations and modelling and conclusions remain from the previous Hydrogeological Risk Assessment.

1.1.6 The EA had a number of queries from our previous submission which are addressed as follows:-

1. Review the likely source term associated with the additional APC wastes and other requested additional waste codes. Update the HRA (if necessary) depending on the outcome of the source term review.

The inclusion of these additional waste codes, including APC residues, has not changed the approach to waste acceptance at the site, nor does it affect the modelling or outcomes of the HRA.

The HRA has assessed source terms equal to or in excess than the WAC non-hazardous leaching limit values, and the site only accepts wastes up to the non-hazardous leaching limit values.

The site is only able to accept less challenging APC residues, or those that have been stabilised to have leaching limit values which meet the non-hazardous leaching limits values. Therefore, these wastes have already been accounted for in the HRA.

2. *Confirm the time periods for the available groundwater monitoring data.*

More recent monitoring data is available for the site, and has been reviewed, e.g. sulphate background concentrations have been updated. However, no major changes to the groundwater flow direction, levels or other background concentrations have been noted since the 2016 HRA. Up to date Groundwater data is shown in Appendix B.

The CSM for the HRA is considered to remain valid.

3. *Clarify whether the hydraulic containment modelling assesses the whole of Phase 9 (existing and extension) or just the extension?*

The modelling accounts for both the existing area of Phase 9 and the extension.

4. *Either*

a. Explain any constraints associated with the modelling methodology and site conceptualisation that prevent modelling of the whole site in an integrated fashion, or

b. Update the modelling to include the existing Phase 9 area and other areas covered by the permit (Phases 1-8) so that the site is modelled in its entirety.

The modelling only accounts for the SNRH waste cells in phase 9 (and extension). The remainder of the site comprises inert wastes which were emplacement many years ago; qualitatively, the risks associated with these wastes will be low, as the sand and gravel aquifer will be largely removed by surrounding quarrying, and the base of the wastes will comprise an unproductive aquifer (Ampthill Clay).

It would be difficult to integrate the impacts of both the SNR diffusion modelling, and more conventional modelling of the inert wastes in one model; the potential risks associated with the SNRH waste cells are considered to be higher, and should therefore form the focus of the risk assessment.

1.1 Site location

1.1.1 The site is located in a relatively flat agricultural landscape known as the Fens, approximately 1.5km north of Mepal village. Elevations are nearly at sea level, do not vary significantly across the site and range from 0.5mAOD to approx. 1.0mAOD.

1.1.2 Access is along the A1421 (Ireton's Way). The centre of the proposed installation is approx. at NGR TL4400 8396.

1.2 Brief site history

Quarrying activities and planning permission

1.2.1 Mepal Landfill is a working sand and gravel quarry which will be restored to agriculture. The regulated installation subject of this HRA report is known as Phase 9 and its outline is shown in Drawing MGL/B070447/PER/01A.

1.2.2 The original planning permission to import waste was granted by Cambridgeshire County Council in 2001 with subsequent amendments and variations in response to changes to the imported materials.

1.2.3 In 2024 CC granted planning permission (CCC/24/065/FUL) for continued disposal of SNRHW with the revised final contours and restoration. This planning permission is given in Appendix M of this application.

1.3 Prior investigations

1.3.1 The last round of drilling was undertaken in December 2015, bringing the current number of boreholes dedicated to monitoring the groundwater system around Phase 9 (see Drawing MGL/B070447/LOC/01). The newest boreholes are designated as NBH1, etc. Borehole logs for these new boreholes are included in Appendix E.

1.4 Landfill design philosophy

1.4.1 The deepening of Phase 9 will utilise the agreed engineering design as existing surrounding cells which consists of an engineered clay base with side seals. The boundary of Phase 9 is shown on MGL/B070447/PER/01A.

1.4.2 Engineering details of basal and sidewall liner systems, leachate sump/collection system, etc. are shown in Drawing MGL/A075924/ENG/04A and are identical to those in the previous permit variation application. The Phase 9 extension area is detailed in Drawing Numbers MGL/B070447/LOC/01, MGL/B070447/LOC/02 and MGL/B070447/LOC/03.

1.4.3 The engineering design allows for any groundwater encountered with the Cementstone bands as detailed in the Operating Techniques document.

1.4.4 The capping system is proposed to be a 0.5m engineered clay layer overlain by 1.0m of restoration soils.

1.5 Regulatory context, groundwater and surface water protection

1.5.1 The original MWS 2012 report identified no licensed groundwater abstractions for potable water supply local to the site and that Mepal Landfill also lies outside any Source Protection Zones (SPZ) as defined by the Environment Agency for groundwater abstractions under the “Policy and Practice for the Protection of Groundwater”.

1.5.2 The closest licensed groundwater abstraction was located about 0.6 km to the north-west of the site and used for spray irrigation purposes. There were eight other reported licensed groundwater abstractions within a 1km radius of the site’s boundary.

1.5.3 The area is drained by an extensive network of drainage ditches active in periods of high groundwater levels or when receiving surface water drainage from surrounding agricultural lands. The direction of surface water flow in the local drainage catchment is generally south-south-west towards the Mepal Pumping Station.

1.5.4 The site has a consent to discharge site drainage (issued by Sutton and Mepal IDB in April 2004) from both the restoration and mineral extraction areas to the IDB drainage network. Prior to discharge off site, the drainage is subject to treatment in three lagoons.

2.0 Conceptual hydrogeological model

2.0.1 The conceptual hydrogeological model for the site is based on the following source-pathway-receptor linkages, and relies on the geological and hydrogeological information gathered during site investigations and is presented in Drawing MGL/A094946/ENG/04 with the Phase 9 Extension given in Drawing Number MGL/B070447/LOC/03.

2.1 Source term

Leachate definition and estimated quantity

2.1.1 During the operational phase there will be an amount of direct rainfall infiltrating through the waste and moisture contained within the wastes themselves when received at site. The waste material will absorb a finite amount of moisture, part will be evaporated and the excess will percolate and accumulate at the base of the cell due to the low permeability of the engineered basal liner. (The term “leachate” will still be used throughout this document to describe the liquid thus formed, bearing in mind that its chemical composition/characteristics will not be the same as the contaminated liquid formed within non-hazardous and hazardous sites).

2.1.2 The design gradient of 1:100 towards the centre of the cell will ensure that any liquid emanating from the imported materials will be collected and extracted via the current sump infrastructure and monitoring will take place at the proposed point locations.

2.1.3 Following the capping of completed Phase 9 including the extension and then restoration of the landform, leachate generation within the waste mass will be reduced dramatically as it is intended to have a slightly raised profile and rainfall will be shed into the surrounding surface water management system.

2.1.4 The estimated amount of leachate generated during the operational stage is provided in the simplified water balance below:

- An annual rate of approx. 200,000m^3 per year (proportioned between SNRHW, asbestos and gypsum) has been applied for and over the proposed seven years’ life cycle of the installation. This will total a volume of waste material imported into Phase 9 of 1,740,000m^3. The reported effective infiltration is 92mm/year (0.092m/y), therefore theoretically 20,200m^3/year (220,000m^3 x 0.092m/y) or 55m^3/day would be absorbed by the total waste mass. Proportionally, the contribution of leachate generated from the amount of gypsum to be imported (estimated at 20,000m^3/y) will be 1840m^3/y or 5m^3/d.

- However, not all the rainfall which reaches the waste will percolate onto the base of the cell as a proportion will be retained by the material's soil matrix and part of the SNRHW will reportedly solidify. Assuming the waste material to have a general composition similar to a sandy silty soil (after treatment and washing), its porosity will be around 25% i.e. approximately 5,000m^3/year (25% of 20,200m^3) or nearly 14m^3/day will be theoretically released by the material and will be eventually drained into the leachate sump. This volume is considered to be negligible when distributed over the surface area of the whole of Phase 9.
- Although the porosity is relatively high, the assumed average permeability of the material will be low at around 1 x 10^{-8} m/s. In practical terms this means that the time for the liquid retained in the first 1m of deposited material to reach the monitoring location will take about 3 years and for a 5m thick layer this will be approximately 16 years. Therefore, leachate generation will occur at a significantly slower rate than an instantaneous release from the soil matrix but over a longer period.

Leachate concentrations

2.1.5 Phase 9 started accepting waste materials since mid November 2015, and only two quality samples have been taken from the sumps (see data in Appendix A), therefore no site-specific leachate data are available at this stage to provide a meaningful interpretation and input parameters for the quantification of the source term quality.

2.1.6 During the application for previous Mepal variations, the Geoscience Operations Team (GOT) undertook a technical review and accepted that existing/literature values for leachate could be used in the assessment. An approach previously proposed by MWS (and re-used in this report) is the application of leaching limit values for hazardous waste (as defined in Council Decision 2003/33/EC also referred to as Waste Acceptance Criteria (WAC limits)) for the acceptance criteria of the waste.

2.1.7 The reader is referred to Section 2.2.2. of the Annex of Council Decision 2003/33/EC for a list of the proposed limits and included as Appendix A for completeness.

2.1.8 In particular, the potential maximum concentrations of contaminants within the leachate from the defined hazardous WAC limits (reported in mg/kg) and diluted by the 1:10 ratio are suggested (it was assumed as a worst-case situation that all solid species would leach out of the materials and go into solution, thereby producing an equivalent value in mg/l). This is considered a reasonably robust and conservative assessment for the leachability potential of the material to be imported.

Leachate collection, removal and head control systems

2.1.9 The leachate collection and removal system in the remaining parts of Phase 9 will comprise of 3 leachate monitoring chambers.

2.1.10 The slope toward the collection sump is 1V:100H. This angle will be sufficient to promote drainage of leachate toward the collection sump from where leachate head can be both monitored and controlled by pumping.

2.1.11 The arrangement of the leachate collection system is illustrated in Drawing MGL/A075924/ENG/04A with the Phase 9 Extension given in Drawing Number MGL/B070447/LOC/03.

Leachate monitoring infrastructure

2.1.12 The leachate monitoring infrastructure is illustrated on Drawing MGL/A075924/ENG/04A and MGL/B070447/LOC/01. The monitoring points are labelled accordingly. The SNRHW cell (Phase 9) has one leachate collection point and 2 leachate monitoring points per sub section.

2.1.13 However, in order to have the ability to remove liquid from the cell to ensure no overtopping and to maintain the in waste gas monitoring status quo, the cells will have 3 “monitoring points” installed. It is envisaged that any generated liquid generated that is above the derived compliance limit will be removed and held in a bunded storage tank and then tankered off site to a permitted treatment facility.

Restoration cover

2.1.14 A minimum 1m cover of restoration soils will directly overlie the cap.

Leak detection systems

2.1.15 Leak detection systems are not proposed.

2.2 Pathways

Geology

2.2.1 The geological sequence is described in previous reports and based on geological logs from drilling investigations is (from top to bottom): River Terrace Deposits (RTDs) composed of sands and gravels, underlain by Ampthill Clay Formation. The Ampthill Clay is characterised by lenses/bands of argillaceous limestone (Cementstone) reported to be

dipping in a north east direction and which have been proven as discontinuous around the site.

2.2.2 The RTDs will be systemically removed as Phase 9 progresses, as well as from within the wider surrounding area, as part of the ongoing mineral extraction and processing operations. The thickness of the RTDs has been confirmed to be extremely variable; being thicker along the north-western boundary of the site (ranging from about 6.3m to 4.1m) and thinner along the south-eastern boundary of the site (generally less than 2m thick).

2.2.3 The drilling information gathered during the latest investigation (Dec. 2015) investigation has confirmed the depths and distribution of the various lithologies previously encountered on site and in particular the absence of groundwater past the contact with the Cementstone Bands down to the final depth of the boreholes.

2.2.4 Location of the groundwater monitoring infrastructure around the boundary of the proposed installation is shown on Drawing MGL/B070447/LOC/01.

2.2.5 There is no evidence for deep mine workings beneath the site.

2.3 Hydrogeology

Aquifer designation

2.3.1 The RTDs have been classified as ‘Secondary A Aquifer’ (ex minor aquifer) under the revised aquifer classification scheme of the Environment Agency and described as “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers”. The mapped extent of the RTDs indicates that it is naturally a relatively small and isolated hydrogeological unit.

Groundwater levels

2.3.2 Groundwater level measurements recorded from monitoring points around Phase 9 are presented in Appendix B.

2.3.3 Original readings have been used to prepare a series of groundwater contour plans showing minimum, maximum and average levels and these are illustrated in Drawings MGL/A094946/HYD/01, MGL/A094946/HYD/02 and MGL/A094946/HYD/03 respectively.

2.3.4 The last round of drilling work has highlighted the lack of any groundwater in these new boreholes both within the overlying RTDs and the contact zone between the Cementstone bands and the surrounding geology (Boreholes logs in Appendix E).

2.3.5 The available level data were also used to plot the hydrograph in Appendix C. The following comments apply to the hydrograph, the statistically derived data and plans:-

- The hydrograph displays groundwater levels in metres Below Ordnance Datum (mBOD) and illustrates an initial lowering of groundwater levels in most boreholes towards the latter part of 2010, followed by a steady increase and levelling off to present. An exception is GW10 in which the trend is declining throughout the monitoring period in question until around Aug. 2013 after which these levels are seen to steadily increase, almost to rebound towards the remainder of the boreholes;
- Average level values show the highest water table to be recorded in borehole GW2 in the east (1.55mBOD), with the lowest levels measured in borehole GW10 (2.8mBOD), located in the western portion of the site. From these data it is inferred a general groundwater flow direction through the site from the east to west;
- The flow directions depicted in the three plans (showing minimum, maximum and average groundwater levels) remain broadly similar between each of these three hydraulic representations i.e. from east to west; and
- The largest fluctuation in groundwater levels is approx. 2.8m (in GW11 and GW12). An hydraulic gradient of 0.001 has been estimated from the current levels.

2.3.6 The direction of groundwater flow has identified those boreholes that are currently up-gradient and down-gradient of the site's boundary, and used in setting the compliance limits for the permit, namely:-

Up-gradient: GW2, GW11, and GW12

Down-gradient: GW1, GW8, GW9 and GW10.

Baseline groundwater quality

2.3.7 The historical groundwater quality data for the original permit application were for the period March 2010 to December 2015. The groundwater quality results for the most widely-used indicator substances (ammonia and chloride) were interpreted and the data plotted to derive time series chemographs. Thisd permit variation wishes to look at the sulphate levels at the site have been specifically investigated using all available site data up to present day and is shown in Appendix C.

The following comments apply to the original data:-

Up gradient boreholes

- The ammonia chemograph illustrates a relatively homogeneous behaviour over the monitoring period with no discernible trends. Concentrations are below 0.20mg/l in all monitoring boreholes with the exception of a couple of spikes, one with maximum value of 0.32mg/l, seen in GW2.
- Chloride concentrations show an initial fluctuation between 100mg/l and 150mg/l in all three boreholes. After Dec. 2012 trends started to decrease steadily in GW11 and GW12 to date. In GW2 the decreasing trend reversed after March 2013 to show an increasing trend. Concentrations range between a minimum of 61mg/l in GW2 and a maximum of 230mg/l also in GW2.

Down gradient boreholes

- The Ammonia plot of the down gradient boreholes also illustrates a relatively homogeneous behaviour and with a marginally lower recorded maximum of 0.25mg/l (in GW1) than in the up gradient boreholes. The recorded spiked values are anomalous against relatively linear trends in concentrations.
- Chloride concentration for the four down gradient boreholes display very spiky plots but this is due to the width of the Y-axis. In reality the values range between a minimum of 45mg/l in GW10 and a maximum of 180mg/l in GW9. This recorded variation is closely associated to that shown by the up gradient boreholes. Trends of plotted concentrations are also relatively similar to those displayed in the up gradient boreholes.

2.3.8 As an overall conclusion there is no marked difference in groundwater quality between the up and down gradient boreholes.

Long term hydrogeological changes

2.3.9 Hydrogeological changes are expected as a result of the extraction of the sand and gravel deposits. These may manifested as localised impacts on recharge characteristics and flow directions, but will not affect aquifer resources as the RTDs in the area is considered to be poor yielding. The impact of the proposed extraction activity (combined with proposed deepening of void space, and changes to engineering design of the cell) on recharge and flow direction is assessed as being minor, but long term, due to the localised nature of the development.

2.3.10 The impacts in terms of both magnitude and duration that future climatic changes could bring about on the groundwater regime are too difficult to predict given the rather localised nature of the development.

2.4 Surface water quality

2.4.1 Three surface water monitoring points surround the installation i.e. SW3, SW4 and SW5. Two points (SW3 and SW4) are chosen in the current permit for monitoring purposes. The results showed that the quality of the surface water generated by the site is generally good, with all constituents showing concentrations below the relevant EQS values, with the exception of sulphate. This issue is not part of this permit variation application.

2.5 Receptors

Current licensed/exempt groundwater or surface water abstractions

2.5.1 The closest licensed groundwater abstraction was located about 0.6 km to the north-west of the site and used for spray irrigation purposes. There were eight other reported licensed groundwater abstractions within a 1km radius of the site's boundary.

2.6 Sites of ecological or nature conservation significance

2.6.1 The site is located within about 1 km of the Ouse Washes which at a national level has been classified as a Site of Special Scientific Interest (SSSI). In addition there are five County Wildlife Sites (CWS) namely: Block Fen Gravel Pits, Mepal Gravel Pits, Sutton & Mepal Pumping Station Drains, Wimblington Gravel Pits and Manea Pits.

2.6.2 Potential receptors with respect to controlled waters considered in the risk assessment are:-

- Groundwater in the River Terrace Deposits (primary receptor).

2.6.3 For risk assessment purposes, we have assumed that compliance points for Hazardous substances will be any groundwater directly below the proposed cell and for Non-hazardous pollutants, will be a monitoring point immediately on the down gradient boundary.

3.0 Quantitative hydrogeological risk assessment

3.1 The nature of the assessment

3.1.1 The development receives a limited amount of non-hazardous waste streams hence the Groundwater Directive (2006/118/EC) is applicable, resulting in the requirement to undertake a groundwater risk assessment.

3.1.2 Although Phase 9 is not within or close to an SPZ, a complex risk assessment has been carried out to ensure that the uncertainty associated with the identified source, pathway and receptor terms within the hydrogeological conceptual model are considered.

3.2 Potential accidents and their consequences (Qualitative Risk Assessment)

3.2.1 In previous HRAs for the Mepal Landfill it was mentioned that part of the site lies within the zone defined by the Environment Agency as likely to be affected by a flood that has a 1% (1 in 100) or greater chance of happening each year and/or a major flood with up to a 0.1% (1 in 1000) chance of occurring each year. The development has, however, been the subject of a flood risk assessment (FRA) which concluded that: "… the proposed development is not at risk itself."

3.2.2 Another accident scenario likely to occur is considered to be damage to the engineered clay cap which would allow increased infiltration of effective rainfall into the site. However, this component is unlikely to be realised due to the proposed CQA supervision of the works, which will assure any remediation repairs are carried out in a timely manner.

3.2.3 Additional potential accidents are leakage of hydraulic fluids and oil from plant (e.g. transfer pumps, excavators, etc.) utilised on haul roads and leakage from site fuel storage tanks (risked out due to use of bunded containers).

3.2.4 In general the probability of any of the above accidents happening is closely related to efficient site management and conscientious equipment and plant operators who will ensure lowering/minimising of risk through a robust implementation of site procedures included in the Operating Techniques document accompanying this application.

3.3 Quantitative risk assessment modelling

3.3.1 Because of the nature of the surrounding geology and elevation of the water table relative to the proposed basal elevations and leachate head level of Phase 9, landfilling will be

undertaken beneath current average groundwater levels i.e. sub-water table conditions will prevail.

3.3.2 As a result of these circumstances, the site would be operated on the principle of hydraulic containment and previous HRAs evaluated the remainder of the site on this basis. The Environment Agency's 2004 Report "Contaminant fluxes from hydraulic containment landfills – a review" provides guidance and a modelling tool to evaluate contaminant transport concentrations within such a system. This risk assessment approach is considered to be suitable for this purpose and will therefore be applied to this report.

3.4 Contaminants to be modelled and Environmental Assessment Limits (EALs)

3.4.1 The contaminant concentrations are defined by the WAC limits for hazardous waste as described in Section 2. The GOT review mentioned the need to include the following interim hazardous substances in the risk assessment, in addition to those chosen previously i.e. ammonia, cadmium and chloride. Because of the intended importation of gypsum (hydrated calcium sulphate) it proposed to add sulphate to the list below as an indicator substance for the risk assessment process.

- Arsenic;
- Boron;
- Chromium VI;
- Selenium;
- Antimony;
- Sulphate;
- Lead; and
- Nickel.

3.4.2 An Environmental Assessment Limit (EAL) is defined as a value set at the Compliance Point calculated to be a maximum concentration allowable at that point in order to protect a receptor.

3.4.3 The Agency's recognised statistical approach of the mean plus three standard deviations of the up-gradient (background) values for the non hazardous pollutants ammonia and chloride (as present in the current EPR permit) as well as sulphate to indicate the presence

of gypsum has been applied to derive EALs for these substances as shown in Table 1. Sulphate has been changed and its derivation shown in Appendix C.

3.4.4 For hazardous substance, cadmium in the current EPR permit has been replaced by Arsenic and Lead).

Table 1: Priority substances and EALs

Determinants	Statistical Concentration in groundwater boreholes	MRV	Compliance Limits
Hazardous substance			
Arsenic (μg/l)		0.005	0.005
Lead		0.005	0.005
Non-hazardous pollutants			
Ammonia (mg/l)	0.14		0.14
Chloride (mg/l)	214		214
Sulphate (mg/l)	1102		1102

3.4.5 It is recommended these EALs be reviewed during the annual monitoring reporting procedure but also informally following each monitoring visit.

3.4.6 The spreadsheet modelling tool for hydraulically contained sites developed by the Agency for the chosen substances contains the various input parameters, assumptions and justifications. The reader is referred to the various spreadsheets attached to this application for this information.

3.4.7 Justifications for the various inputs are presented in Appendix D.

3.5 Predicted emissions to groundwater

3.5.1 The concentration, as predicted by the spreadsheet model, of the Hazardous substances Arsenic and Lead are not predicted to breakthrough the liner at concentrations greater than the Minimum Reporting Values, within 10,000 years.

3.5.2 The same result is obtained for the concentrations of the modelled Non-hazardous pollutants.

Leachate head

3.5.3 Although the guidance on hydraulically contained landfills (Contaminant fluxes from hydraulic containment landfills – a review, 2004) highlights the need to maintain a leachate head lower than the surrounding groundwater levels, there are occasions in which such a situation can cause instability in the lining system, especially when a large difference in

heads between leachate and groundwater occurs. An optimum leachate head limit of >1.6m below the surrounding groundwater level has been mentioned in the guidance with regards to clay liners in order to prevent egress of solute.

3.5.4 This would mean that a leachate head of approximately 3.2m measured from the base of the sump(s) could be maintained without adverse impact on the groundwater system at current average groundwater levels. This value is rounded down for the sump to 3m above the base of the deepened cell whilst management control is active. Within the monitoring wells the heads will be at 2m following the engineered basal slopes of the cell at 1:100 and distance to these points.

3.5.5 This proposed compliance limit is also supported by practical and operational reasons since pumps installed in sumps should always be set at least 1.5m above the base of the well as with time heavy deposits and silting up would impact on pump performance and operation (potential for breakdowns), with associated increases in leachate heads during maintenance periods.

4.0 Review of technical precautions

4.1 Review of technical precautions

4.1.1 The findings of this hydrogeological risk assessment have demonstrated that the proposed changes in Phase 9 comply with the requirements of the Groundwater Directive.

4.1.2 Nonetheless, a series of necessary technical precautions have been identified as part of this risk assessment, which will be reviewed during the life of the permit.

Capping

4.1.3 On completion of infilling to final waste levels, the cell will be capped to minimise rainfall infiltration and control leachate generation. This will be achieved by the importation of inert material.

Lining Design

4.1.4 The base and side slopes have an engineered containment system which has been risk assessed on the basis of the proposed design and according to the waste stream to be imported. The predicted results from the model simulations have indicated that the lining system meets the requirements of the Landfill Directive with respect to potential pollution to controlled waters.

4.1.5 Additional confidence in the robustness of these designs will be provided by the CQA supervision programme to be implemented during the construction of this cell.

Leachate Drainage

4.1.6 The base of Phase 9 and its extension will slope towards the collection sump at a gradient of 1V:100H. The engineered basal liner will have a lower permeability than the overlying deposited material and this will act as a barrier along which any leachate will accumulate. Ultimately the leachate will convey to the central monitoring point from where it is abstracted and discharged if necessary.

Leachate Head Control

4.1.7 The proposed cell extension has been designed (and will be constructed) to operate on the principle of hydraulic containment with a leachate head of 3m at the sump(s). It is therefore essential that leachate heads are maintained in the long term via leachate extraction.

Groundwater Management

4.1.8 An insignificant amount of groundwater is expected during removal of the in situ minerals within the RTDs and possibly at the contact with between the Cementstone band and the surrounding Ampthill Clay Formation, although drilling information from the latest site investigation (Dec. 2015) showed no evidence of groundwater intersection.

Surface Water Management

4.1.9 Surface water run-off will be collected in normal surface water drains around the perimeter of the site.

5.0 Requisite surveillance

Leachate monitoring

5.0.1 The leachate monitoring wells and collection point in Phase 9 are labelled and their positions shown on Drawing MGL/A075924/LOC/01 and MGL/A075924/LOC/02. This arrangement will ensure that leachate heads at the monitoring locations will be maintained at 2m (given the 1:100 basal fall and distance from the sump) above the base of the cell, whilst at the collection point(s) the head will be at 3m.

5.0.2 Leachate levels monitoring frequency and suite of substances to be sampled are to be undertaken in accordance with the conditions stipulated in Table S3.6 of current Environmental Permit EPR/LP3996ND. Table 2 below summarises these parameters for completeness. An additional parameter to the permit's table is sulphate.

Table 2: Leachate monitoring determinants and sampling frequency

Monthly	Quarterly	Annually
Level	pH, Chloride, Alkalinity, Ammonia, Sulphate, COD, BOD, Sodium, Potassium, Iron, Manganese, Cadmium, Chromium, Copper, Calcium, Selenium, Nickel, Lead, Boron, Zinc, Electrical conductivity, DOC, TPH (C10-C40), Antimony, Arsenic, Mercury, Magnesium	*To include quarterly suites plus:* Hazardous substances

Groundwater monitoring

5.0.3 Groundwater level and chemical data are to be collected from dedicated monitoring points around Phase 9. Boreholes GW1, GW8, GW9 and GW10 are identified as being down-gradient of the site.

5.0.4 The relevant table of the current Environmental Permit (Table S3.8) contains reference points, parameters to be sampled and monitoring frequency, as applied to the whole site. These requirements are considered adequate in providing an ongoing characterisation of the groundwater conditions and therefore the monitoring programme in place at the site should be continued. The addition of sulphate as a sampled parameter will however be required, see Table 3 below.

Table 3: Groundwater determinants and sampling frequency

Monthly	Quarterly	Annually
Level	pH, Chloride, Alkalinity Ammonia, Sulphate, COD, BOD, Sodium, Potassium, Iron, Manganese, Cadmium, Chromium, Copper, Calcium, Selenium, Nickel, Lead, Boron, Zinc, Electrical conductivity, DOC, TPH (C10-C40), Antimony, Arsenic, Mercury, Magnesium	*To include quarterly suites plus:* Hazardous substances

Surface water

5.0.5 The frequency, location and sampling suite currently being implemented are considered to be suitable for the characterisation of surface water quality and recording of potential breaches should be continued following construction of the remainder of the cell. Table 4 below summarises the data to be collected. Table S3.7 of the current permit should be referred to for completeness.

Table 4: Surface water determinants and sampling frequency

Quarterly
pH, Chloride, Ammonia, Phosphorous, Suspended Solids, **Sulphate**, COD, Electrical conductivity

5.1 Compliance limits

5.1.1 The current compliance limits (for leachate, surface water and groundwater) applied to the site are presented in Tables S3.1 S3.2 and S3.3 respectively of the latest permit variation (EPR/LP3996ND/V003) for chosen monitoring locations and chemical parameters. The new sulphate figure should be added to these tables.

5.2 Leachate compliance limits

5.2.1 The proposed leachate level compliance limit should be set at 2m as measured within the monitoring wells and 3m at the collection point(s).

5.3 Groundwater compliance limits

5.3.1 Compliance limits are set for down-gradient boreholes GW1, GW8, GW9 and GW10, as it is not a regulatory requirement to derive compliance limits for those boreholes up gradient of the proposed development.

5.3.2 The limits for non-hazardous pollutants have been calculated following a statistical protocol of the mean plus three standard deviations.These compliance limits are to be applied similarly to all the chosen down-gradient boreholes.

5.3.3 Cadmium has been replaced by Arsenic and Lead for the hazardous substance). Table 5 contains the new compliance limits for sulphate, which should replace those contained in the latest variation EPR/LP3996ND/V003.

Table 5: Groundwater compliance limits changes to Sulphate

Location	Compliance limits
GW1	1102
GW8	1097
GW9	989
GW10	1064

*Additional for this application remainder already included in previous variation

5.4 Surface water compliance limits

5.4.1 The compliance limits presented in Table S3.2 of current permit EPR/LP3996ND specifically for points SW3 and SW4 are applicable to satisfy monitoring requirements.

5.5 Contingency action plan

5.5.1 An annual review of the proposed compliance limits should be carried out and any alterations in the compliance levels will be discussed and agreed with the EA.

5.5.2 Where the site monitoring programme identifies an increase in determinants that could lead to the control levels being breached, then a series of contingency actions will be required. Suggested contingency actions, which will need to be agreed with the Environment Agency, are presented in Table 6.

Table 6: Suggested contingency actions and time frames

Appropriate Contingency Action	Timescale
Advise Site Management	Immediately
Advise Environmental Manager of Mick George Limited	1 Week
Advise Environment Agency	1 Week
Confirm by repeat sampling and analysis	1 Month
Review existing monitoring information	1 Month
Review site management/operations, implement actions to prevent future failure of a trigger level	3 Months
Review assumptions in conceptual site model	3 Months
Review existing Hydrogeological Risk Assessment, Compliance Limits	6 Months
Consult Environment Agency about need for corrective action	6 Months

6.0 Conclusions

6.1 Compliance with the Landfill Directive, 1999/31/EC

6.1.1 The proposed engineered designs for Phase 9 and its extension comply with the Landfill Directive in terms of containment and collection of contaminated water and leachate. Leachate will be removed from the containment landfill and stored in a bunded tank on site before being tankered for disposal to a suitably permitted facility.

6.1.2 Surface water runoff is to be collected in normal surface water drains around the perimeter of the site.

6.1.3 The installation complies with current engineering design, materials and specifications applicable to current landfill containment best practices.

6.1.4 An independent CQA procedure will be carried out for all aspects of the basal and sidewall lining and capping procedures. This ensures that the liner and cap meet the required engineering standards and thus comply with the Landfill Directive and will not have an impact on the groundwater system as a result of the proposed importation of gypsum as supported by the results of the hydraulic containment modelling results.

6.1.5 Compliance limits for leachate and groundwater have been updated for sulphate.

6.2 Compliance with the Groundwater Directive, 2006

6.2.1 The modelling results indicate that even in the long term, Hazardous substances will not reach the aquifer in discernible concentrations as long as the current hydraulic containment will be maintained. Hence, the proposed discharge will comply with the Groundwater Directive.

6.2.2 It has been demonstrated that the introduction of Non-hazardous pollutants to groundwater is most likely to be sufficiently limited so as not to cause pollution at the off-site compliance point, as required by the Groundwater Directive, 2006.

6.2.3 The requirements of the Groundwater Directive include that requisite surveillance of the groundwater quality is carried out regularly as discussed in Section 5.

6.2.4 The findings (in terms of the hydraulic containment modelling results and risk assessment scenarios) of this HRA have demonstrated that the presence of gypsum has not produced an impact on the primary groundwater environmental receptor i.e. the River Terrace Deposits.

Drawings

MGL/B070447/PER/01A – Permit Boundary Plan

MGL/A075924/ENG/04A – Phase 9 engineering concept

MGL/B070447/LOC/01 – Phase 9 Extension Area

MGL/B070447/LOC/02 – Close up of Phase 9 Extension area

MGL/B070447/LOC/03 – Engineering Section Through Phase 9 Extension area

MGL/A094946/HYD/01, 02 and 03 – Groundwater contours (Min., Max. and Ave. values)

Appendices

Appendix A: WAC acceptance criteria limits and leachate quality data

Appendix B: Groundwater level data and hydrograph

Appendix C: Sulphate quality data and chemographs

Appendix D: Hydraulic containment models - justifications

Appendix E: Newly drilled groundwater monitoring - boreholes

Appendix A: WAC acceptance criteria limits and leachate quality data

Determinand □	Limit values for compliance leaching test using BS EN 12457-3 at L/S 10 l/kg
Arsenic	2
Barium	100
Cadmium	1
Chromium	10
Copper	50
Mercury	0.2
Molybdenum	10
Nickel	10
Lead	10
Antimony	0.7
Selenium	0.5
Zinc	50
Chloride	15000
Fluoride	150
Sulphate	20000
Total Dissolved Solids	60000
Phenol Index	
Dissolved Organic Carbon	800

Appendix B: Groundwater level data and hydrograph

Appendix C: Sulphate quality data and chemographs

Appendix D: Hydraulic containment models - justifications

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Ammonia	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List II	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	150	mg/l	Reasonable value for SNR Wastes
Free water diffusion coefficient	Dw_cl	2E-9	m2/s	GSI Environmental database
Partition coefficient in clay	Kd_cl	2	l/kg	LandSim manual V2.5 - maximum value
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient
STEADY STATE DILUTION				
Hydraulic gradient in the aquifer	aq_I	0.0025	-	Based on GWL data
Hydraulic conductivity of the aquifer	k_aq	0.00058	m/s	
Downgradient distance of compliance point from landfill	dist_cp	0.1	m	
Dilution flow in aquifer downstream to the landfill	aq_Q	0.0010759	m3/s	

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Arsenic	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	2.5	mg/l	Average values obtained from Rowe et al. "Barrier systems for waste disposal" 2nd ed. 1995
Free water diffusion coefficient	Dw_cl	7E-10	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	249.6	l/kg	ConSim Suggested value
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years

CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Boron	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	5	mg/l	Average values obtained from Rowe et al. "Barrier systems for waste disposal" 2nd ed. 1995
Free water diffusion coefficient	Dw_cl	1.12E-9	m2/s	Value from Mackin, J.E. "The free-solution diffusion coefficient of boron: influence of dissolved organic matter", 1986
Partition coefficient in clay	Kd_cl	3	l/kg	Same as Arsenic - Periodic Table Metalloid
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	

MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Cadmium	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	0.5	mg/l	Calculated from WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	5.8E-10	m2/s	Effective diffusion coefficient - Shackleton et el., 1989
Partition coefficient in clay	Kd_cl	1.6	l/kg	EA R&D report P120 (minimum)
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.00000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Chloride	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List II	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	2500	mg/l	Calculated from WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	2.2E-9	m2/s	Effective diffusion coefficient - Shackleton et el., 1989
Partition coefficient in clay	Kd_cl	0	l/kg	EA R&D report P120 (minimum)
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient
STEADY STATE DILUTION				
Hydraulic gradient in the aquifer	aq_I	0.0025	-	Based on GWL data
Hydraulic conductivity of the aquifer	k_aq	0.00058	m/s	
Downgradient distance of compliance point from landfill	dist_cp	0.1	m	
Dilution flow in aquifer downstream to the landfill	aq_Q	0.0010759	m3/s	

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Chromium_VI	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	0.5	mg/l	WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	5E-10	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	965	l/kg	LandSim V2.5 manual
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years

CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Nickel	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	0.4	mg/l	Minimum WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	1.95E-9	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	300	l/kg	LandSim V2.5 manual
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	

MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Lead	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	5	mg/l	Minimum WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	1.4E-9	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	1.6E4	l/kg	ConSim suggested value
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years
CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Antimony	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	0.06	mg/l	Minimum WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	2.3E-9	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	2.4	l/kg	Allison et al. "Partition coefficients for metals in surface water, soil, and waste", 2005
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	
MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Mepal (Witcham Meadlands) Landfill

CONCEPTUAL MODEL AND LANDFILL CONSTRUCTION				Justification / Reference / Notes
Scenario		3		CSM
Is a geomembrane present?		No		
Basal width perpendicular to groundwater flow	Width_LF	200	m	Site plan - width Phase 9
Basal length parallel to groundwater flow	Length_LF	420	m	Site plan - length Phase 9
Elevation of base of landfill	LFbase_elev	-17	maOD	Approx. 3.0 m below Lower Cementstone horizon in NBH01
Elevation of base of aquifer	Aqbound_elev	-5.97	maOD	Base of RTD in GW1
Leachate head inside landfill	Head_inLF	-4	maOD	Proposed head at sump
Groundwater head outside landfill	Head_outLF	-2.26	maOD	Average recorded GWL over 4 years

CONTAMINANT PARAMETERS				
Contaminant name	Cont_Nme	Selenium	-	
Contaminant type	Cont_Type	Inorganic	-	
Contaminant classification	Cont_Class	List I	-	Groundwater Directive 2006
Concentration in landfill leachate	Conc_LF	5000	mg/l	Minimum WAC limit for hazardous waste at 10:1 ratio
Free water diffusion coefficient	Dw_cl	2.2E-9	m2/s	SGI Environmental database
Partition coefficient in clay	Kd_cl	1	l/kg	Allison et al. "Partition coefficients for metals in surface water, soil, and waste", 2005
Half life in clay (0 for no decay)	thalf_cl	0	days	
Decay in sorbed phase?	Decay_sorb	No	-	

MINERAL BARRIER / LINER				
Thickness of mineral liner	thick_clbr	1	m	Proposed thickness of engineered basal liner above Ampthill Clay
Hydraulic conductivity	k_cl	0.000000001	m/s	Maximum permissible under Landfill Directive
Average pore radius	pore_radius	0	m	No data available
Effective porosity	n	0.34	-	Minimum total porosity for clay - Domenico & Schwartz 1990
Dry bulk density	rho	1589	kg/m3	Mean value from site testing (36 samples)
Tortuosity	tau_cl	1	-	Accounted for in effective diffusion coefficient

Appendix E: Latest groundwater monitoring - boreholes