Appendix I.4

(Documents in support of Attachment I.4)

Tier 3 Assessment

Baseline Report

Note in Relation to Tier 3 Report

20-11-14

At the time the Tier 3 Report was being prepared, CCC was concerned about elevated levels of ammonia in GW1. It was deemed unlikely that the potential contamination source was the unlined portion of the landfill (Phase 1). Recent investigations of the leachate pipeline which runs close to this borehole have concluded that contamination may have come from this source. On foot of these investigations, this section of the pipeline has now been re-routed. The Tier 3 Report requires a revision in view of this finding. Additional stream monitoring is now in progress as part of the investigation.

May 2014

CARLOW
COUNTY COUNCIL
COMHAIRLE CHONTAE CHEATHARLOCHA

Powerstown Landfill

Waste Licence Reg. No. W0025-03

Environmental Risk Assessment

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Job Number: **E1024**

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Revision Record

Issue No.	Date	Description	Remark	Prepared	Checked	Approved
1	28/05/2014	Environmental Risk Assessment	Final	DD	CC	EB

Powerstown Landfill & Civic Amenity Site

Carlow County Council

Environmental Risk Assessment

May 2014

Contents

TABLES

GRAPHS

Drawing

TABLES

APPENDICES

1.0 INTRODUCTION

Malone O'Regan (MOR) was commissioned by Carlow County Council (CCC) (the Client) to undertake a Detailed Qualitative Risk Assessment (DQRA) for the Powerstown Landfill & Civic Amenity facility (the site). The site is operated by CCC in accordance with Waste Licence W0025-03.

This report presents the findings of the DQRA completed for the site.

1.1 Project Objective

The primary objective of this work was to complete a DQRA in order to evaluate the environmental issues of concern identified in the Generic Quantitative Risk Assessment that was undertaken for the site in 2012 (MOR, 2012). The focus of this DQRA is on the identified groundwater contamination beneath the site with the following key objectives:

- To evaluate whether there are any risks to identified environmental receptors associated with the groundwater contamination beneath the site.
- To derive groundwater compliance monitoring points and values that are protective of the identified receptors.

1.2 Scope of Works

The scope of works was undertaken was agreed with CCC and comprised of the following:

Task 1:

A desk-based study that comprised of a review of published geological and hydrogeological information (e.g. Geological Survey of Ireland (GSI) databases), historical maps, utility drawings, previous environmental assessment reports and information provided by the Client pertaining to site including the following as set out in:

- Tier 1 Risk Assessment contained in MOR report titled 'Tier 1 Qualitative Risk Assessment 2012'. (MOR, 2012)
- Annual Environmental Reports 2003-2011as provided by CCC (CCC, 2003-2011).
- Environmental Impact Statement prepared in February 2003 (Fehily Timoney and Company, 2003).
- Detailed environmental monitoring records where available and reports submitted to the EPA as provided by CCC.
- Borehole logs provided by CCC
- Waste Licence W0025-03, as amended.
- Technical Amendment of Waste Licence W0025-03, dated 15/01/2013.

Task 2:

A Tier 2 assessment was undertaken in accordance with the document 'Guidance, *Procedures and Training on the Licensing of Discharges to Surface Waters and to Sewer for Local Authorities*' (DoEHLG, 2010) that included the following elements:

- A groundwater and surface water monitoring programme was completed by MOR including: surface water sampling of the Powerstown Stream and River Barrow at seven locations on a monthly basis over three months; groundwater level measurement on a monthly basis over three months and groundwater sampling on two occasions.

- A review of all of the monitoring data compiled by CCC.

- Review and revision of the preliminary GQRA prepared for the site using all of the available data.

Task 3:

Undertake a detailed Tier 3 assessment that included the following:

- Review and refine of the Conceptual Site Model (CSM) that was developed for the site.
- A site specific DQRA was completed to determine if there are any plausible risks to identified environmental receptors associated with the current site condition. This DQRA was completed taking cognisance of EPA documents including '*Guidance on the Management of Contaminated Land and Groundwater at EPA Licensed Sites' (EPA, 2013) and the* EPA '*Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites'* (EPA, 2007).
- Refine CSM based on findings of DQRA.

Task 4:

Screening based on the results of the Tier 3 DQRA in accordance with the EPA document "Guidance on the Authorisation of Discharges to Groundwater" was completed with recommendations outlined in relation to setting of groundwater compliance locations and values.

The findings from the above tasks were presented in a comprehensive report.

1.3 Disclaimer

The conclusions presented in this report are professional opinions based solely on the tasks outlined herein and the information made available to MOR. They are intended for the purpose outlined herein and for the indicated site and project. The report is for the sole use of the Client. This report may not be relied upon by any other party without explicit agreement from MOR. Opinions and recommendations presented herein apply to the site conditions existing at the time of the assessment. They cannot apply to changes at the site of which MOR is not aware of and has not had the opportunity to evaluate. This report is intended for use in its entirety; no excerpt may be taken to be representative of this assessment. All work carried out in preparing this report has utilised, and is based on MOR professional knowledge and understanding of the current relevant Irish and European Community standards, codes and legislation.

2.0 SITE LOCATION AND DESCRIPTION

2.1 Site Location and Surrounding Landuse

The site is located approximately 6km south of Carlow Town (National Grid Reference: E271,000; N168,800). The site covers approximately 23.9 hectares in the townland of Powerstown, located adjacent to the R448. The site location is shown on Drawing 1.

The site is located in a rural setting where the predominant land use is mixed agriculture. The site boundaries include the Powerstown Stream which is a tributary of the River Barrow, agricultural lands to the north, the R448 roadway to the west, a quarry site to the southwest, a third class road which is used to access the site to the south and agricultural lands to the east. The M9 Dublin-Waterford motorway is located approximately 185m from the northwest boundary of the site.

The site slopes to the west and northwest towards the R448 and the Powerstown Stream with a change in elevation from approximately 46mAOD (metres above Ordnance Datum) in the eastern portion of the site to approximately 42mAOD along the northwest boundary of the site.

The closest Integrated Pollution Prevention and Control (IPPC) licensed activity to the site is located over 3km northwest of the site in Clogrennane, Co. Carlow (EPA, 2014). There are no other waste facilities licensed by the EPA are located within 2km of the site (EPA, 2014).

2.2 Site History

The landfill at the site has been developed in three phases:

- Phase One consists of the old unlined landfill, which are located in the southern portion of the site and covers an area of approximately 2.5 hectares. This landfill was filled from 1975 to 1990 and is now permanently capped.
- Phase Two consists of the engineered landfill cells 1 to 13, which were filled since the closure of the old landfill between 1990 until August 2006. All of these cells have been permanently capped.
- Phase Three consists of four engineered landfill cells (Cells 15-18), which are still operational. Cell 17 is currently being filled. The majority of cells 15 and 16 have been temporarily capped. There is still a small portion of these cells required for truck access to cells 17 and 18.

2.3 Current Site Use and Description

The site is operated by CCC in accordance with the conditions of the EPA waste licence (W0025-03) as a landfill and civic amenity centre. The facility is licensed to accept household (residual) waste, commercial waste, treated sewage sludge, construction and demolition waste and industrial non-hazardous solids waste for landfilling. There was a technical amendment to the conditions of this licence in January 2013 where the waste acceptance schedule ‘A 8.8.2’ was adjusted so that the volume of municipal solid waste would be reduced accordingly over the next three years. The anticipated closure date for the site is sometime in 2016. However, the facility closure may be extended to 2018 as the waste intake quantity has dropped in recent times. The closure of the landfill facility outlined in planning permission for the site is 2018. A civic amenity area and recycling facility has been operated by CCC at the site since 2006. The current site layout is shown on Drawing 2.

The active landfill cells 15 to 18 (Phase Three) are located in the north of the site. The historical unlined landfill (Phase One) is located in the southwest of the site while Phase

Two is located between the old landfill and Phase Three in the west/northwest of the site.

The civic amenity area is located adjacent to the administration building inside the entrance (refer to Drawing 2). Materials accepted at the civic amenity area include cans, polystyrene, glass (plate/bottled), waste oils, timber, scrap metal, cooking oil, green waste, textiles, oil filters, ink cartridges, plastics, batteries, paper, fluorescent tubes, CDs/DVDs, tetrapac, Waste Electronic and Electrical Equipment (WEEE), household light bulbs, mobile phones and cardboard.

A bungalow, located near the site entrance is used as the administration office for the site. Two weighbridges are located beside the civic amenity centre.

Site facilities also include a green waste/compost area south of Phase Three and a waste quarantine area located beyond the weighbridge area and civic amenity area.

A leachate tank is located to the north east of the civic amenity area and beyond the weighbridge, while a leachate lagoon is located to the northwest of Phase One and adjacent to a former entrance to the site directly off the R448. The stormwater settling pond is located between Phase Three and the northern site boundary. Leachate is removed of site by tanker to the Mortarstown Waste Water Treatment Plant (WWTP) in accordance with the conditions of the EPA waste licence (W0025-03).

The onsite gas flare compound is located to the west of the civic amenity area.

Services onsite include electricity, water supply and sanitary facilities. The sewage and wastewater from the administration building is directed to a small waste water treatment system for primary treatment. The heating for the office is supplied from an aboveground bunded oil tank which is located adjacent to the office.

3.0 METHODOLOGY

3.1 Groundwater Level Monitoring

Static groundwater levels at the site were recorded in accordance with best practice guidelines and were measured on three occasions using a Solinst water level meter. Measurements were taken from 9 no. monitoring wells (BH1, BH2, BH3, GW1, GW2, GW3, GW8, RCA1 and RAC2). The level measurements were over a three month period (29th November 2013, 13th December 2013 and 28th January 2014). All measurements were taken relative to arbitrary reference points (i.e. top of the well inner casing (mbtoc) with the exception of GW8 where the outer casing was utilised as a reference point. These reference points were surveyed during the location survey. The results of the groundwater level monitoring are presented in Table 3.

3.2 Groundwater Sampling

The groundwater monitoring programme was conducted by MOR at the site in accordance with ISO 566-11 'Guidance on Sampling of Groundwaters'. Nine (9 No.) groundwater monitoring wells were sampled on two occasions (13th of December 2013 and 28th of January 2014). Wells were purged using an inertial pump with dedicated tubing and footvalves to prevent cross-contamination between wells. The volume of groundwater purged at each well (three well volumes or volume at which field parameters had stabilised) was recorded.

Stabilised field measurements were recorded from all wells using calibrated equipment together with observations on the physical appearance of purged water. Field measurements were recorded for pH, dissolved oxygen, temperature and electrical conductivity.

Following purging, samples were decanted into labelled containers supplied by Alcontrol. The samples were kept cool, in darkness and sent to Alcontrol for analysis. In order to maintain sample integrity, a Chain of Custody document (Appendix A) was completed to track sample possession from time of sample collection to time of analysis.

3.3 Surface Water Sampling

The surface water monitoring programme was conducted by MOR at the Powerstown site on three separate occasions. Surface Water samples were collected from seven (7 No.) surface water sample points on three occasions (29th November 2013, 13th December 2013 and 28th January 2014). Samples were collected using a telescoop which was decontaminated between sampling locations to ensure cross contamination was avoided.

Field measurements were recorded for all sampling points using calibrated equipment together with observations on the physical appearance of the samples. Field measurements were recorded for pH, dissolved oxygen, temperature, electrical conductivity and oxidation reduction potential.

Samples were decanted into labelled containers supplied by Alcontrol. The samples were kept cool, in darkness and sent to the lab for analysis. In order to maintain sample integrity, a Chain of Custody document was completed to track sample possession from time of sample collection to time of analysis. Refer to Appendix A.

3.4 Laboratory Analysis

Groundwater and surface water samples were submitted to Alcontrol, a UKAS and ISO 17025 accredited laboratory for the analytical suites outlined in Table 3.5.1 and Table 3.5.2 respectively.

Table 3.1: Groundwater Laboratory Analysis

- Ammonia
- Chloride
- Fluoride
- Nitrate
- Nitrite
- Orthophosphate
- Iron
- Potassium
- Sodium
- Phosphorus
- Aluminium
- Arsenic
- Cadmium
- Chromium
- Copper
- Mercury
- Manganese
- Nickel
- lead
- Selenium
- Zinc
- pH
- Electrical Conductivity

Note: Electrical Conductivity and pH were recorded in the field.

Table 3.2: Surface Water Laboratory Analysis

- Total Ammonia
- Suspended Solids
- Chloride
- Potassium
- Sodium
- Iron
- Manganese
- pH
- Electrical Conductivity
- Temperature

Note: Electrical Conductivity, Temperature and pH were recorded in the field.

4.0 ENVIRONMENTAL SITE SETTING

4.1 Geology

4.1.1 Subsoil

Subsoil beneath the site has been mapped as predominantly glaciofluvial sands and gravel with alluvium along the northern site boundary adjacent to the Powerstown Stream (Refer to Drawing 5) (GSI, 2014).

The presence of glaciofluvial sand and gravel deposits beneath the site has been confirmed through a number of site investigations (Geotechnical Environmental Services Ltd (GESL), 1999); (Glover Site Investigations Ltd, 2006); (IE Consulting, 2011) and (MOR, 2011).

4.1.2 Bedrock Geology

Bedrock beneath the site has been mapped as Carboniferous limestone comprising of the dolomitised Ballysteen Formation beneath the eastern portion of the site and the dolomitised Milford Formation beneath the western portion of the site (GSI, 2014). The dolomitised Ballysteen Formation comprises of dark-grey muddy limestone while the dolomitised Milford Formation comprises of dolomitised peloidal calcarenitic limestone (Refer to Drawing 6). The findings of site investigations completed at the site confirm the presence of pale grey, pale to dark grey and brown grey with occasional layers of muddy limestone beneath the site at depths ranging from 11m below ground level(GES Ltd. 1999), and (MOR,2011).

4.2 Hydrogeology

4.2.1 Aquifer Classification

Two regionally important aquifer units beneath the site and surrounding area have been mapped by the GSI (2014) as follows:

- The regionally important karstified aquifer with diffuse flow (Rkd) within the Carboniferous limestone formations (Refer to Drawing 7).
- The regionally important gravel aquifer (Rg) comprising the Barrow Valley glaciofluvial sand and gravel (Refer to Drawing 8).

4.2.2 Groundwater Vulnerability Rating

The GSI (2014) has assigned an interim groundwater vulnerability rating of ‘High’ for the groundwater in the bedrock aquifer beneath the site (Refer to Drawing 10).

4.2.3 Aquifer Characteristics

The gravel aquifer located beneath the site forms part of the Barrow Valley Groundwater Body. (GSI, 2014)

Inferred groundwater flow direction beneath the site has been interpreted to be generally to the west towards the River Barrow with a local component of flow likely influenced by the Powerstown Stream and topography of the landfill (Refer to Drawing 9).

Groundwater was encountered during drilling at the site at depths ranging 7.3m (GW7) to 14m (GW3) within the gravel, 18.8m (GW6) to 25.3m (GW6) within the bedrock and 14.6m at the interface between bedrock and gravel (GES Ltd, 2011). During the drilling works for installation of BH1, BH2, and BH3 groundwater was encountered within the sand and gravel at 8mbgl (BH3), 9.5mbgl (BH1) and 13mbgl (BH2) (MOR, 2011). Based on site observations it is considered that the sand and gravel and underlying limestone aquifers are in direct hydraulic connection.

The measured average hydraulic gradient across the site was in the order of 3.1×10^{-3}. The calculated hydraulic conductivity for the tested portions of the gravel aquifers was $9m.d^{-1}$.

4.2.4 Groundwater Use and Protection

A review of the GSI groundwater well database (2014) identified a total of 54 wells within a 2km radius of the site, of which 24 wells are classified as "Industrial use", 17 as "Domestic and Agricultural use", 11 as "Unknown", 1 as "Public supply", and the remaining 1 as "Domestic Use Only". 19 of the wells classified as industrial on the GSI well database are within the site boundary although it is believed that some of these may have been decommissioned. The reported yield from supply wells ranges from $14.2m^3$/day (unknown use) to 1,635 m^3/day (unknown use) (GSI, 2014). The results of the well search are displayed on Drawing 11.

It has been confirmed by CCC in the 2013 AER that no groundwater abstraction occurs on site, while no groundwater supply wells were identified within 500m of the site or downgradient of the site (GSI, 2014).

The GSI Source Protection Area data (2014) indicates that there are no designated Source Protection Zones in the immediate vicinity of the site. The closest Source Protection Zone is the Paulstown Source Protection Area over 8km south west of the site (Refer to Drawing 12). Carlow County Council have indicated that there are also Source Protection Zones for groundwater public supplies at Bagenalstown, and Leighlinbridge which are located approximately 7 km and 6km respectively to the south of the site and Old Leighlin supply located to the southwest on the opposite side of the River Barrow.

The South Eastern River Basin District (SERBD) River Basin Management Plan (RBMP) 2009-2015 and the SERBD Groundwater Action Plan (2010) sets the objective to protect groundwater with good status and sets deadlines to restore groundwater with poor status. The groundwater body beneath the site is:

- The Barrow Valley Groundwater Body (GWB) (Code IE_SE_G_018). The SERBD Groundwater Action Plan classifies Barrow Valley GWB as of good status and sets the objective to protect the good status of this GWB.

4.2.5 Groundwater Quality

Historical groundwater quality for the site indicates that groundwater beneath the site within the gravel aquifer has been impacted with ammonia and chloride in excess of applicable groundwater threshold values and site specific groundwater trigger values. These impacts are attributed to leachate from the landfill that has migrated to the underlying gravel aquifer.

4.3 Hydrology

4.3.1 Hydrometric Characteristics

The site is located within the Barrow Hydrometric Area (HA14) approximately 500m east of the River Barrow and in the South Eastern River District Basin. The Powerstown stream, a tributary of the River Barrow, is located along the northern boundary of the site.

The closest hydrometric station to the site in the River Barrow is the OPW monitoring station No. 140034, which is located north of Carlow Town approx. 12km upstream of the confluence of the River Barrow and the Powerstown stream. This station reports flow rates for the River Barrow of 5.4 m^3/s occurring 95% of the time (EPA, 2013b). The River Barrow catchment area at this station is 2,252.1 km^2 (EPA, 2013b).

There is no published hydrometric data available for the Powerstown Stream upstream or downstream of the site. Morrissey's Quarry located approximately 1.2 km upstream of the site discharges groundwater from the quarry operations to the Powerstown Stream in accordance with the conditions of the Discharge Licence for the quarry.

No flooding event has been recorded by the OPW within or in the vicinity of the site (OPW, 2014). The closest recorded flooding event, which occurred in 1996, is located over 1.5 km northwest of the site in Milford on the River Barrow (Flood ID 2960). There was local flooding encountered along the River Barrow during the sampling conducted in January 2014.

4.3.2 Surface Water Protection

The South Eastern River Basin District (SERBD) River Basin Management Plan (RBMP) 2009-2015 sets the objective and deadlines in order to achieve and protect good status in surface water bodies. As part of the SERBD RBMP (2009-2015), detailed action plans and programmes were prepared for more locally focused catchment areas. The Barrow Main Water Management Unit (WMU) Action Plan, which was published in 2010, classifies the Powerstown stream (Code SE_14139) as of poor status while the River Barrow is classified as of good status upstream and downstream of the site.

The SERBD RBMP and its relevant action plans and programmes establish objectives and timelines in order to restore and protect good status in surface waters in accordance with the Surface Water Regulations, 2009 and the Water Framework Directive (WFD) (2000/60/EC). An objective for the Powerstown Stream is to restore good status by 2021 while the objective for the River Barrow is to protect the existing good status.

There are two designated or proposed protected areas in the vicinity of the site which are detailed in Table 4.3 below (National Parks and Wildlife Service (NPWS), 2012).

Table 4.3: Designated Protected Areas

Area Code	Area Name	Protected Status	Distance from Site
002162	River Barrow and Nore	Special Areas of Conservation	15m to the west
000806	Cloghristick Wood	Proposed Natural Heritage Area	250m north west (within and adjoining the River Barrow and Nore SAC)

The River Barrow and Nore Special Area of Conservation (SAC) boundary extends from the River Barrow to the R705 bounding the western side of the landfill. Refer to Drawing 13.

4.4 Surface Water Quality

Historical data for the Powerstown Stream provided by CCC indicate that ammonia concentrations are generally higher downstream of the landfill compared to upstream with exceedances of the surface water EQS value.

The 2013 biological assessment completed by Conservation Services (CS) in August 2013 conclude that both upstream and downstream locations of the Powerstown stream have a biological Q rating of Q3-Q4, indicating slightly polluted waters. The latest report by CS concludes that the biological data from August 2013 indicate no evidence of an impact from Powerstown Landfill on the biological quality of Powerstown stream. This is consistent with the finding of the Appropriate Assessment Screening Report completed by Sweeney Consultancy in January 2012 with regard to the impacts of Powerstown Landfill on the River Barrow and River Nore SAC do not show less than Q4 since 2003 either in the Powerstown stream downstream of the landfill or in the River Barrow at the next site downstream.

5.0 GENERIC QUANTITATIVE RISK ASSESSMENT

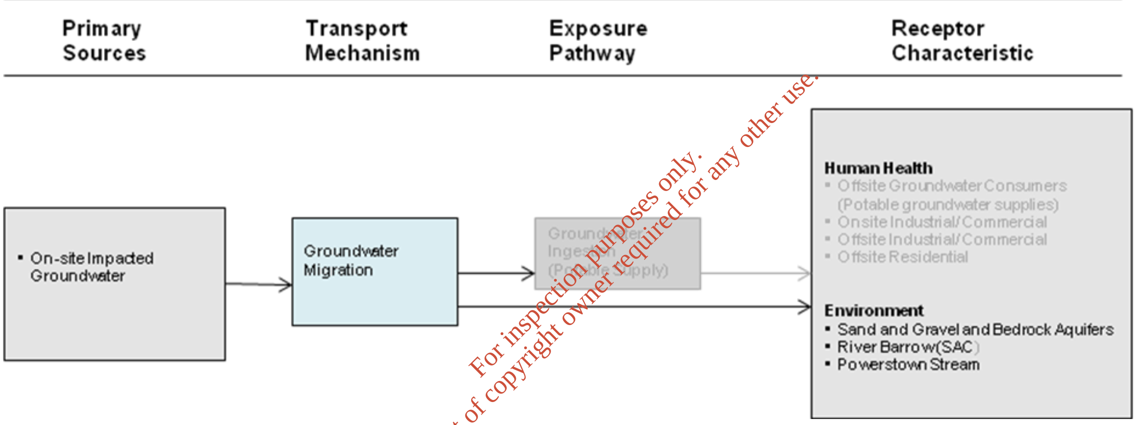
5.1 Conceptual Site Model

A Risk Assessment is undertaken to provide an understanding of the risk associated with the presence of any potentially contaminating materials and/or activities on a site. The risk based approach involves developing a conceptual site model (CSM) for a site whereby contamination **sources,** migration **pathways** and **receptors** are identified. If one or more of these three elements are missing, the exposure pathway is considered incomplete and there is no risk associated with the activity (i.e. it does not present a means of exposure).

A Conceptual Site Model (CSM) has been developed for the site as part of the Generic Quantitative Risk Assessment (GQRA) that was previously carried out for the site in 2012 (MOR, 2012). This CSM was used to identify plausible exposure pathways for the identified contaminant of concern and potential human health and environmental receptors.

The revised CSM from the GQRA carried out in 2012 (MOR, 2012) is presented in Table 5.1.

Table 5.1: Revised GQRA Conceptual Site Model



Human Health Receptors

The nature of the identified parameters that exceeded the relevant generic groundwater assessment criteria (e.g. ammonia) could only present a human health risk if groundwater was directly ingested. It has been confirmed by the client that there are no groundwater supply wells within 500m of the site, accordingly this exposure pathway will not be considered further.

Environmental Receptors

In regards to environmental receptors, the principal contaminant of concern is ammonia and the identified potential at risk receptors are the downgradient gravel aquifer and bedrock aquifer and also the downgradient surface water receptors including the adjoining Powerstown Stream and River Barrow.

5.2 Results and Generic Risk Assessment Update

This risk assessment considers the conditions associated with both the onsite and offsite identified groundwater issues and the identified source–pathway–receptor linkages.

Table 5.2: Transport Mechanisms and GQRA Assessment Criteria

Source	Transport Mechanism	Assessment Criteria
GROUNDWATER	Risk to groundwater within the Gravel and Bedrock aquifers from downgradient migration offsite of impacted groundwater	Groundwater Regulations 2010 and 2012 (S.I. No 9 of 2010 and S.I. No 149 of 2012) Surface Water Regulations 2009 and 2012 (S.I. No. 272 of 2009 and S.I. No. 327 of 2012) EPA Interim Guideline Values (EPA, 2003)
	Risk to River Barrow and Powerstown Stream from migration off-site of impacted groundwater.	Surface Water Regulations 2009 and 2012 (S.I. No. 272 of 2009 and S.I. No. 327 of 2012)

For the purposes of the GQRA update historical data for the site together with the analytical results for supplementary groundwater and surface water sampling carried out by MOR in November and December 2013 and January 2014 were used. The results of the supplementary sampling are summarised in the following sections and where applicable are compared with the available historical data provided by CCC.

5.3 Groundwater Results

Groundwater analytical and field measured results were assessed relative to the following generic assessment criteria. The analysis results of the revised assessment completed by MOR during January and February 2012, December 2013, and January 2014 at wells BH1, BH2, BH3, GW1, GW2, GW3, GW8, RCA1 and RCA2 are presented below. The results are compared to the standards below:

- European Communities Environmental Objectives (Groundwater) Regulations (S.I. No. 9 of 2010 and amendment S.I. No 149 of 2012);
- European Communities Environmental Objectives (Surface water) Regulations (S.I. No. 272 of 2009 S.I. No. 327 of 2012);
- Environmental Protection Agency Interim Groundwater Guideline Values (IGVs) (EPA, 2003) (Where there are no Environmental Quality Standards (EQS) or threshold values under the 2010 Regulations) (used in the absence of the groundwater regulation values only)
- Site specific Groundwater Trigger Levels (GTLs) set for each monitoring well at the Powerstown Landfill (Fehily Timoney & Company, 2005).

The certified laboratory reports are provided in Appendix B. A summary of the results for the site is presented below. Groundwater analytical results, together with relevant assessment criteria, where available, are presented in Table 2.

5.3.1 Electrical Conductivity and pH

Measured electrical conductivity values ranged from 442µS/cm to 867.3µS/cm. Results for all samples collected were within the relevant groundwater standards with the exception of GW2 on one occasion (867.3µS/cm) which is just slightly exceeding the assessment criteria. Measured pH results ranged from 7.02 to 7.39 pH units for all samples, which is the acceptable range of 6.5-9.5 pH units

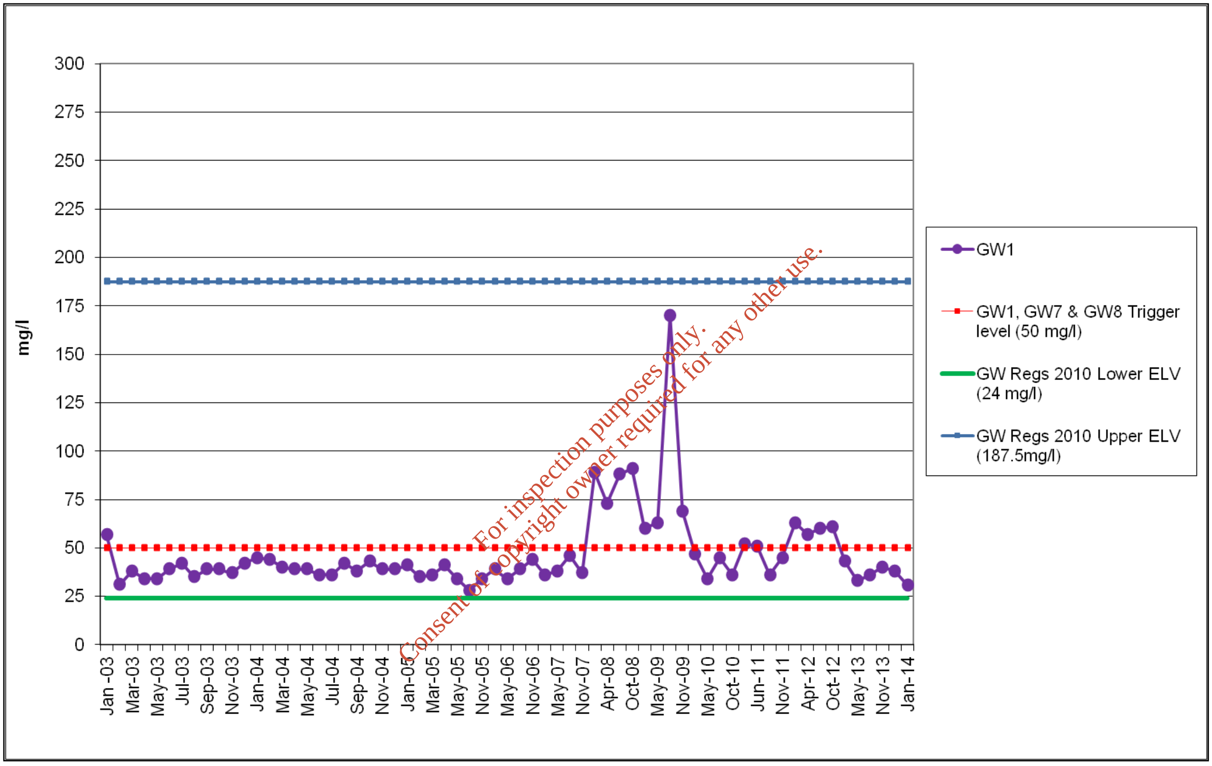
5.3.2 Indicators

Chloride

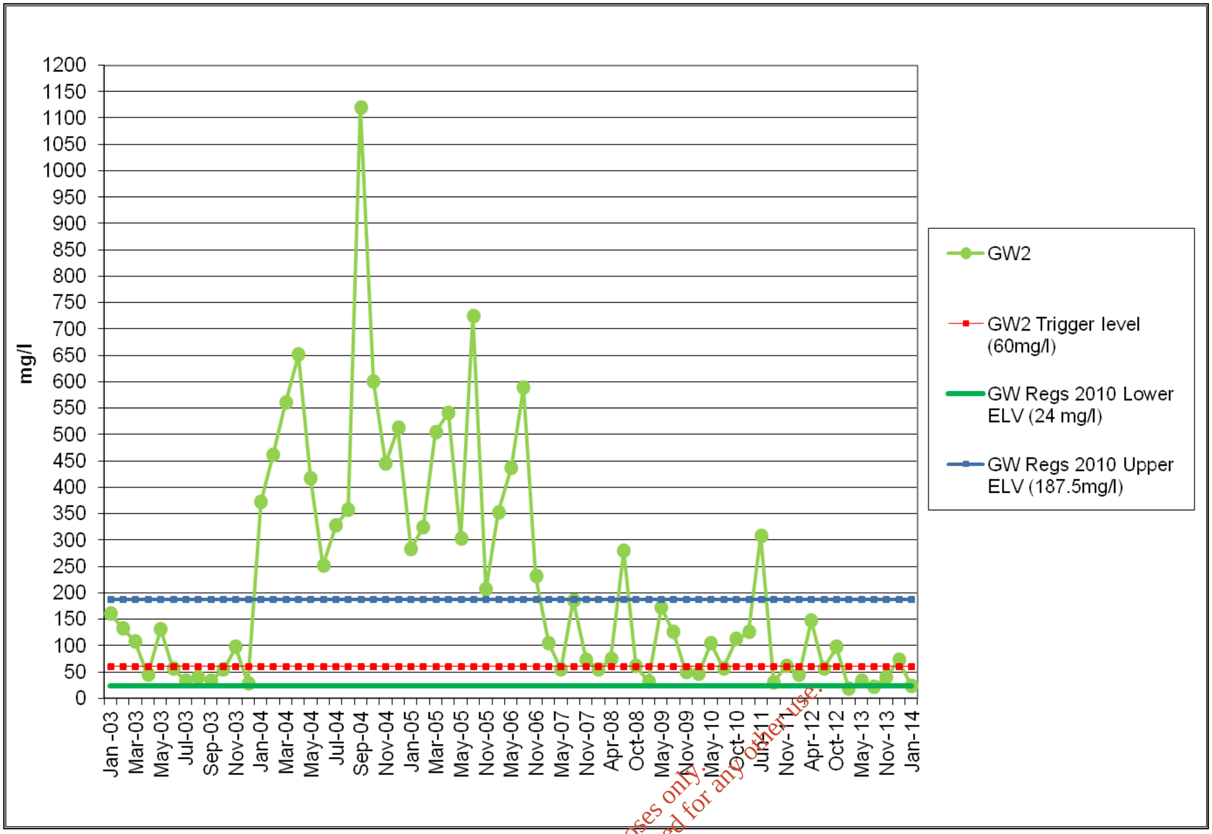
Reported chloride concentrations for all groundwater samples ranged from 17.1 to 72.1mg/l and were below the groundwater regulations upper threshold value of 187.5mg/l for both up gradient and downgradient wells. There was only one exceedance of the applicable GTL (60mg/l) reported for GW2 (72.1mg/l), which occurred during the December 2013 monitoring event.

Upgradient chloride results are consistent with historical results and are beneath the groundwater upper threshold value (RCA1 and RCA2) and the GTL (GW3 and GW8). .
The historical chloride results together with the recently compiled supplementary data are presented graphically in Graph 5.1 to Graph 5.6.

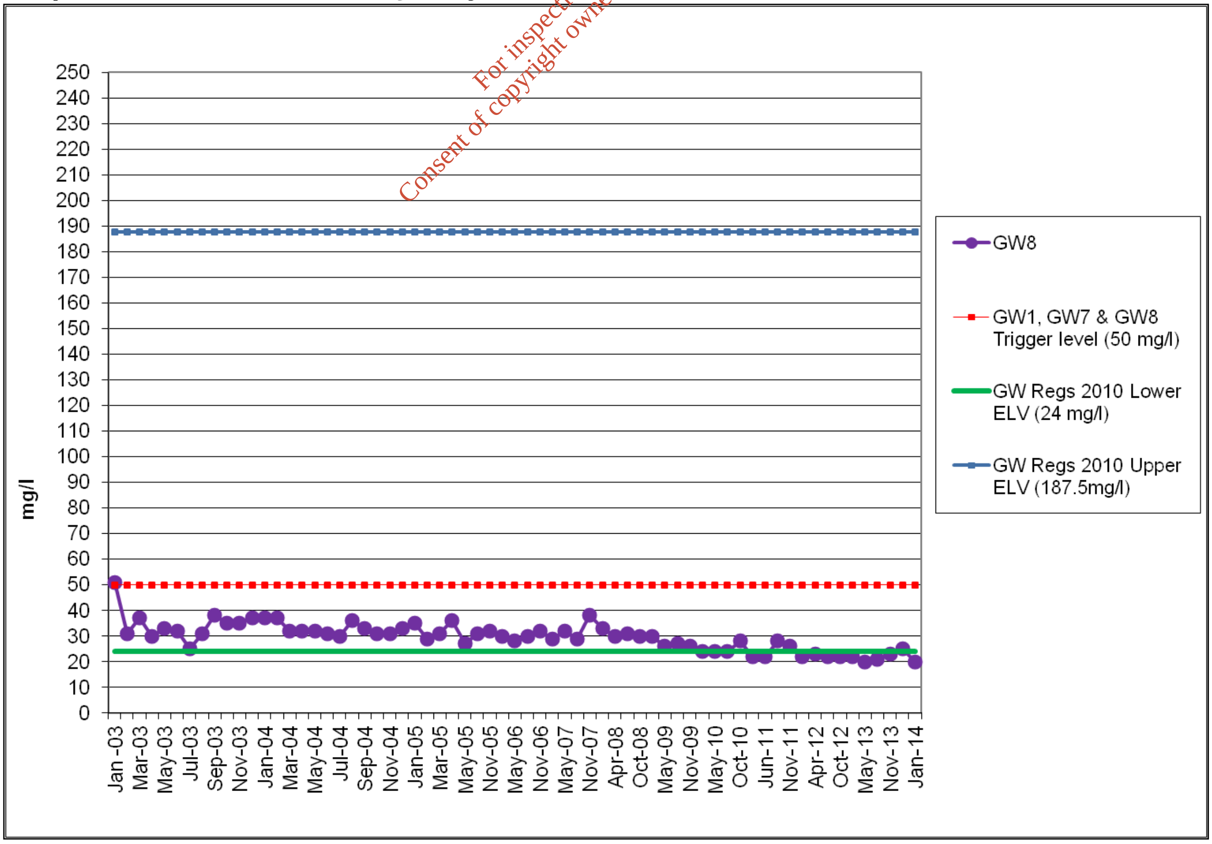
Graph 5.1 Groundwater Quality Data: Chloride at GW1



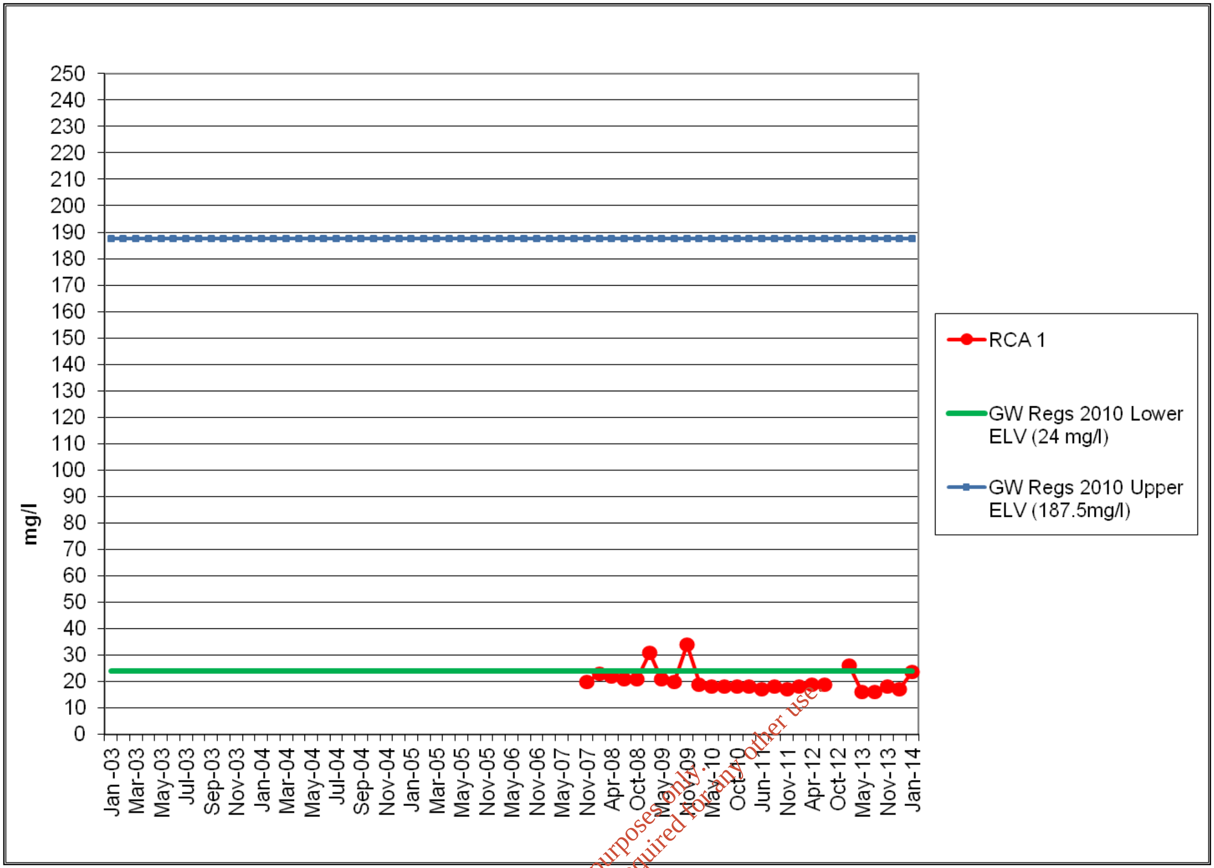
Graph 5.2 Groundwater Quality Data: Chloride at GW2



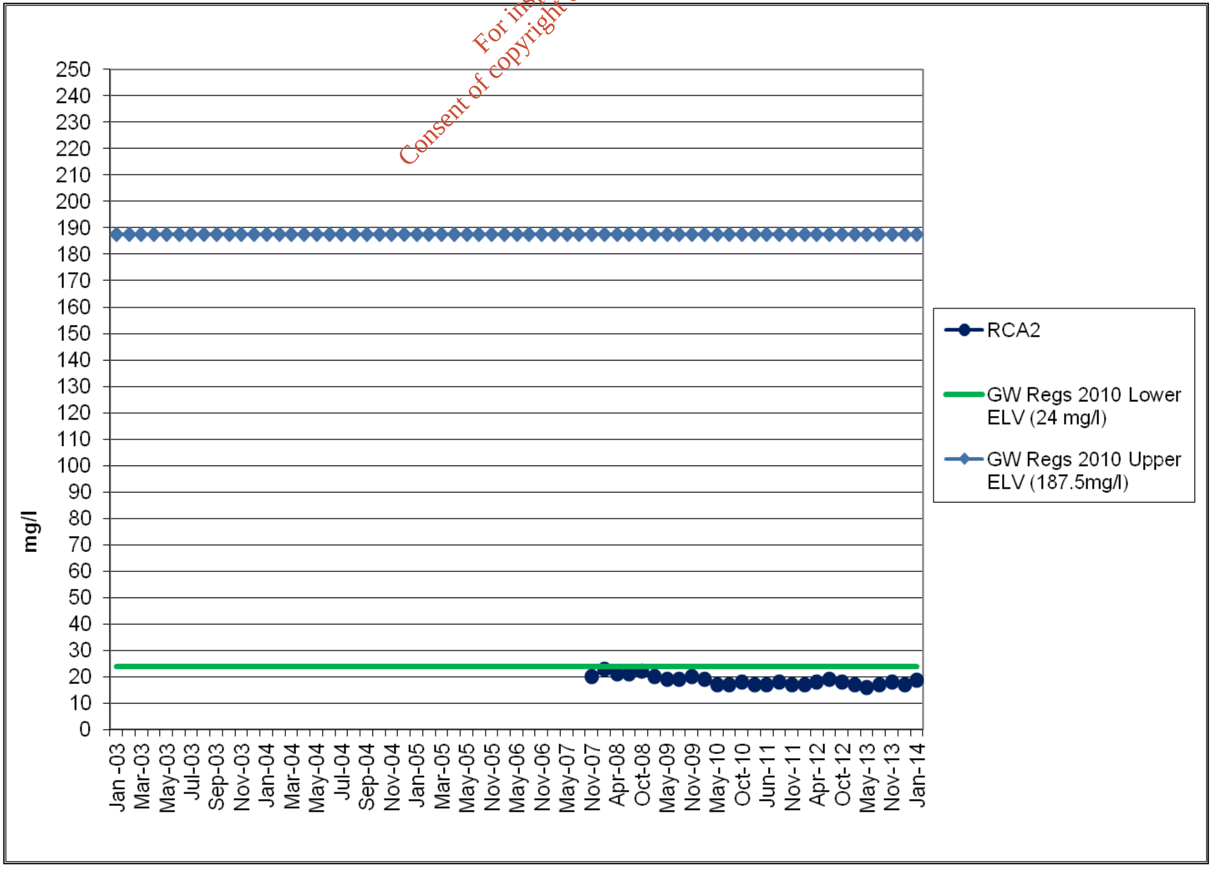
Graph 5.3 Groundwater Quality Data: Chloride at GW8



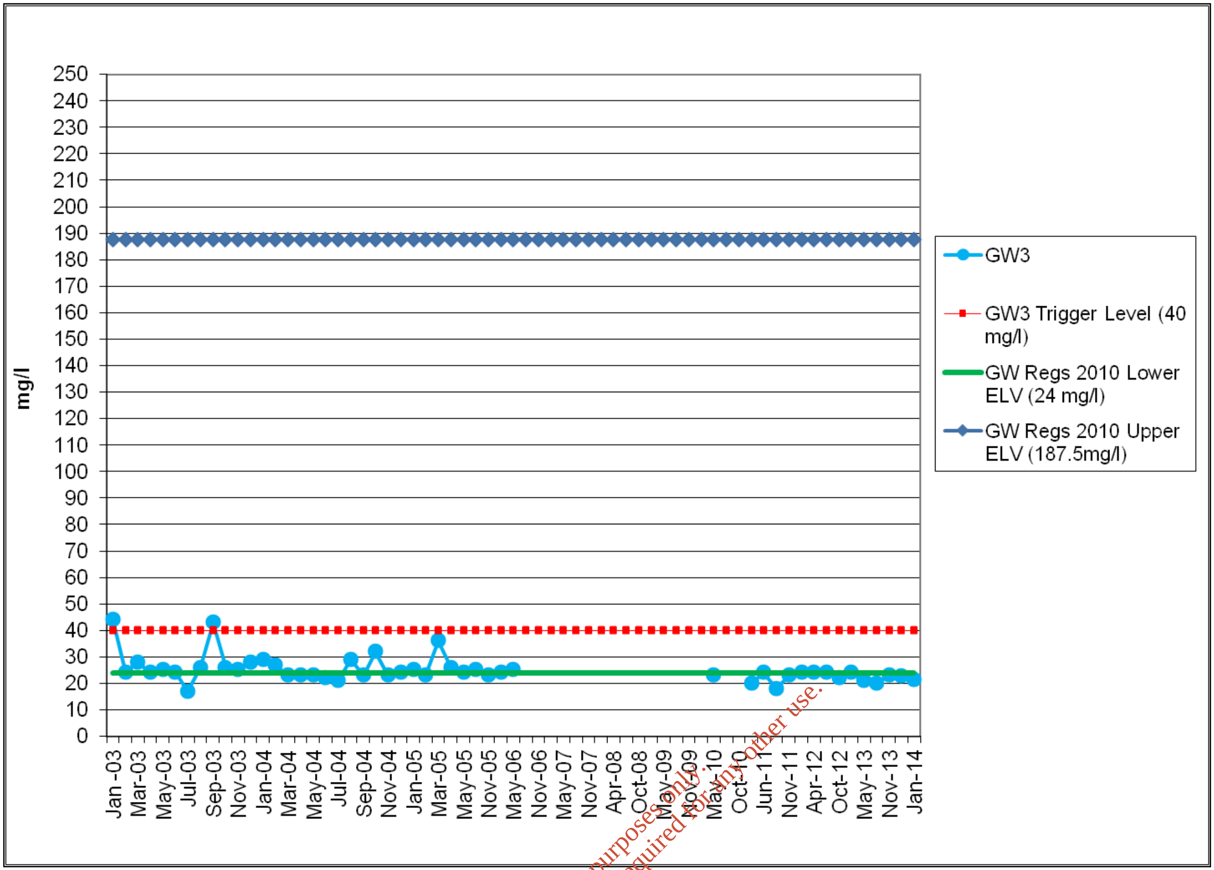
Graph 5.4 Groundwater Quality Data: Chloride at RCA1



Graph 5.5 Groundwater Quality Data: Chloride at RCA2



Graph 5.6 Groundwater Quality Data: Chloride at GW3



Fluoride

Reported Fluoride concentrations were below the laboratory MDL of 0.5mg/l at every monitoring well with the exception of BH2 which was 1.17mg/l. This concentration is above the surface water Environmental Quality Standard (EQS) of 0.5mg/l.

Sodium

Dissolved sodium concentrations ranged from 8.17 to 43mg/l. No samples contained concentrations of dissolved sodium exceeding the groundwater threshold value of 150mg/l.

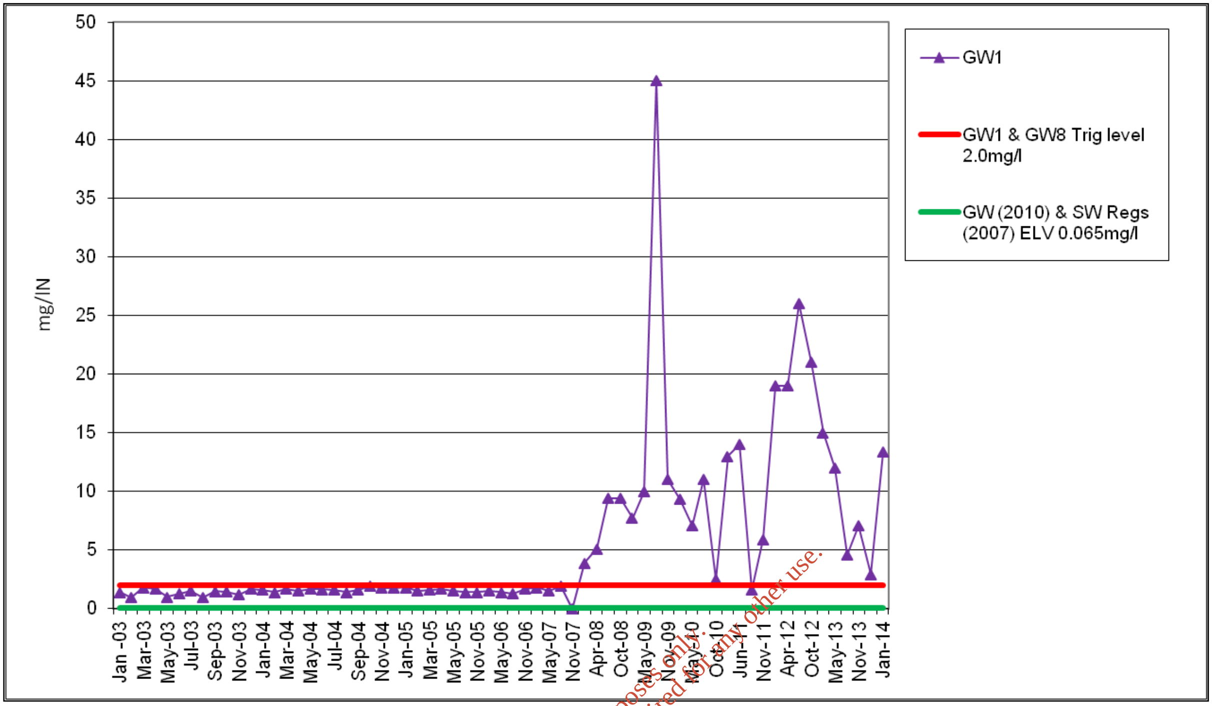
5.3.3 Nutrients

Ammonia

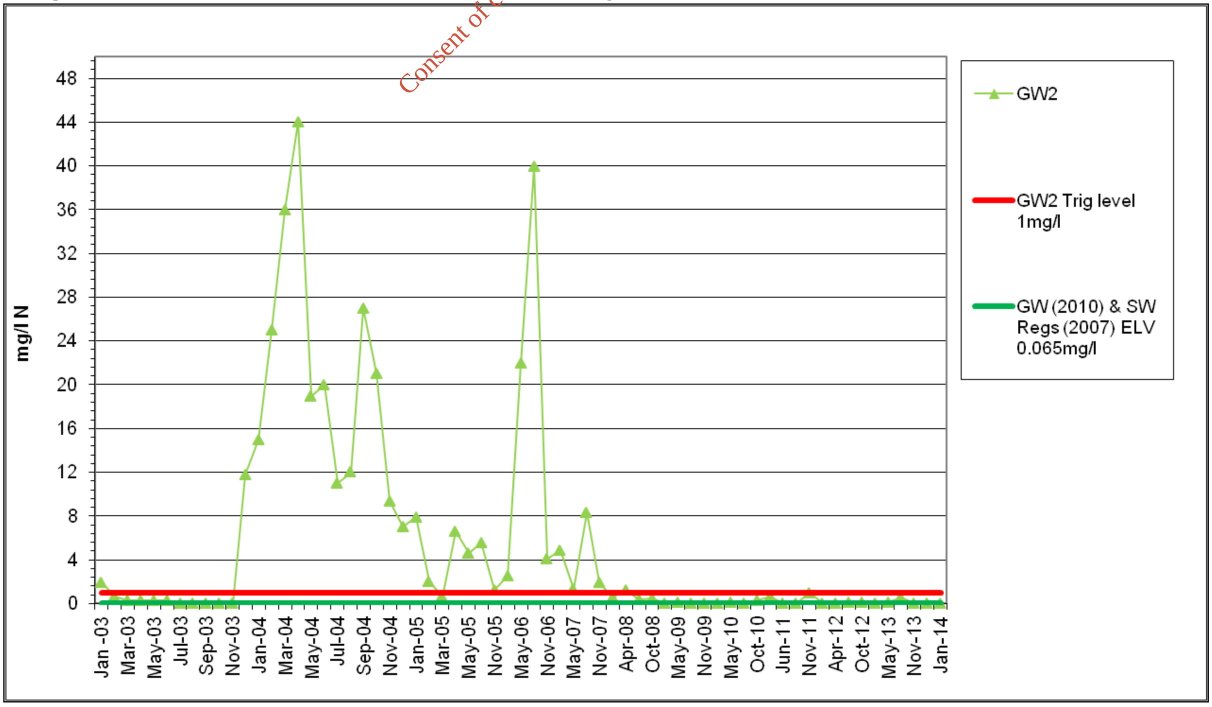
The reported concentrations of ammonia ranged from the MDL(<0.03) to 18mg/l N. There were exceedances recorded above the upper threshold value (0.175mg/l N) at each monitoring location with the exception of the upgradient GW3 and RCA2. The maximum recorded ammonia concentrations have been at GW1 and this was the only monitoring well for which an exceedance of the GTL (2mg/l N) was reported. Data for January 2013 indicates an increase in ammonia concentrations relative to the previous four monitoring events. There were two exceedances recorded at the up gradient well RCA1 during January 2012 (0.7mg/l N) and February 2012 (0.17mg/l N). The data compiled in December 2013 and January 2014 indicates that ammonia concentrations downgradient of the site at BH1 and BH3 however concentrations at BH2 continue to fluctuate with exceedances of the groundwater threshold value. In summary groundwater within the gravel aquifer beneath and immediately downgradient of the site has been impacted with elevated ammonia.

The historical ammonia results together with the recently compiled supplementary data are presented graphically in Graph 5.7 to Graph 5.13.

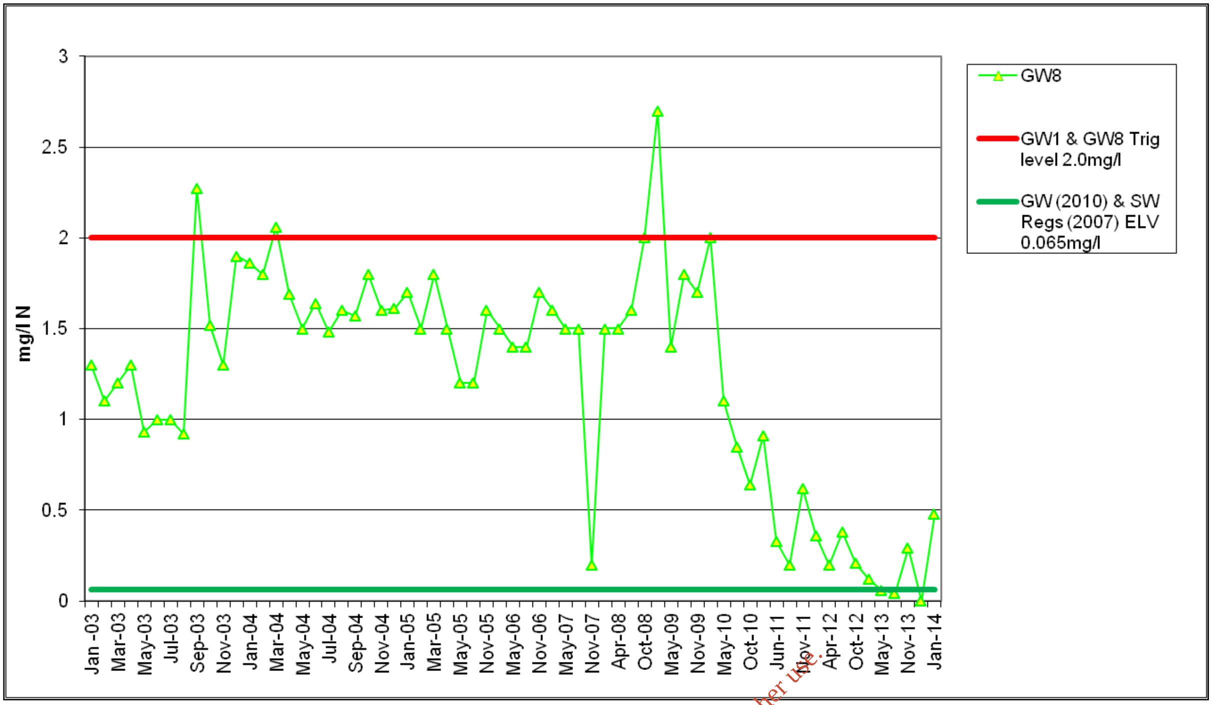
Graph 5.7 Historical Groundwater Quality Data: Ammonia at GW1



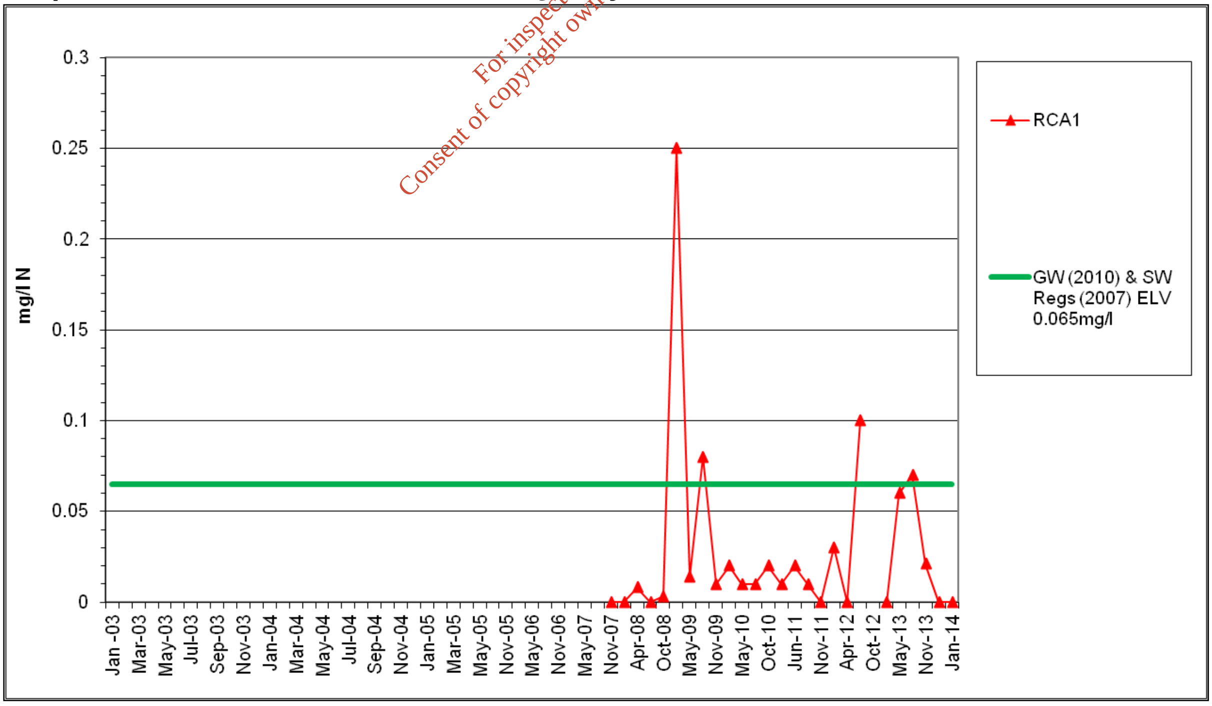
Graph 5.8 Historical Groundwater Quality Data: Ammonia at GW2



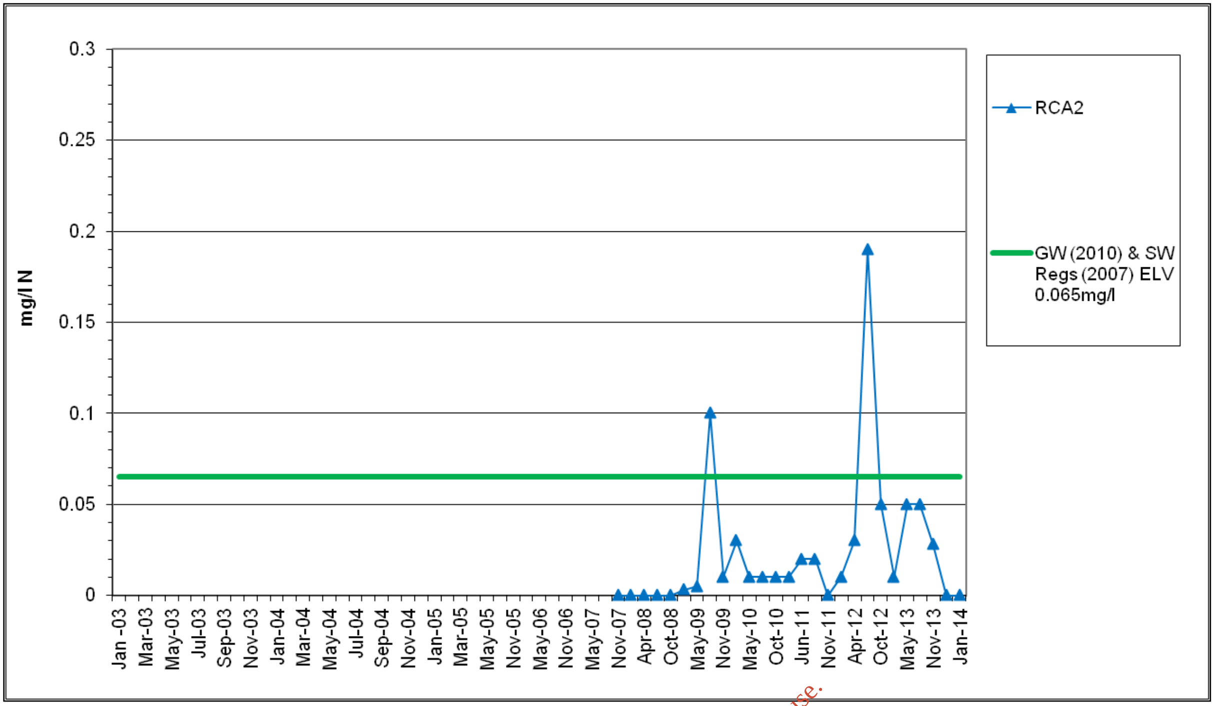
Graph 5.9 Historical Groundwater Quality Data: Ammonia at GW8



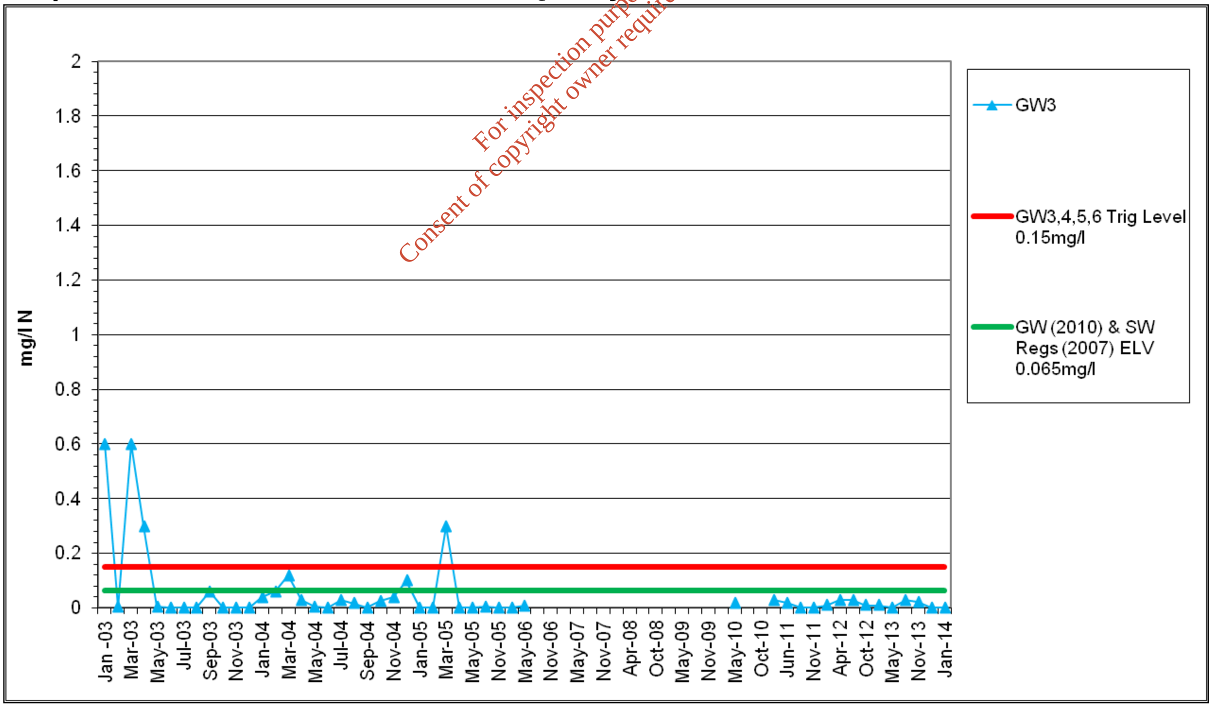
Graph 5.10 Historical Groundwater Quality Data: Ammonia at RCA1



Graph 5.11 Historical Groundwater Quality Data: Ammonia at RCA2



Graph 5.12 Historical Groundwater Quality Data: Ammonia at GW3



Nitrate

Reported nitrate concentrations ranged from the MDL (<0.3) to 49.1mg/l. Results for all samples were below the groundwater regulation value of 50mg/l.

Nitrite
Reported nitrite concentrations ranged from below the MDL (<0.05) to 0.309mg/l and did not exceed the groundwater regulation value of 0.375mg/l.

Orthophosphate
Reported orthophosphate as P was only identified at GW3 (0.029 mg/l P) during the December 2013 monitoring event. It was below the respective laboratory MDL (<0.02mg/l P) at each monitoring well for other monitoring events.

Phosphorus
Reported dissolved phosphorus concentrations ranged from laboratory MDL (<0.006) – 0.042mg/l P. There is no groundwater threshold value for phosphorous. Results for GW3 and BH3 exceeded the surface water EQS (0.035mg/l P) for phosphorous during December 2013 and January 2014 respectively.

Potassium
Reported potassium concentrations ranged from the MDL (<0.5) to 27mg/l. There were exceedances of the IGV (5mg/l) at GW1 and GW2. The concentrations recorded at GW1 ranged from 7.1 – 27 mg/l while GW2 had concentrations ranging from 4.55 – 21mg/l. There were no other exceedances throughout the site.

5.3.4 Metals
All reported results for aluminium, arsenic, cadmium, copper, lead, mercury nickel, and zinc were below the relevant assessment criteria.

Chromium
Dissolved chromium concentrations ranged from 2.55 to 9.17µg/l. The concentrations reported were below the groundwater regulation value. The surface water EQS for Chromium IV of 3.4µg/l was exceeded by all monitoring wells on at least one occasion with the exception of BH3 which was within the relevant threshold value.

Manganese
Results for dissolved manganese concentrations ranged from the laboratory MDL (<0.01) to 680µg/l. Results for BH3, GW1, and GW2 exceeded the IGV (50µg/l).

Selenium
Reported concentrations of selenium in excess of the MDL were recorded to range from 0.41 to 5.1mg/l. There are no applicable assessment criteria available for selenium.

5.5 Surface Water Results
The surface water analytical and field measured results were assessed against the following assessment criteria;

- SI No. 272 of 2009 European Communities Environmental Objectives (Surface Waters) Regulations, as amended 2012.
- SWTLs set for the Powerstown Stream (Fehily Timoney & Company, 2005) for parameters electrical conductivity (EC), ammoniacal nitrogen and chloride.

5.5.1 Electrical Conductivity, pH, and Temperature
Measured electrical conductivity values ranged from 464.7µS/cm to 637.5µS/cm. There is no surface water EQS available for conductivity. Reported results were below the Surface Water Trigger Levels (SWTL). Temperature readings ranged from 7.0 to 11.09 degrees Celsius. Measured pH values ranged from 7.26 to 8.26 pH units, which are within the surface water EQS range of 6.0 to 9.0 pH units.

5.5.2 Nutrients

Reported ammonia results for all Powerstown Stream and River Barrow samples were below laboratory MDL (<0.03mg/l N) and so were below the relevant surface water EQS (0.065mg/l N) and SWTL (0.5mg/l N).

Dissolved potassium ranged from 2.38 to 3.93mg/l. There is no applicable surface water EQS available for potassium.

5.5.3 Indicators

The chloride concentrations recorded at all surface water sampling points ranged from 23.5 to 30mg/l over the three monitoring events. There is no surface water EQS for chloride. All reported results were below the SWTL (50mg/l) for both upstream and downstream of the landfill. Refer to Table 2

Total suspended solid concentrations ranged from 3mg/l to 10mg/l. There is no applicable surface water quality value for this parameter.

5.5.4 Metals

Dissolved iron was below the laboratory detection limit of <0.019mg/l at all monitoring locations with the exception of SW6 and SW7 which are located on the River Barrow which is downstream of the site. The concentrations ranged from 0.0266 to 0.057mg/l

Dissolved manganese concentrations ranged from below the MDL (<2.14) to 39.5µg/l. There is no applicable surface water EQS for manganese.

Dissolved sodium concentrations ranged from 9.77 to 14.1mg/l. There is no applicable surface water EQS for sodium.

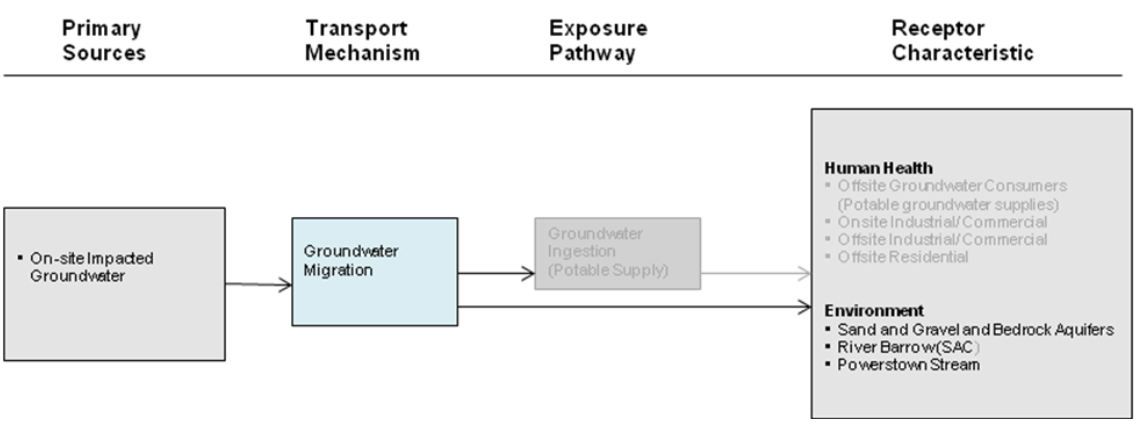
5.5.5 Summary of Results

Historically elevated levels of ammonia were reported for both upstream and downstream locations on the Powerstown Stream. The results of the recent sampling indicate that the concentrations of measured parameters including ammonia were within the applicable surface water EQS, however these samples were collected during periods of unusually high flows in the stream and may not be characteristic of overall surface water quality in the stream. The analytical results for all samples collected from the River Barrow met with the relevant surface water EQS.

5.6 Revised Conceptual Site Model

Based on the assessment of the revised groundwater and surface water monitoring results and evaluation of the CSM the identified pollutant linkages associated with of offsite migration of impacted groundwater remains valid. Recent surface water results were below the relevant assessment critiera however based on the fact that historically elevated surface water concentrations and high flow was noted during sampling it is considered that the pollutant linkage of groundwater migration to surface water remains valid.

Table 5.2: Updated GQRA Conceptual Site Model



5.7 Risk Screening

Based on the updated CSM and taking cognisance of the EPA risk screening procedures (EPA, 2001) further evaluation of the identified plausible environmental source-pathway-receptor linkages that pose a potential risk to the identified sensitive environmental receptors is warranted and a Tier 3 Detailed Quantitative Risk Assessment (DQRA) is required.

6.0 DETAILED QUANTITATIVE RISK ASSESSMENT

The revised CSM was used as the basis for the Detailed Quantitative Risk Assessment (DQRA) in which the identified source–pathway–receptor linkages were evaluated.

The DQRA incorporates, where available, site-specific data such as site characteristics, concentrations and extent of contamination, empirical data relating to aquifer properties, etc. in order to develop site-specific risk assessment criteria which are conservatively protective of identified receptors. The DQRA has been conducted to assess the potential risks to identified environmental receptors associated with impacted groundwater migrating from the site under current site conditions.

The DQRA assessment methodologies used to evaluate the potential risk associated with contaminated groundwater at the site identified in the GQRA are shown below in Table 6.1.

Table 6.1: Transport Mechanisms and DQRA Assessment Methodology

Source	Transport Mechanism	Assessment Criteria
GROUNDWATER	Risk to groundwater within the Gravel and Bedrock aquifers from downgradient migration offsite of impacted groundwater	England and Wales Environment Agency Remedial Target Worksheet v.3.1 - P20 (EA, 2006). Environmental Protection Agency Guidance on the Authorisation of Discharges to Groundwater Version 1, (EPA, 2011). Groundwater Regulations 2010 and 2012 (S.I. No 9 of 2010 and S.I. No 149 of 2012) Surface Water Regulations 2009 and 2012 (S.I. No. 272 of 2009 and S.I. No. 327 of 2012) EPA Interim Guideline Values (EPA, 2003)
	Risk to River Barrow and Powerstown Stream from migration off-site of impacted groundwater.	England and Wales Environment Agency Remedial Target Worksheet v.3.1 - P20 (EA, 2006). Environmental Protection Agency Guidance on the Authorisation of Discharges to Groundwater Version 1, (EPA, 2011). Surface Water Regulations 2009 and 2012 (S.I. No. 272 of 2009 and S.I. No. 327 of 2012)

6.1 Groundwater Migration Offsite

The potential for migration of impacted groundwater offsite was modelled using the UK Environment Agency P20 model, Level 3 for the following pollutant migration scenarios:

- Migration of dissolved phase ammonia and chloride in groundwater within the gravel to the downgradient gravel and bedrock aquifers.

- Migration of dissolved phase ammonia and chloride in groundwater within the gravel to the River Barrow and Powerstown Stream.

Elevated concentrations of the contaminants (ammonia and chloride) have been confirmed to be present immediately downgradient of the Phase Two and Phase Three portions of the landfill and to a lesser extend the former Phase One landfill. The original source of these contaminants is considered to be landfill leachate that has migrated into the gravel aquifer beneath the site however the specific source and migration pathway into the aquifer is unknown.

In order to determine if groundwater downgradient of the site boundary is at risk of not meeting the relevant groundwater quality standards at selected compliance points, groundwater site specific target values (SSTVs) for site specific compliance locations were calculated for the site. Likewise SSTVs for groundwater were derived that would be protective of surface water whereby an exceedance of the SSTV indicates that groundwater contamination onsite potentially poses an unacceptable risk to receiving water at the Powerstown Stream and the River Barrow.

The compliance distances chosen for the assessment include the downgradient Powerstown Stream (5m) and the River Barrow (400m) and the gravel aquifer downgradient of the site at a distance of half way to the River Barrow from the downgradient site boundary (200m). This distance is presented as a reasonable distance taking account of the EPA Guidelines (EPA, 2011) as there are no groundwater abstraction wells located downgradient of the site.

For the purposes of this assessment the groundwater within the gravel aquifer was selected as the target aquifer as the gravel aquifer is the immediate aquifer unit beneath the landfill and is in direct hydraulic connectivity and the underlying bedrock aquifer Therefore it is considered to be a more conservative evaluation of the potential risk to the gravel and bedrock aquifers. In addition as baseflow to the River Barrow is from the gravel aquifer using the gravel aquifer is a more realistic conceptual hydrogeological model for the site setting.

The P20 Model Report including assumptions and results is presented in Appendix C.

The P20 Model groundwater results are discussed in the following sections and presented below in Table 6.2 together with the maximum recorded groundwater concentrations onsite.

Based on the available dataset compiled for the site including the downgradient offsite groundwater data the P20 modelling was used to determine the potential extent of the offsite groundwater impacts. It was predicted that for the average source concentration the ammonia groundwater plume with concentrations above the 0.065mg/l groundwater threshold value could potentially extend approximately 150m off-site from the downgradient site boundary. The modelled chloride plume with concentrations above the 187.5mg/l groundwater threshold value was predicted to extend a maximum of approximately 25m from the landfill based on the concentrations beneath landfill which is considered reasonable based on the recorded chloride concentrations at the offsite wells.

A ‘calibration’ of the P20 results has been performed in order to evaluate the level of conservatism in the P20 results for this particular hydrogeological site setting by comparing the P20 predicted concentrations in the downgradient aquifer with measured concentrations of ammonia and chloride at the offsite monitoring wells. As the P20 model does not account for dilution within the aquifer which given the hydrogeological site setting is likely to provide considerable attenuation. A comparison of the modelled and predicted results for ammonia and chloride is summarised below:

- The P20 modelled ammonia concentrations at downgradient monitoring well locations are greater than the measured concentrations by an approximate factor of two.

- The P20 modelled chloride concentrations at downgradient monitoring well locations are greater than the measured concentrations by an approximate factor of five.

Therefore the actual plume extent off-site is likely to be notably less than the modelled plume length. Accordingly it is considered that the derived set of SSTVs for groundwater are conservative and therefore protective of the identified groundwater and surface water receptors. These are summarised in Table 6.2.

Table 6.2: Derived SSTV$_{gw}$ Protective of Surface Water Receptors

Contaminant	**SSTV$_{gw}$ Powerstown Stream**	**SSTV$_{gw}$ for River Barrow**			
	GW1/GW2	**GW1**	**BH1/ BH2**	**BH3**	**GW8**
	(mg/l)	**(mg/l)**	**(mg/l)**	**(mg/l)**	**(mg/l)**
Ammonia	0.07	21200	5170	512	10500
Chloride	50	219	200	167	210

Table 6.3: Derived SSTV$_{gw}$ Protective of Groundwater Receptors

Contaminant	**SSTV$_{gw}$ for Gravel Aquifer**			
	GW1	**BH1/ BH2**	**BH3**	**GW8**
	(mg/l)	**(mg/l)**	**(mg/l)**	**(mg/l)**
Ammonia	62	13	0.81	28.5
Chloride	512	423	265	468

River Barrow
The measured concentrations of ammonia and chloride in the groundwater at the offsite groundwater monitoring locations are typically below the derived SSTVs for both ammonia and chloride. In addition as the modelled ammonia and chloride plume lengths do not extend to the River Barrow, impacted groundwater migrating from the site is considered unlikely to present a risk to the River Barrow.

Powerstown Stream
The predicted plume lengths suggest that given that the Powerstown Stream is adjoining the landfill, impacted groundwater migrating from the site would reach the Powerstown Stream. The reported groundwater concentrations are above the derived SSTV for ammonia and chloride therefore based on this evaluation impacted groundwater migrating from the site is considered to present an unacceptable risk to the Powerstown Stream.

Results indicate that water has historically been impacted with elevated levels of ammonia and although the results for 2013 were below the surface water EQS. It is important to note however, that these samples were collected during periods of unusually high flow in the stream and are not considered not to be representative of the overall surface water conditions taking account of applicable guidance (i.e. DEHLG, 2010 and S.I. No. 278 of 2009). In addition, based on available data it could not be confirmed if groundwater migrating from the site discharges as baseflow to the Powerstown Stream. Accordingly, it is considered that a potential risk to the Powerstown Stream remains and further consideration is warranted.

Gravel Aquifer

Groundwater within the gravel aquifer at the site has been impacted with chloride contamination however the reported groundwater ammonia and chloride results for the recently compiled data were below the relevant SSTVs which would achieve the groundwater threshold value 200m downgradient of the site. Accordingly, it is considered that there is no unacceptable risk the gravel aquifer downgradient of the site.

6.2 Refined Conceptual Site Model

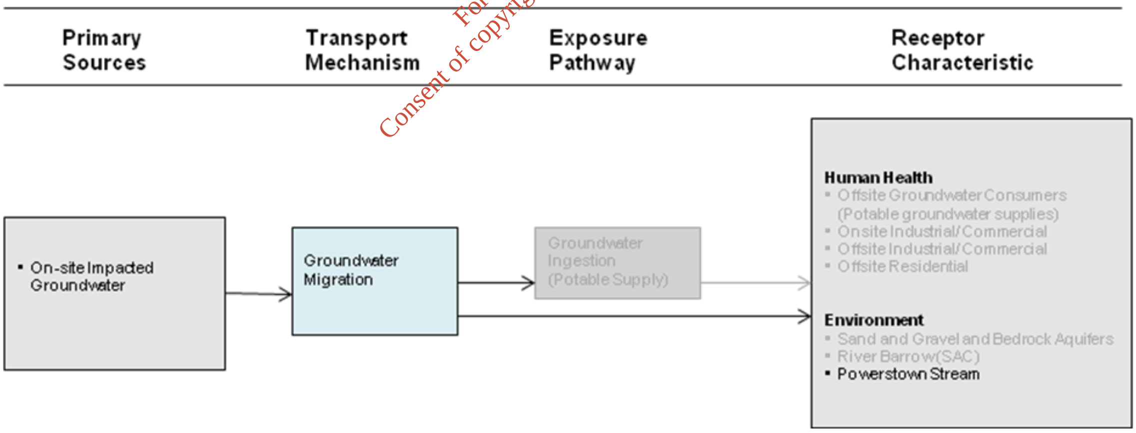
Based on the results of the DQRA which included detailed modelling of the identified groundwater contaminant sources of ammonia and chloride, the CSM and identified pollutant linkages for the site were revised.

The transport mechanism of offsite migration of groundwater impacted with ammonia and chloride off-site to the River Barrow and downgradient gravel aquifer have been eliminated following the DQRA.

The remaining issue of concern is the potential risk to the Powerstown Stream which warrants further evaluation.

The Revised CSM identifying the remaining pollutant linkages of discharge to the Powerstown Stream and offsite migration of ammonia impacted groundwater within the gravel aquifer is presented in Table 6.3.

Table 6.4: Refined DQRA Conceptual Site Model



7.0 GROUNDWATER COMPLIANCE MONITORING

Based on the results of the P20 modelling undertaken as part of the DQRA, groundwater compliance points and groundwater compliance values have been selected that would be protective of the identified downgradient groundwater and surface water receptors.

7.1 Selection of Compliance Points

As set out in the EPA 'Guidance on the Authorisation of Discharges to Groundwater' (EPA, 2011) the most appropriate groundwater compliance monitoring points are those located as close to the site boundary as possible downgradient of the source. Accordingly the monitoring wells located immediately downgradient of the site at BH1, BH2, BH3 and GW8 are identified as the most appropriate Compliance Points.

7.2 Selection of Compliance Values and Parameters

Compliance values that are protective of the identified groundwater and surface water receptors were derived based on the P20 model used for the DQRA. The selected compliance values for ammonia and chloride are presented in Table 7.1.

Table 7.1 Selected Groundwater Compliance Values

Parameter	Selected Compliance Value (mg/l)		
	BH1/ BH2 (mg/l)	BH3 (mg/l)	GW8 (mg/l)
Ammonia	13	0.8	28.5
Chloride	200	167	210

7.3 Compliance Checking

In accordance with the EPA Guidance the annual arithmetic mean of the ammonia and chloride concentrations calculated from the results of groundwater monitoring for each of the compliance points will be compared against the selected compliance values. Compliance monitoring will be carried out quarterly to coincide with the quarterly monitoring carried out in compliance with the conditions of the Licence for the facility. Any exceedance of the compliance value will be investigated and evaluated.

8.0 CONCLUSIONS

Based on the findings of the Detailed Qualitative Risk Assessment that specifically focused on the issues of concern associated with impacted groundwater and identified environmental receptors it is reasonable to conclude the following:

- The aquifer beneath the downgradient portion of the site has been impacted by elevated concentrations of ammonia. The primary source is considered to be leachate from the Phase Two landfill at the site with some residual impacts associated with historical leaching from the Phase One landfill that is now capped.
- The site is underlain by regionally important gravel and bedrock aquifers. The GSI has assigned a vulnerability rating of high for groundwater in the vicinity of the site.
- The River Barrow located approximately 400m downgradient of the site is within the designated River Barrow and Nore Special Area of Conservation which extends to within 15m of the site boundary.
- Based on the site location and specific environmental setting the site would be considered an environmentally sensitive site.
- There was no risk to the groundwater within the underlying gravel aquifer at a distance of 200m downgradient of the site associated with the current site condition and offsite migration of impacted groundwater.
- There was no identified unacceptable risk to the identified sensitive environmental receptor, the River Barrow associated with the identified ammonia and chloride contamination. It is also considered reasonable to assume that there does not appear to be any resulting impacts on the qualifying interests of the nearest ecological receptor i.e the SAC.
- There remains a potential risk to the Powerstown Stream, however based on the available hydrogeological data it could not be confirmed if this stream is hydraulically connected to groundwater migrating from the site. Potential liabilities remain in regards to the Powerstown Stream and further evaluation of this pollutant linkage is warranted.

9.0 RECOMMENDATIONS

Based on the results of the Detailed Quantitative Risk Assessment for groundwater conditions at the site it is recommended that the following supplementary assessment should be carried out:

Powerstown Stream Assessment

- A surface water sampling programme should be undertaken on a bi-monthly basis for six events over a 12 month period to collect water samples from the Powerstown Stream at the five identified sampling locations upstream of the site, adjoining the site and downstream of the site. The surface water monitoring events should coincide with the quarterly groundwater monitoring events undertaken as part of the Waste Licence compliance monitoring. At each location the samples should be tested for the following parameters: Ammonia; pH and Temperature.

- An additional groundwater monitoring well should be installed at the northern bank of the Powerstown Stream between sampling points SW2 and SW3 to facility collection of additional groundwater level data in this area.

- A topographical survey of the Powerstown Stream in a defined area upgradient, adjacent to the site and downgradient of the landfill and at the identified surface water sample locations should be completed. Fixed water level monitoring points should be installed at the sampling points at a minimum of three locations along the Powerstown stream.

- During each of the aforementioned site visits, groundwater level measurements should be collected from all of the onsite and offsite wells.

- The groundwater and surface water level data would be used to develop a more accurate groundwater contour map and to evaluate any hydraulic connection between groundwater and surface water in the Powerstown Stream.

- All of the available data would then be used to revise the CSM for the site and to review the DQRA to further evaluate the identified potential pollutant linkage of discharge of impacted groundwater to the Powerstown Stream.

Groundwater Compliance Monitoring

- A groundwater compliance monitoring programme should be undertaken on a quarterly basis incorporating the offsite groundwater monitoring wells. This monitoring should coincide with the quarterly groundwater monitoring events undertaken as part of the Waste Licence compliance monitoring.

- Groundwater Compliance checking should be carried out to identify any exceedances of the selected compliance values.

- The selected set of groundwater compliance points and values should be updated to include values for the additional well installed at the Powerstown Stream.

10.0 REFERENCES

Carlow County Council (2004). Powerstown Landfill Annual Environmental Report 2003

Carlow County Council (2005). Powerstown Landfill Annual Environmental Report 2004

Carlow County Council (2006). Powerstown Landfill Annual Environmental Report 2005.

Carlow County Council (2007). Powerstown Landfill Annual Environmental Report 2006

Carlow County Council (2008). Powerstown Landfill Annual Environmental Report 2007

Carlow County Council (2009). Powerstown Landfill Annual Environmental Report 2008

Carlow County Council (2010). Powerstown Landfill Annual Environmental Report 2009.

Carlow County Council (2011). Powerstown Landfill Annual Environmental Report 2010.

Carlow County Council (2012). Powerstown Landfill Annual Environmental Report 2011.

Carlow County Council (2014). *Powerstown Landfill Annual Environmental Report* 2013.

Conservation Services, 2013, *Biological Assessment of Surface Water Quality in the Vicinity of Powerstown Landfill,* County Carlow.

Department of Environment, Heritage and Local Government (DoEHLG) (2010) *Guidance, Procedures and Training on the Licensing of Discharges to Surface Waters and Sewer for Local Authorities.* Monastery Road, Roscrea, Co Tipperary.

Environment Agency (2006) En*gland and Wales Environment Agency Remedial Target Worksheet v.3.1 (P20)*, 2006. Bristol, England.

Environmental Protection Agency (EPA), (2003). *Towards Setting Guideline Values for the Protection of Groundwater in Ireland*. Wexford. Ireland.

Environmental Protection Agency (EPA), (2007) *Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites*. Wexford, Ireland.

Environmental Protection Agency (EPA), (2011a) *Guidance on the Authorisation of Discharges to Groundwater*. Wexford, Ireland.

Environmental Protection Agency (EPA), (2011b) *Hydrometric Area*s. Available online at http://hydronet.epa.ie/introduction.htm. Wexford, Ireland.

Environmental Protection Agency (EPA), (2013a). *Guidance on the Management of Contaminated Land And Groundwater at EPA Licensed Sites*. Wexford, Ireland

Environmental Protection Agency (EPA), (2013b). Available online at: http://www.epa.ie/pubs/reports/water/flows/95tileflowstatisticsatselectedhydrometricstations.html#.U2J0IYFdU1E. Wexford, Ireland.

Environmental Protection Agency (EPA), (2014a). *EPA ENVision map* Available at: http://maps.epa.ie/internetmapviewer/mapviewer.aspx. Wexford. Ireland.

Environmental Protection Agency (EPA). (2014b). *Register of Hydrometric Stations* 2014. Wexford. Ireland.

Fehily Timoney & Company, (2003) *Environmental Impact Assessment for the Proposed Extension of Powerstown Landfill*. Pouladuff Road, Cork.

Fehily Timoney & Company, (2005a) *Powerstown Landfill WL 25-2 Groundwater Trigger Level Review*. Pouladuff Road, Cork.

Fehily Timoney & Company, (2005b) *Powerstown Landfill WL 25-2 Surface Water Trigger Level Review*. Pouladuff Road, Cork.

Glover Site Investigations Ltd, (2006). *Monitoring Wells at Powerstown Landfill*, Co. Carlow (Report No. 06-164).

Geological Survey of Ireland (GSI), (2014). *Groundwater web-mapping*, Available at: http://193.178.1.182/website/Introduction to Groundwater WebMapping.htm.GSI, Ireland.

Geological Survey of Ireland (GSI), (2014). *Public Data Viewer web-mapping site* Available at: http://spatial.dcenr.gov.ie/imf/imf.jsp?site=GSI_Simple. GSI, Ireland

Geological Survey of Ireland (GSI), (2014). *Groundwater Body Descriptions*. Available at: https://www.gsi.ie/Programmes/Groundwater/Projects/Groundwater+Body+Descriptions.htm. GSI, Ireland.

Geological Survey of Ireland (GSI), (2014). *Groundwater Body Descriptions (Bagnelstown)*. Available at: https://www.gsi.ie/NR/rdonlyres/AD95EA6F-8C2F-4852-97C7-E92B2567AFB8/0/Bagenalstown.pdf. GSI, Ireland.

Geological Survey of Ireland (GSI), (2014*). Groundwater Body Descriptions (Barraghcore)*. Available at: https://www.gsi.ie/NR/rdonlyres/51D11B16-ECDF-4069-A86A-825D7E4E2631/0/Barraghcore.pdf. GSI, Ireland.

Geological Survey of Ireland (GSI), (2014). *Groundwater Body Descriptions (Barrow Valley)*. Available at: https://www.gsi.ie/NR/rdonlyres/3997D698-F11E-4506-BF6E-1C61C0BA8B4E/0/BarrowValley.pdf. GSI, Ireland.

Geotechnical and Environmental Services (GES) Ltd. (1999). *Post Closure Monitoring* (Report 99/02/01).

GES Ltd & IE Consulting. (2011). *Groundwater and Gas Monitoring Installations, Powerstown Landfill.*

GES Ltd., (1999). *Post Closure Monitoring* (Report 99/34/01).

ISO 5667-11 *Guidance on Sampling of Groundwaters* (2009). Geneva, Switzerland.

National Parks and Wildlife Service (NPWS) (2014). *Maps and data*, Available at http://www.designatednatureareas.ie/mapviewer NPWS, Ireland.

Malone O'Regan (2005). Powerstown *Landfill Annual Environmental Reports*. Dublin, Ireland.

Malone O'Regan, (2012). Tier 1 Qualitative Risk Assessment. Dublin, Ireland.

Office of Public Works (OPW). (2014). *National flood Hazard Mapping* Available at http://www.floodmaps.ie/View/Default.aspx. OPW, Ireland.

Statutory Instruments (S.I.) (2009). *S.I. No. 272 of 2009: European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2009.* S.I., Dublin.

Statutory Instruments (S.I.) (2010). *S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010.* S.I., Dublin.

Statutory Instruments (S.I.) (2012). *S.I. No. 149 of 2012: European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2010.* S.I., Dublin.

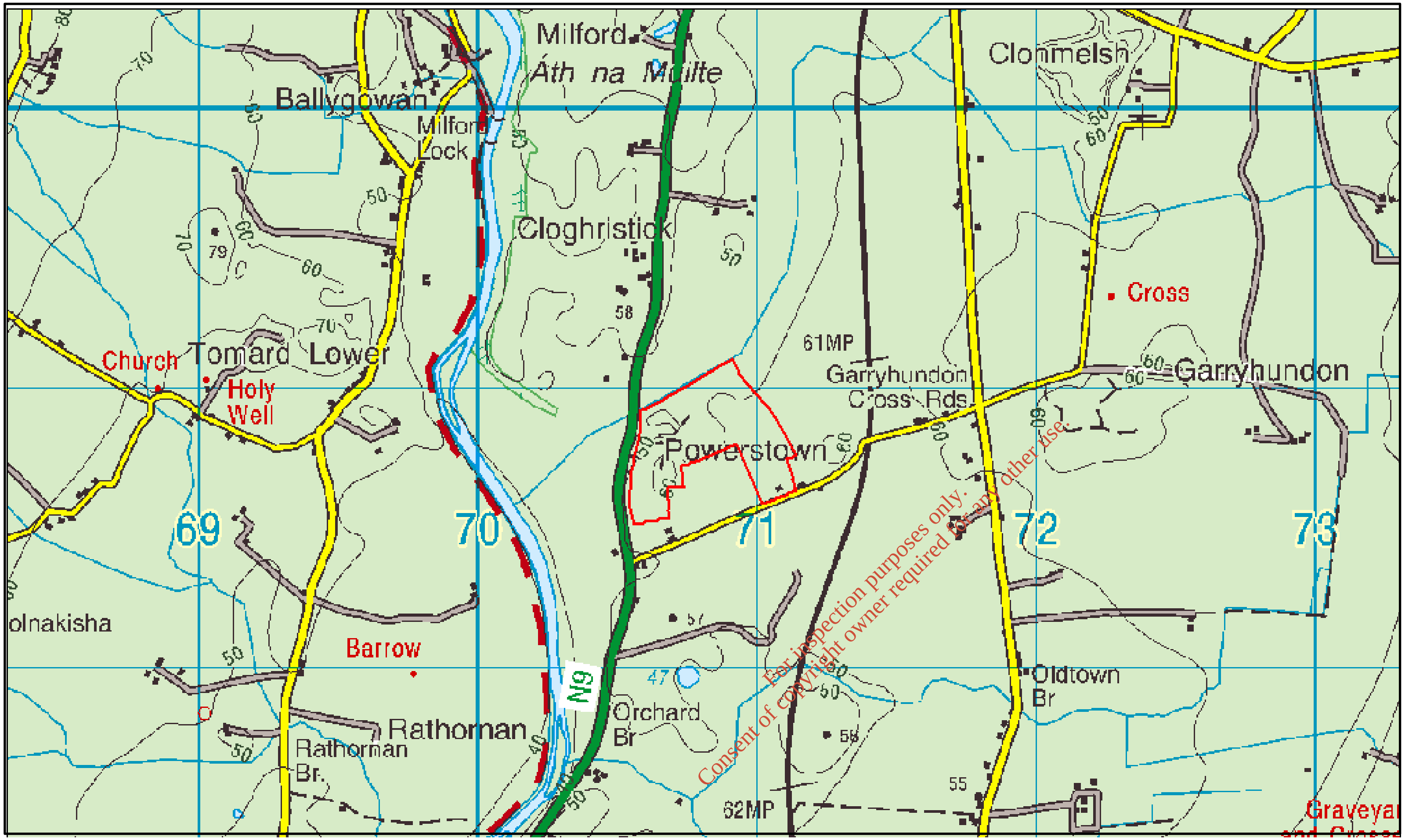
Statutory Instruments (S.I.) (2012). *S.I. No. 327 of 2012: European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2010.* S.I., Dublin.

South Eastern River Basin District (SERBD), (2010), Barrow Main Water Management Unit (WMU) Action Plan.

South Eastern River Basin District (SERBD), (2010), Groundwater Action Plan.

Sweeney Pascal, (2012), '*Screening for Appropriate Assessment Report, Impacts of Powerstown Landfill, Co. Carlow, at Low-Tonnage Intake, on the Conservation Objectives of Special Area of Conservation 002162*'.

DRAWINGS



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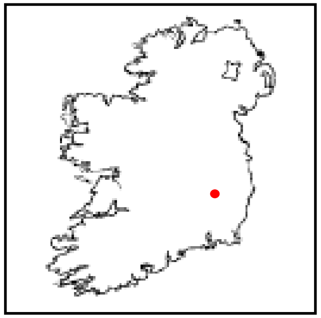

Legend

🟥 Site Boundary

0m 500m 1000m

Ordnance Survey Ireland No. EN0002514

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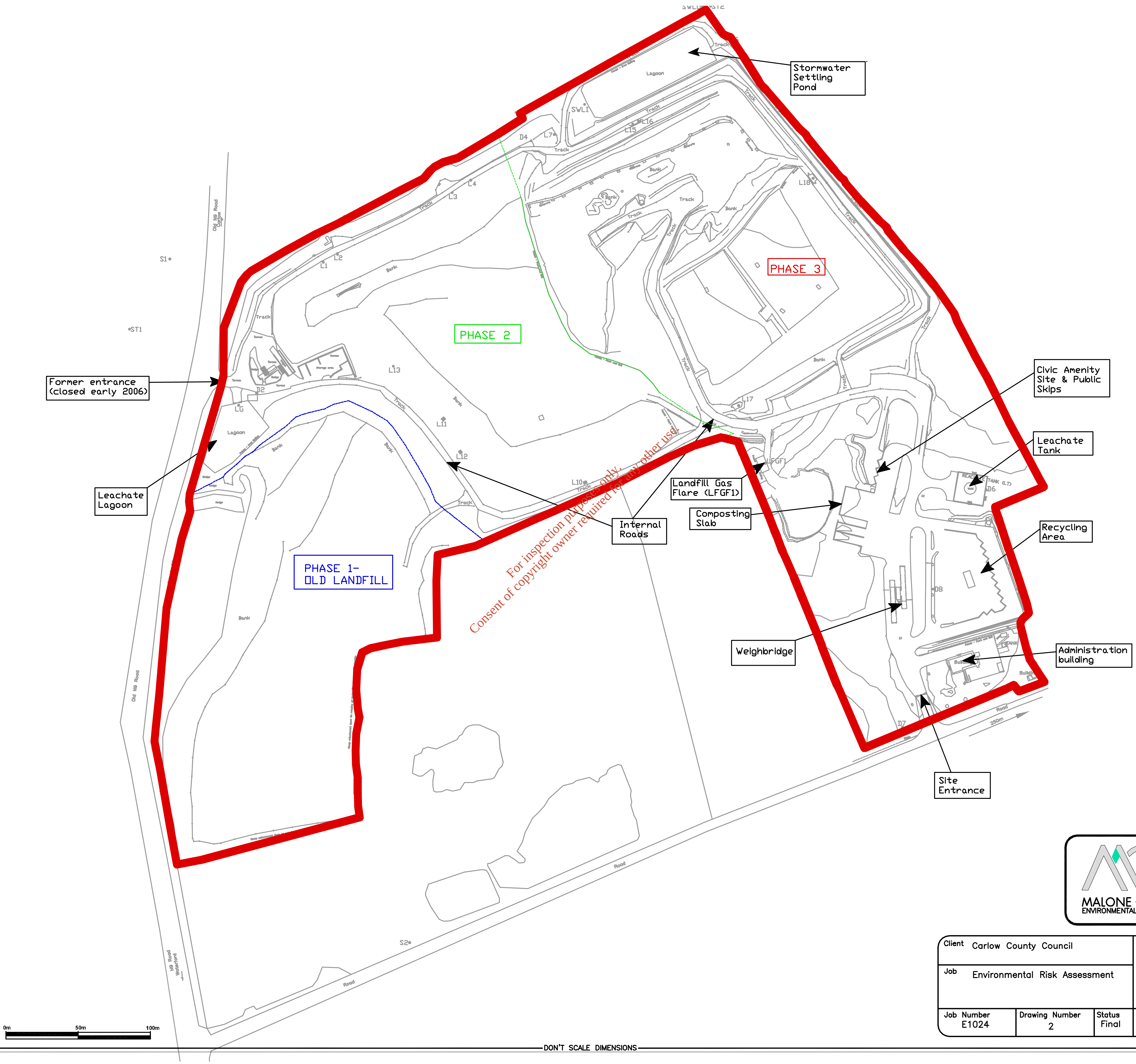
Client **Carlow County Council**

Drawing **Site Location**

Job **Environmental Risk Assessment**

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	1	Final	A4	As Shown	May ‘ 14	AA



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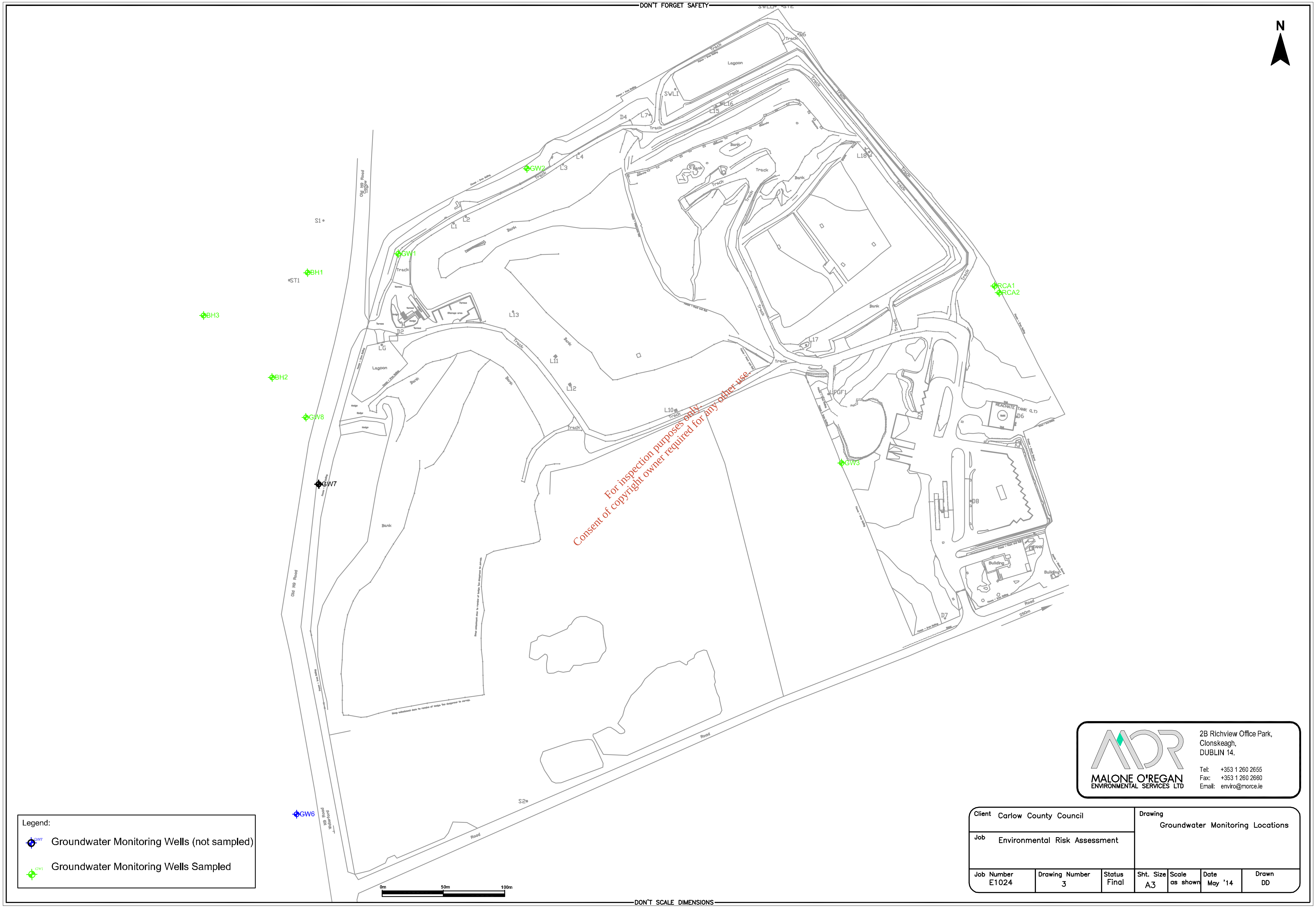
Client Carlow County Council	Drawing Site Layout
Job Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	2	Final	A3	as shown	May '14	DD



Legend:

◆ Groundwater Monitoring Wells (not sampled)

◆ Groundwater Monitoring Wells Sampled

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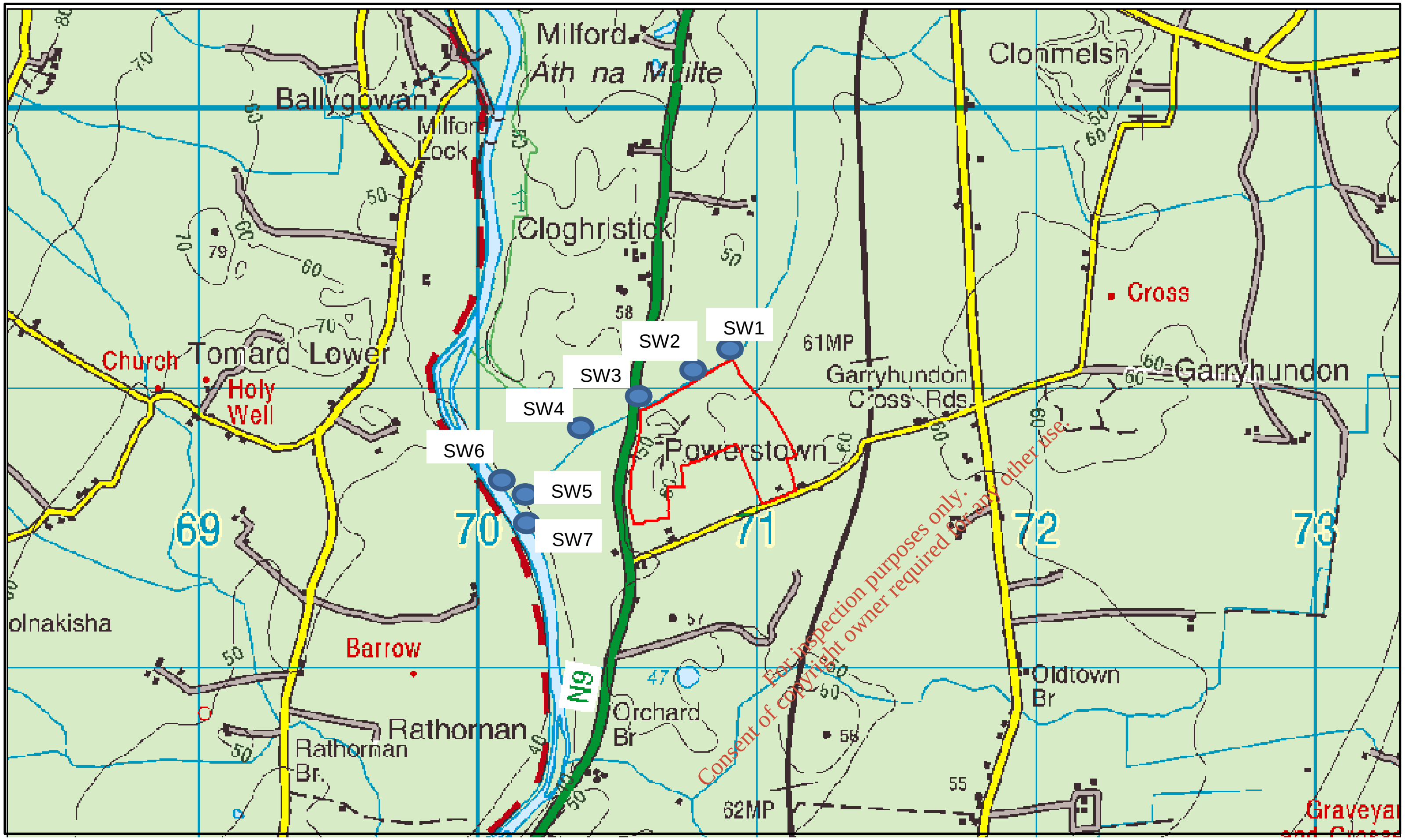
Client	Carlow County Council
Job	Environmental Risk Assessment
Drawing	Groundwater Monitoring Locations

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	3	Final	A3	as shown	May '14	DD



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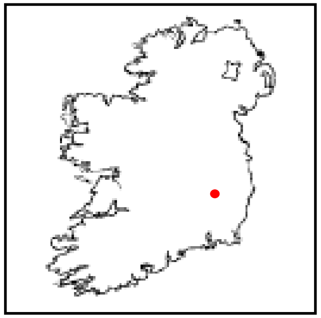

Legend

🟥 Site Boundary

SW2 ● Surface Water Monitoring Points

0m 500m 1000m

Ordnance Survey Ireland No. EN0002514

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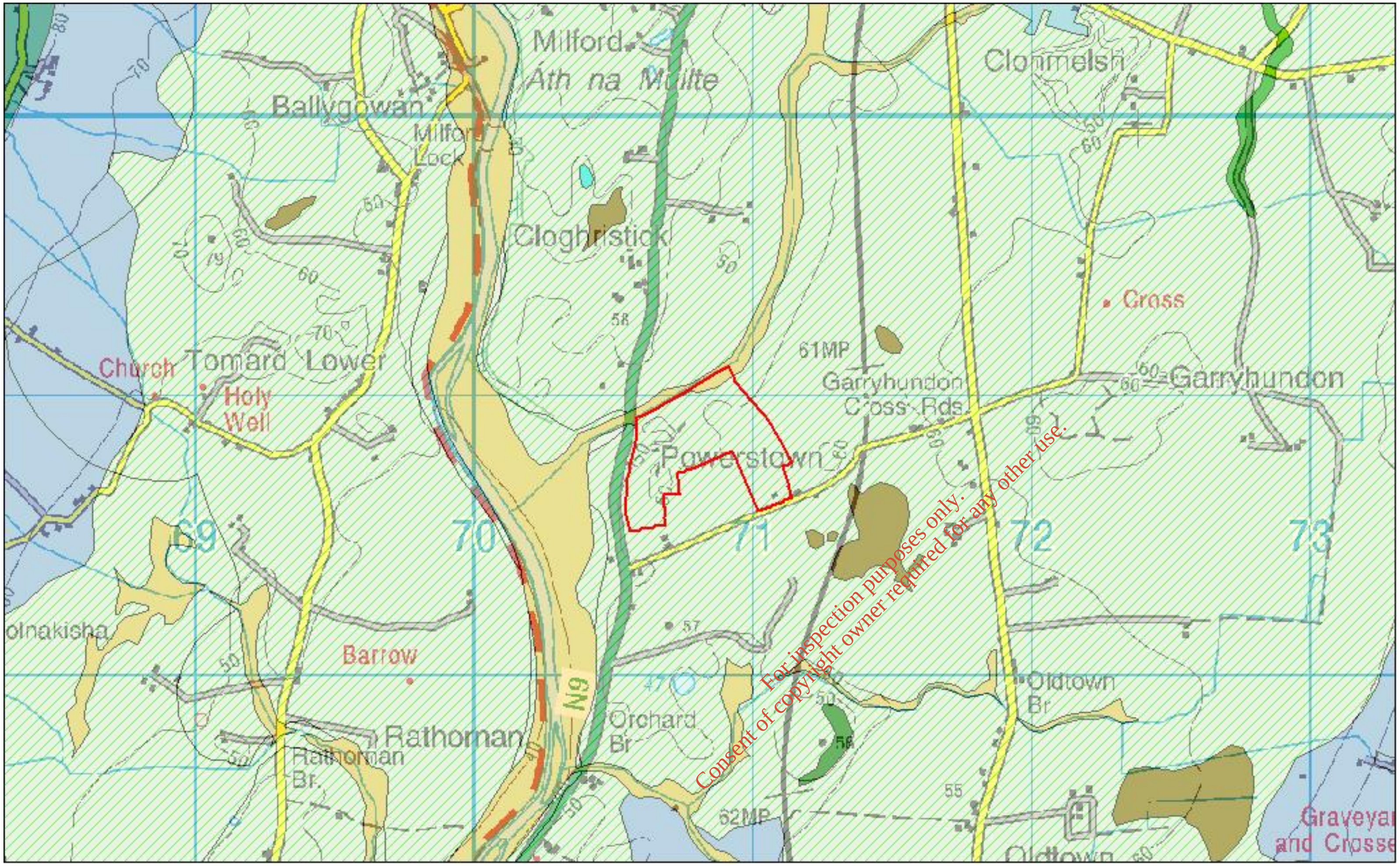
Client Carlow County Council			Drawing Surface Water Monitoring Points			
Job Environmental Risk Assessment						
Job Number E1024	Drawing Number 4	Status Final	Sht. Size A4	Scale As Shown	Date May ' 14	Drawn AA



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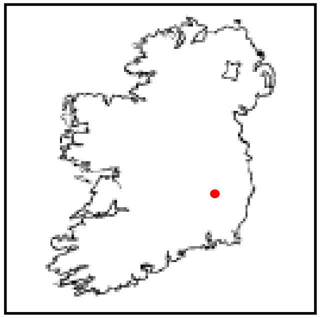

Legend

- 🟥 Site Boundary
- 🟨 A - Alluvium
- 🟩 BasEsk - Esker Sands and Gravel
- 🟫 Peat
- 🟫 Fen Peat
- ▨ GLs - Galciofluvial Sands and Gravel
- 🟦 L - Lake sediment
- 🟦 Made - Made Ground
- 🟩 RckCa - Bedrock outcrop and subcrop
- 🟧 TGr Till derived chiefly from Granite
- 🟦 TLs - Till derived chiefly from Limestone
- 🟩 TNSSs - Till derived chiefly from Namurian Sandstone

0m 500m 1000m

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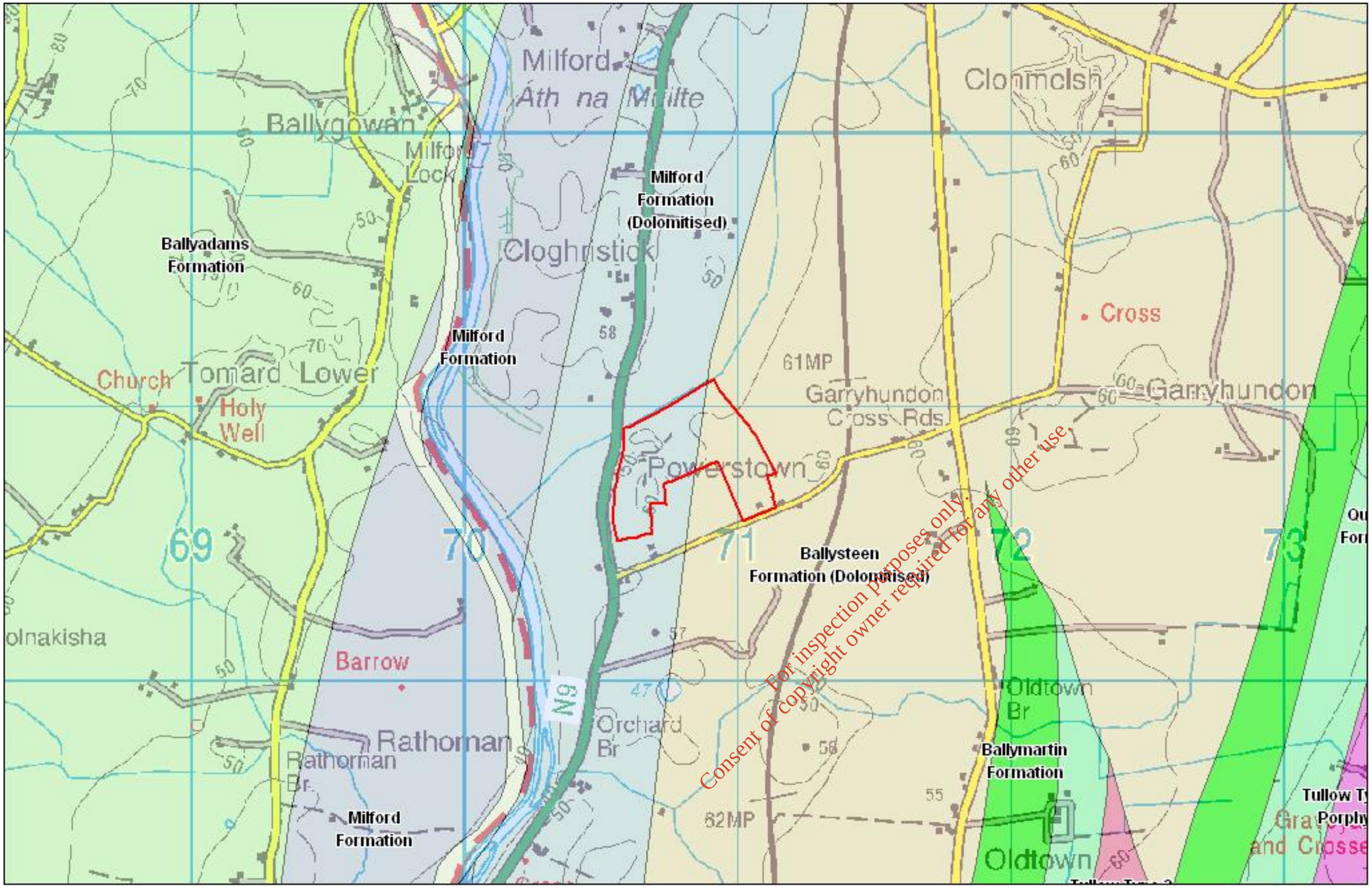
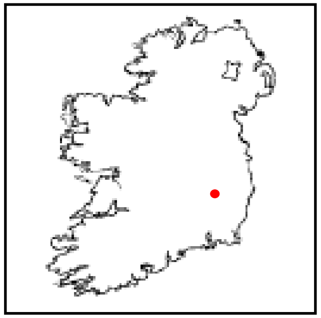
Client **Carlow County Council**	Drawing **Subsoil**
Job **Environmental Risk Assessment**	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	5	Final	A4	NTS	May ' 14	AA





N

Legend

- 🟥 Site Boundary
- 🟩 Ballyadams Formation
- 🟩 Ballymartin Formation
- ⬜ Ballysteen Formation (Dolomitised)
- ⬜ Milford Formation (Dolomitised)
- ⬜ Milford Formation
- 🟩 Quinagh Formation
- 🟪 Tullow Type 2 Equigranular Granite
- 🟪 Tullow Type 2 Sparsely Porphyritic Granite

0m 500m 1000m

Ordnance Survey Ireland No. EN0002514

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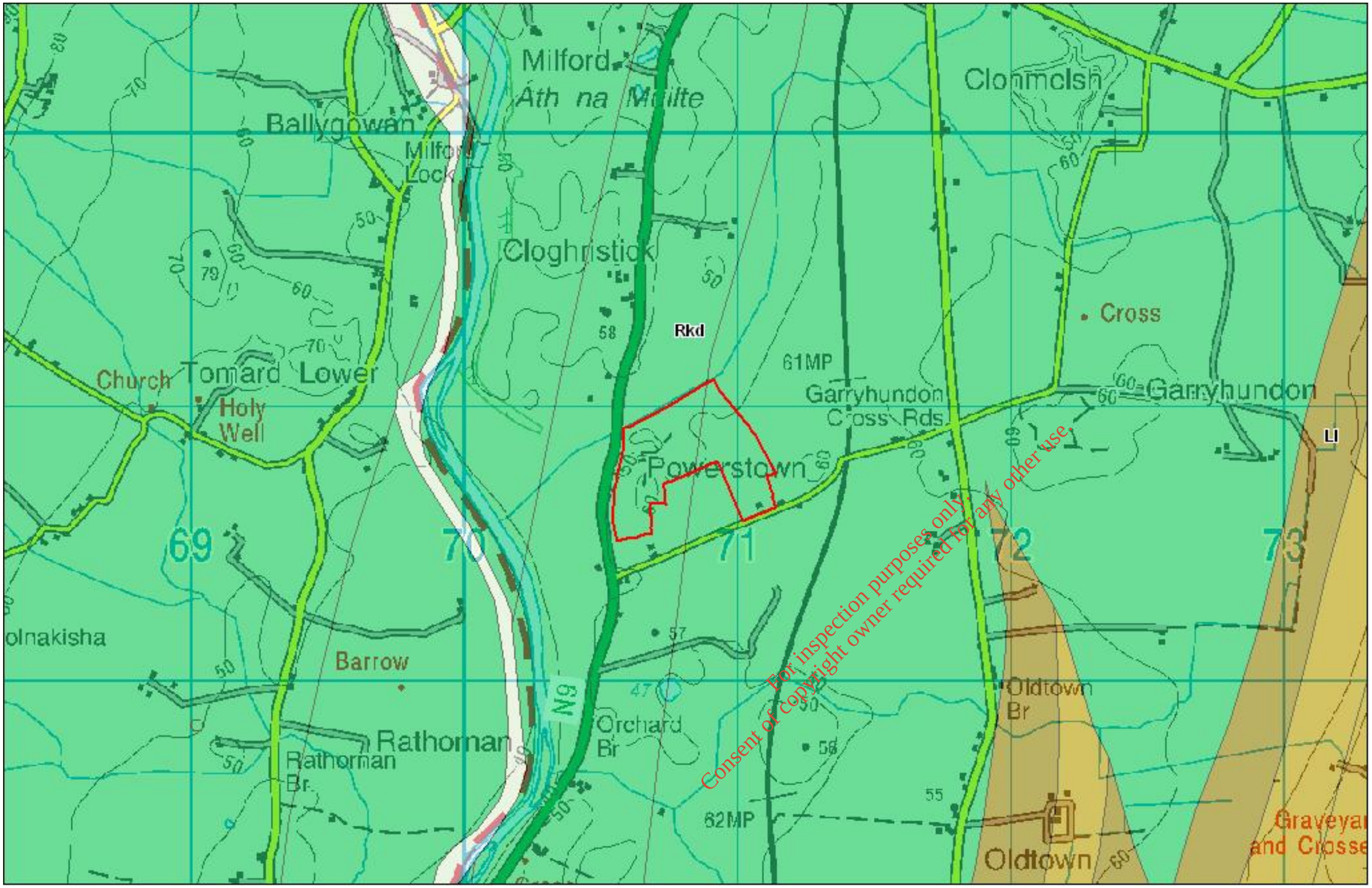
Client **Carlow County Council**

Job
Environmental Risk Assessment

Drawing
Bedrock Geology

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	6	Final	A4	As Shown	May ' 14	AA



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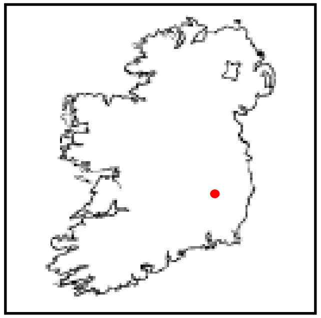

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Legend

- 🟥 Site Boundary
- 🟩 Rkd- Regionally Important Aquifer, Kerstified (diffuse)
- 🟫 LI- Locally Important Aquifer,Bedrock gen. moderately productive in Local Zones
- 🟨 Pl- Poor Aquifer. Bedrock which is generally unproductive except for Local Zones

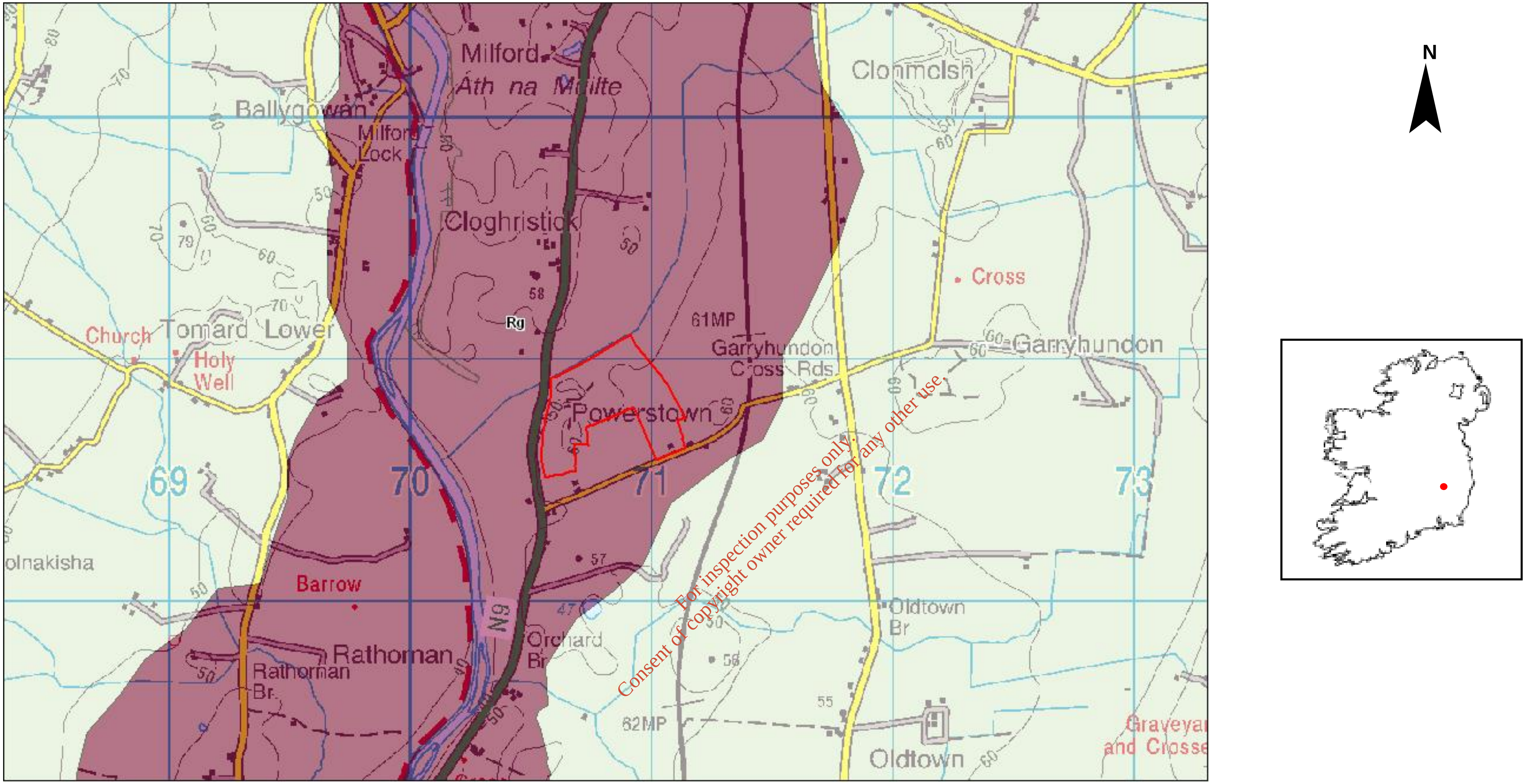
0m 500m 1000m

Client Carlow County Council

Job Environmental Risk Assessment

Drawing Aquifer Classification

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	7	Final	A4	As Shown	May ' 14	AA



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Legend

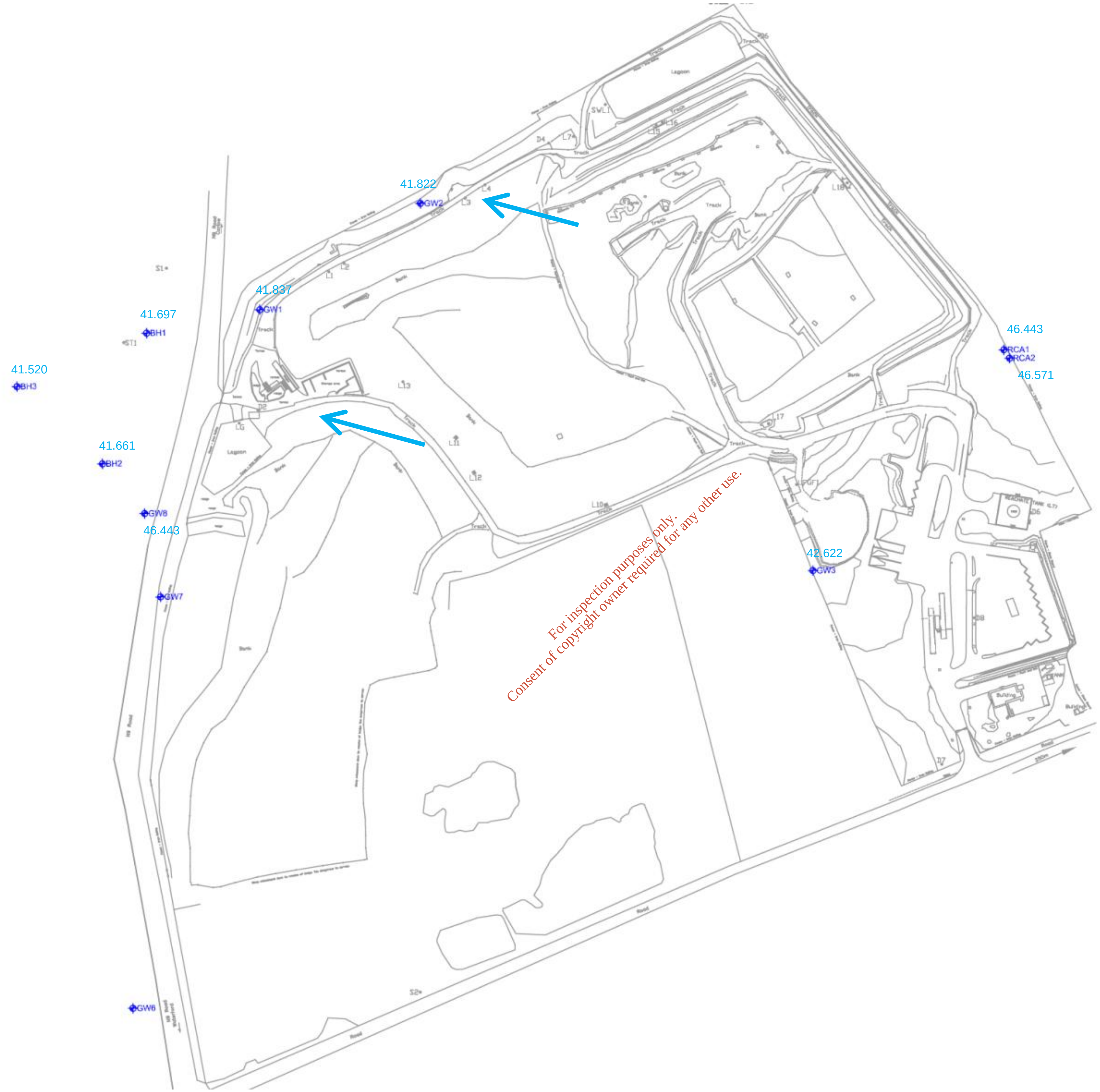
☐ Site Boundary

■ Rg - Regionally Important Extensive Sand/Gravel Aquifers

0m 500m 1000m

Client	Carlow County Council	Drawing	Gravel Aquifer Classification
Job	Environmental Risk Assessment		

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	8	Final	A4	As Shown	May ' 14	AA



Legend

18.67	Groundwater Level (mAOD) (metres above ordnance datum) (measured on the 28th January 2014)
⊕	Groundwater Monitoring Wells
↙	Inferred Groundwater Flow Direction

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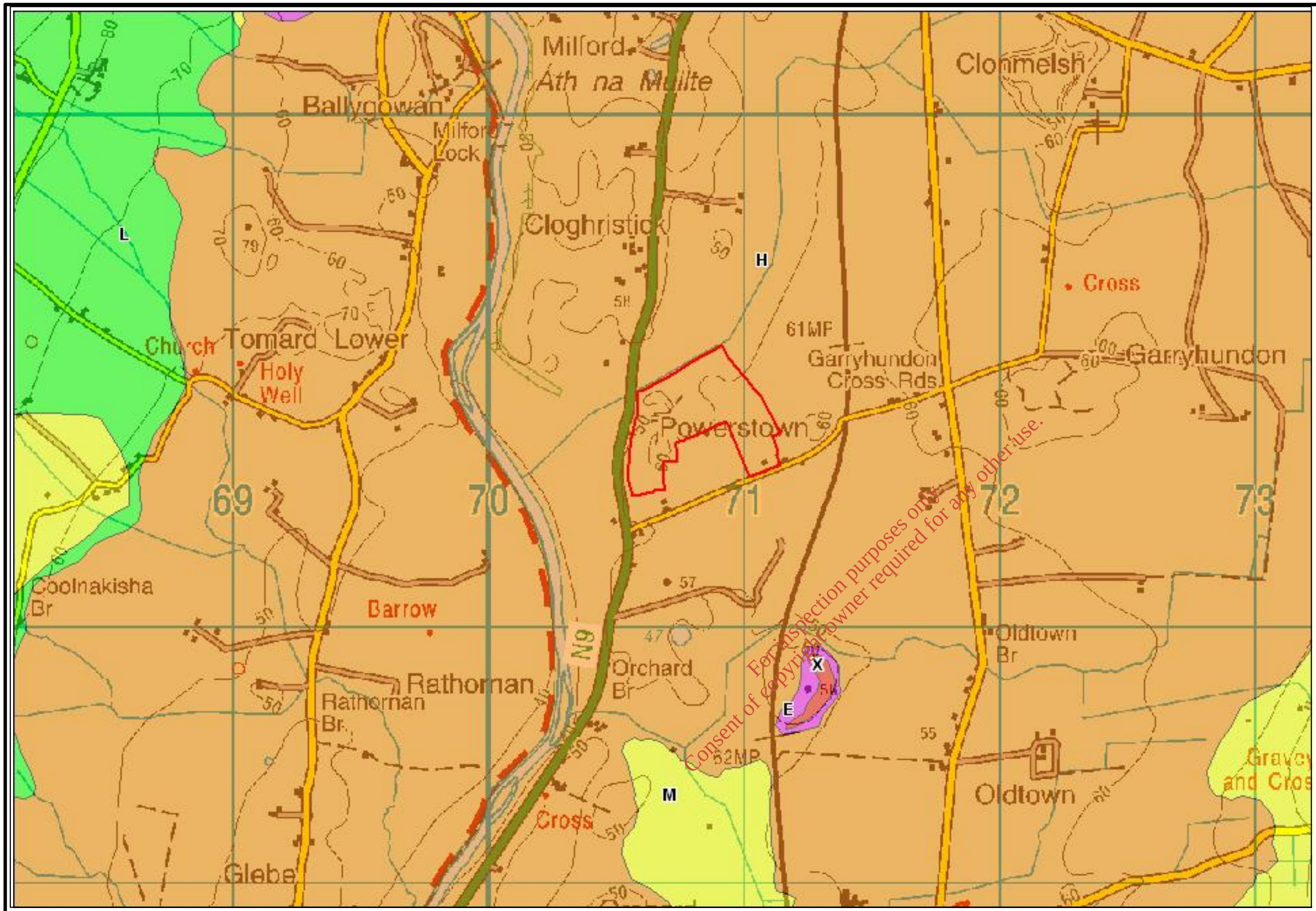
Client Carlow County Council			Drawing **Inferred Groundwater Flow Direction**			
Job Environmental Risk Assessment						
Job Number E1024	Drawing Number 9	Status Final	Sht. Size A3	Scale NTS	Date May ' 14	Drawn JMcC



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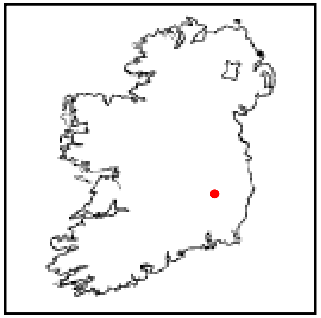

Legend

- □ Site Boundary
- 🟥 X- Rock near Surface or Karst
- 🟪 E- Extreme
- 🟧 H- High
- 🟨 M- Moderate
- 🟩 L- Low

0m 500m 1000m

Ordnance Survey Ireland No. EN0002514

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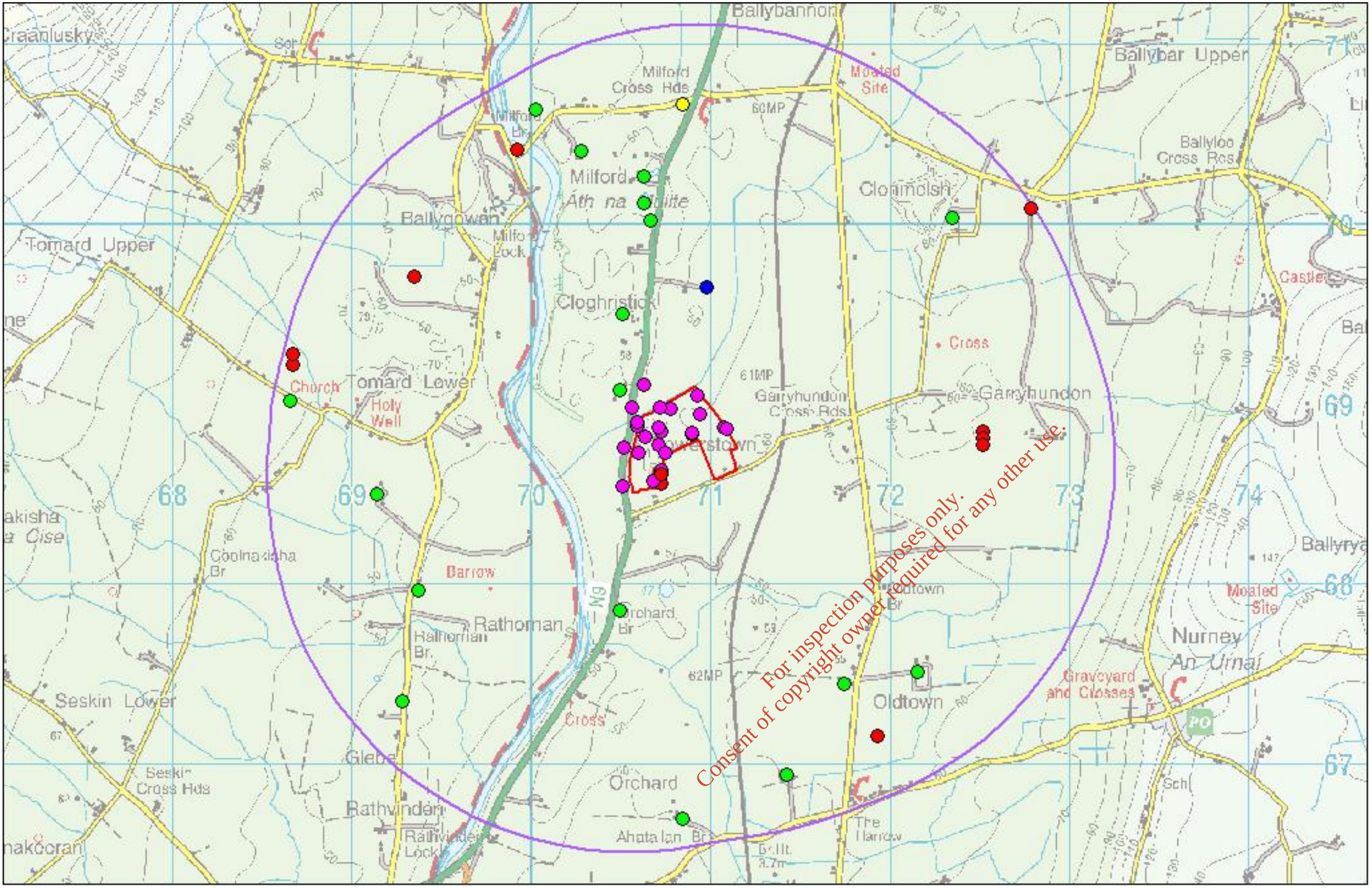
Client **Carlow County Council**

Drawing **Aquifer Vulnerability**

Job **Environmental Risk Assessment**

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	10	Final	A4	As Shown	May ' 14	AA



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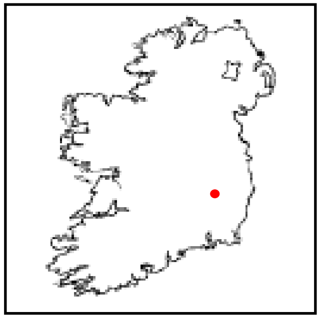

Legend

- ▯ Site Boundary
- ○ 2 Km Radius
- 🟥 Unknown
- 🟩 Agri & domestic use
- 🟦 Domestic use only
- 🟪 Industrial use
- 🟨 Public supply (Co Co)

0m 500m 1000m

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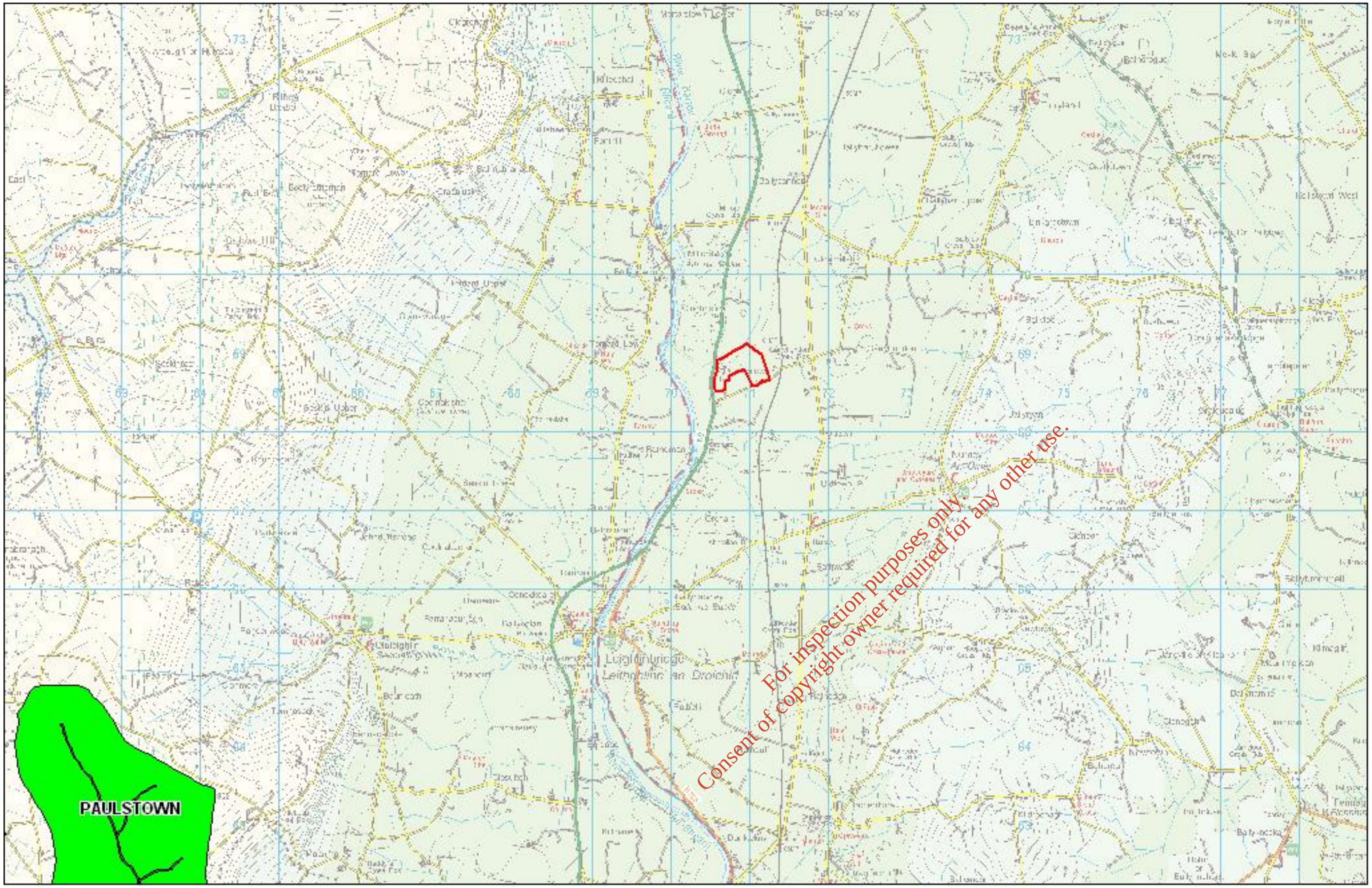
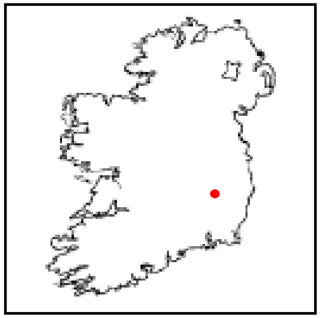
Client Carlow County Council	**Drawing** Wells within 2Km Radius
Job Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	11	Final	A4	As Shown	May ' 14	AA





N

Legend

- 🟥 Site Boundary
- 🟩 SI- Inner Protection Area
- 🟩 SO- Outer Protection Area

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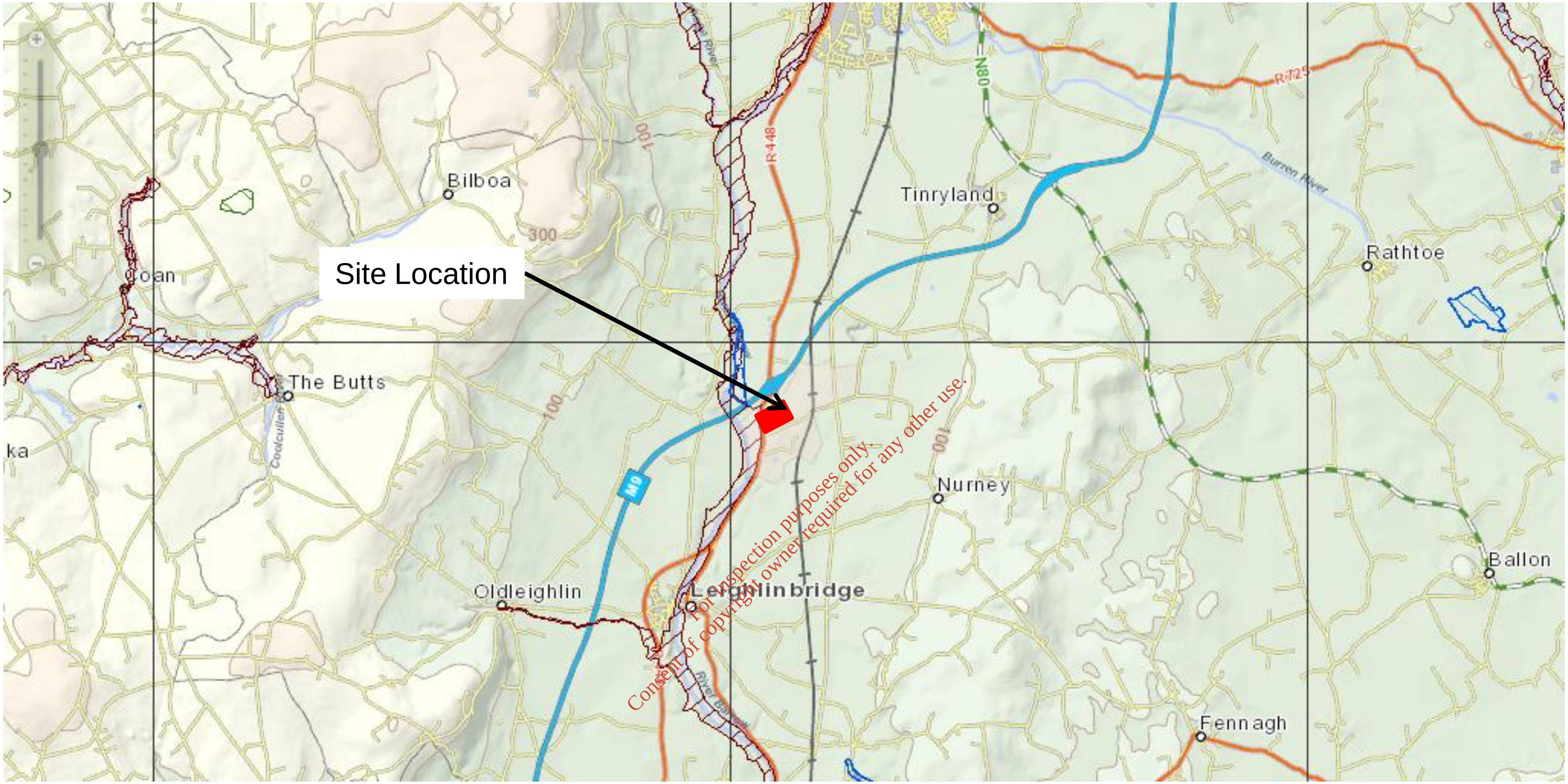
Client Carlow County Council

Drawing
Source Protection Area

Job
Environmental Risk Assessment

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	12	Final	A4	NTS	May ‘ 14	AA



Legend

- 🟥 Site Boundary
- ▯ proposed Natural Heritage Area (pNHA)
- ▨ Special Area of Conservation (SAC)

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Client **Carlow County Council**

Job
Environmental Risk Assessment

Drawing
Natura 2000 Sites Within the Vicinity of the Site

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1024	13	Final	A4	As Shown	May ' 14	AA

TABLES

E1024 Powerstown Landfill
Environmental Risk Assessment

Table 1: Groundwater Monitoring Levels

Measured Parameter		Elevation of Reference (Top of Inner Casing)	Elevation of Reference (Ground Level)	Depth of Water Strike		Gravel	Bentonite	Screen Interval	Total Drill Depth	Total Depth	Water Level		Water Level		Water Level		Water Level		Water Level		Water Level		Water Level		Water Level	
Units		mAOD	mAOD	mbgl	mAOD	mbgl	mbgl	mbgl	mbgl	mbtoc	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD	mbtoc	maOD
Date Measured											29/09/2011		04/01/2012		18/01/2012		31/01/2012		15/02/2012		29/11/2013		13/12/2013		28/01/2014	
Well ID	GW1	47.617	47.512	-	-	-	-	-	-	16.18	6.165	41.452	-	-	6.098	41.519	7.098	40.519	6.082	41.535	6.205	41.412	6.18	41.437	5.78	41.837
	GW2	43.312	43.150	-	-	-	-	-	-	3.42	1.93	41.382	-	-	-	-	1.8	41.512	1.722	41.590	1.882	41.430	1.87	41.442	1.49	41.822
	GW3	58.602	58.204	-	-	-	-	-	-	-	16.7	41.902	-	-	-	-	-	-	-	-	16.13	42.472	16.65	41.952	15.98	42.622
	GW6	49.225	48.897	-	-	-	-	-	-	21.26	8.57	40.655	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	GW7	48.576	47.994	-	-	-	-	-	-	18.33	7.632	40.944	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	GW8*	45.245	45.051	-	-	-	-	-	-	13.1	-	-	-	-	-	-	4.922	40.323	4.777	40.468	4.952	40.293	4.966	40.279	4.174	41.071
	RCA1	58.833	58.351	-	-	-	-	-	-	16.055	12.6	46.233	-	-	12.427	46.406	12.312	46.521	12.162	46.671	12.675	46.158	12.675	46.158	12.39	46.443
	RCA2	59.037	58.339	-	-	-	-	-	-	-	12.793	46.244	-	-	12.427	46.610	-	-	-	-	12.867	46.170	12.867	46.170	12.466	46.571
	BH1	44.612	44.205	3.5, 9.5	40.705, 34.705	1-7.5, 8.5-15	0-1; 7.5-8.5	9-15	15	16.01	-	-	3.263	41.349	3.432	41.180	3.228	41.384	3.42	41.192	3.57	41.042	3.575	41.037	2.915	41.697
	BH2	45.211	44.924	4.0, 13.0	40.924, 31.924	1-11, 12-18	0-1; 11-12	12.5-18	18	18.77	-	-	3.865	41.346	4.057	41.154	3.819	41.392	4.032	41.179	4.197	41.014	4.195	41.016	3.55	41.661
	BH3	41.72	41.5	8	33.5	1-6.5, 7.5-13.5	0-1; 6.5-7.5	7.5-13.5	13.5	12.92	-	-	0.525	41.195	0.732	40.988	0.462	41.258	0.712	41.008	0.85	40.870	0.85	40.870	0.2	41.520

\- Denotes no measurement available

* Denotes measurement for Elevation of Reference (Top of Casing) are taken from Outer casing (CAP)

Table: 1 Groundwater Analytical Results

E1024 Powerstown Landfill
Environmental Risk Assessment

Table: 2 Groundwater Analytical Results

Sample Identity			Site Specific Trigger Values GW1/GW8	Site Specific Trigger Value GW2	Site Specific Trigger Value GW3	Assessment Criteria			BH1				BH2				BH3				GW1			
Laboratory Report No.						Groundwater Regulations 2010 (S.I. No. 9 of 2010) [1]	EPA Interim Guideline Value (IGV) for Groundwater [2]	Surface Water Regulations 2009 (S.I. No. 272 of 2009)[3]	162057	200790	255093	258861	162057	200790	255093	258861	162057	200790	255093	258861	162057	200790	255093	258861
Sample Date									31/01/2012	16/02/2012	13/12/2013	28/01/2014	31/01/2012	16/02/2012	13/12/2013	28/01/2014	31/01/2012	16/02/2012	13/12/2013	28/01/2014	31/01/2012	16/02/2012	13/12/2013	28/01/2014
Parameters	**Unit**	**MDL**																						
Field Measured Parameters																								
Temperature	ºC	♦	~	~	~	~	25	No greater than 1.5 ºC rise in ambient temperature outside the mixing zone	10.9	10.8	11.31	10.8	9.60	11.4	11.48	10.06	10.60	10.9	11.18	9.94	11.05	11.8	12.49	11.09
Dissolved Oxygen	%	♦	~	~	~	~	NAC	>80 - <120	67.9	-	22.1	14.7	12.60	-	50.80	52.1	11.40	-	24.3	24.7	76.20	-	47.5	22.3
Dissolved Oxygen	ppm	♦	~	~	~	~	~	~	7.78	-	2.4	1.63	1.42	-	5.49	5.57	1.32	-	2.65	2.66	1.77	-	5.03	2.35
Electrical Conductivity	µS/cm	♦	1,000	1,300	1,000	800 - 1875 #	1000	~	550	-	608	560.0	508	-	577	514.9	474.60	-	514.4	504.1	867	-	646.2	714.9
pH	pH units	-0.9	~	~	~	~	6.5 - 9.5	6.0 - 9.0	7.22	-	7.32	7.08	7.32	-	7.26	7.37	7.31	-	7.29	7.31	7.52	-	7.17	7.11
Colour	N/A	♦	~	~	~	~	NAC	NAC	Slight brown	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Cloudy brown	Cloudy brown	Very silty	Very silty	Clear	Clear	Clear	Clear
Odour	N/A	♦	~	~	~	~	~	~	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Other observations	N/A	♦	~	~	~	~	~	~	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination
Laboratory Measured Parameters																								
pH ¥			~	~	~	~	6.5 - 9.5	6.0 - 9.0	8.00	7.40	-	-	7.90	7.4	-	-	7.9	7.5	-	-	7.8	7.3	-	-
Electrical Conductivity ¥			1,000	1,300	1,000	800 - 1875 #	1000	~	-	830	-	-	-	750	-	-	-	730	-	-	-	1200	-	-
Nutrients																								
Ammonium (NH$_4$) as N **	mg/l	<0.03	2	1	0.15	0.065 - 0.175	0.117	0.065	0.54	0.15	<0.03	<0.03	1.10	0.69	<0.03	0.45	0.51	0.11	<0.03	<0.03	16	18	2.75	12.6
Ammoniacal Nitrogen (free) NH3	mg/l	<0.02	~	~	~	~	~	~	0.04	<0.01	<0.02	<0.02	0.06	0.01	<0.02	0.55	0.03	<0.01	<0.02	<0.02	0.68	0.24	3.54	15.30
Orthophosphate as P	mg/l	0.2	~	~	~	0.035	0.03	0.075	<0.20	<0.2	<0.02	<0.02	<0.2	<0.2	<0.02	<0.02	<0.20	<0.2	<0.02	<0.02	<0.20	<0.2	<0.02	<0.02
Phosphorous (P)	mg/l		~	~	~	~	~	0.035 - 0.075	<0.20	<0.2	<0.006	0.007	<0.2	<0.2	0.020	0.022	<0.20	<0.2	<0.006	0.042	<0.20	<0.2	0.020	0.028
Nitrate as (NO3)	mg/l	0.5	~	~	~	50	25	~	38.0	41.0	40.0	35.9	41	41	39.5	34.0	0.8	<0.5	<0.3	<0.3	13.0	11.0	48.3	13.0
Nitrite as (NO2)	mg/l	0	~	~	~	0.375	0.1	~	0.047	0.06	<0.05	<0.05	0.079	0.026	<0.05	<0.05	0.026	0.027	<0.05	<0.05	0.027	0.023	<0.05	<0.05
Potassium	mg/l	0.5	~	~	~	~	5	~	<0.5	1.1	2.46	2.13	4.3	3.7	3.7	3.9	<0.5	<0.5	1.44	<1	**27**	**23**	**7.1**	**19.6**
Indicators																								
Chloride	mg/l	0.3	50	60	40	24 - 187.5 #	30	~	35	35	32.8	23.9	26	25	30	19.7	26	34	26.8	24.9	63	63	38.1	30.7
Fluoride	mg/l	0.05	~	~	~	~	1	0.5	0.13	0.097	<0.5	<0.5	0.11	0.11	**1.17**	<0.5	0.14	0.13	<0.5	<0.5	0.11	0.12	<0.5	<0.5
Metals (dissolved)																								
Aluminium	µg/l	10	~	~	~	150	200	~	21	41	<2.9	<2.9	17	28	<2.9	<2.9	48	62	<2.9	<2.9	<10	140	<2.9	3.44
Arsenic	µg/l	2.5	~	~	~	7.5	~	25	<1.0	<1.0	0.32	0.27	<1.0	<1.0	0.36	0.38	<1.0	1.2	0.95	1.23	<1.0	1.2	0.35	0.49
Cadmium	µg/l	0.5	~	~	~	3.75	~	~	<0.080	<0.080	<0.1	<0.1	<0.080	<0.080	<0.1	<0.1	<0.08	<0.08	<0.1	<0.1	<0.08	0.093	<0.1	<0.1
Chromium	µg/l	1.5	~	~	~	37.5	30	3.4	<1.0	<1.0	8.20	3.71	<1.0	<1.0	7.13	3.59	1.10	<1.0	2.55	3.37	1.20	<1.0	5.73	4.90
Copper	µg/l	7	~	~	~	1500	~	30	<1.0	<1.0	1.64	<0.85	<1.0	<1.0	1.82	<0.85	<1.0	<1.0	1.37	<0.85	<1.0	2.6	1.77	1.83
Iron **	mg/l	20	~	~	~	~	0.2	~	<0.019	0.03	<0.019	<0.019	<0.02	0.03	<0.019	<0.019	<0.02	0.04	<0.019	<0.019	<0.02	0.03	<0.019	<0.019
Lead	µg/l	5	~	~	~	18.75	10	7.2	<1.0	<1.0	0.05	<0.02	<1.0	<1.0	0.1	<0.02	<1.0	<1.0	0.04	0.04	<1.0	<1.0	0.27	0.28
Manganese	µg/l	2	~	~	~	~	50	~	4.50	4.40	0.44	0.57	1.60	3.20	1.22	1.34	**600**	**680**	**580**	**624**	**76**	**69**	1.96	**101**
Mercury	µg/l	1	~	~	~	0.75	1	0.05	<0.5	<0.5	<0.01	<0.01	<0.5	<0.5	<0.01	<0.01	<0.50	<0.5	<0.01	<0.01	<0.50	0.65	<0.01	<0.01
Nickel	µg/l	2	~	~	~	15	20	20	<1.0	3.2	2.75	1.92	<1.0	2.40	2.15	2.20	<1.0	2.60	3.07	2.98	<1.0	10.00	3.00	7.29
Selenium	µg/l	3	~	~	~	~	~	~	<1.0	2.90	1.37	1.42	<1.0	3.80	1.48	1.51	<1.0	2.40	0.41	0.71	2.00	3.90	1.3	0.61
Sodium	mg/l	0.5	~	~	~	150	150	~	15.0	12.0	16.4	13.0	14.0	11.0	15.4	11.1	8.9	6.0	8.65	8.17	55.0	49.0	20.6	29.2
Zinc	µg/l	3	~	~	~	~	100	100	<1.0	3.60	1.06	<0.41	<1.0	3.4	1.23	0.933	<1.0	4.5	1.89	1.6	<1.0	5.9	1.35	11.4

Notes:

1: European Communities Environmental Objectives (Groundwater) Regulations 2010; S.I. No. 9 of 2010.

2: Environmental Protection Agency (EPA), 2003. Towards Setting Guideline Values for the Protection of Groundwater in Ireland - Interim Report, EPA, Ireland

3: European Communities Environmental Objectives (Surface water) Regulations 2009; S.I. No. 272 of 2009.

Shaded denotes value exceeds groundwater regulation standards.

Bold denotes value exceeds IGV where no groundwater regulation value is available.

Underline denotes value exceeds surface water regulations

~ denotes water quality standard available

Site Specific Trigger Values are only used for reference purpose only and were not used as screening Criteria

NAC denotes no abnormal change.

N/A denotes not applicable.

¥ Denotes parameters were measured in the lab

# denotes lower value - assessment for the presence of saline/other instrusion; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution

** denotes concentrations were converted for comparison purposes

In the case of Copper the value 30µg/L applies where the water hardness exceeds 100mg/l CaCO ; Surface Water Regulation 2009 (S.I. No 272 of 2009): Alkalinity >100mg/L CaCO within CCC data 'Surface Water Trends'

In the case of Zinc the value 100µg/L applies where the water hardness exceeds 100mg/l CaCO ; Surface Water Regulation 2009 (S.I. No 272 of 2009): Alkalinity >100mg/L CaCO within CCC data 'Surface Water Trends'

E1024 Powerstown Landfill
Environmental Risk Assessment

Table: 2 Groundwater Analytical Results

Sample Identity			Site Specific Trigger Values GW1/GW8	Site Specific Trigger Value GW2	Site Specific Trigger Value GW3	Assessment Criteria			GW2				GW3		GW8				RCA1				RCA2	
Laboratory Report No.						Groundwater Regulations 2010 (S.I. No. 9 of 2010) ^{1}	EPA Interim Guideline Value (IGV) for Groundwater ^{2}	Surface Water Regulations 2009 (S.I. No. 272 of 2009)^{3}	162057	200790	255093	258861	255093	258861	162057	200790	255093	258861	162057	200790	255093	258861	255093	258861
Sample Date									31/01/2012	16/02/2012	13/12/2013	28/01/2014	13/12/2013	28/01/2014	31/01/2012	16/02/2012	13/12/2013	28/01/2014	31/01/2012	16/02/2012	13/12/2013	28/01/2014	13/12/2013	28/01/2014
Parameters	**Unit**	**MDL**																						
Field Measured Parameters																								
Temperature	ºC	♦	~	~	~	~	25	No greater than 1.5 ºC rise in ambient temperature outside the mixing zone	9.50	10	12.58	8.84	11.29	9.87	10.60	11.5	11.53	10.6	9.30	10.9	10.78	8.18	10.80	8
Dissolved Oxygen	%	♦	~	~	~	~	NAC	>80 - <120	28.30	-	29.4	48.2	24.5	42.6	10.20	-	22.1	10.3	57.30	-	78.90	60.7	73.7	76.9
Dissolved Oxygen	ppm	♦	~	~	~	~	~	~	3.27	-	3.09	5.4	2.65	4.63	1.15	-	2.4	1.14	6.50	-	8.64	6.88	8.05	9.07
Electrical Conductivity	µS/cm	♦	1,000	1,300	1,000	800 - 1875 #	1000	~	595	-	**867.3**	442	530.7	494.1	494.80	-	559	535.0	594.00	-	530.10	528.8	584.1	552.0
pH	pH units	-0.9	~	~	~	~	6.5 - 9.5	6.0 - 9.0	7.82	-	7.02	7.25	7.54	7.39	7.55	-	7.24	7.09	6.95	-	7.21	7.08	7.14	7.21
Colour	N/A	♦	~	~	~	~	NAC	NAC	Clear	Light brown	Clear	Orange/ Red	Clear	Clear	Clear	Clear	Cloudy	Clear	Slightly cloudy brown	Clear	Cloudy	Silty	Slight brown	Silty
Odour	N/A	♦	~	~	~	~	~	~	None	None	None	None	Organic	None	None	None	None	None	None	None	None	None	None	None
Other observations	N/A	♦	~	~	~	~	~	~	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination	No Physical Evidence of Contamination
Laboratory Measured Parameters																								
pH ¥			~	~	~	~	6.5 - 9.5	6.0 - 9.0	8	7.4	-	-	-	-	8	7.5	-	-	8.3	7.5	-	-	-	-
Electrical Conductivity ¥			1,000	1,300	1,000	800 - 1875 #	1000	~	-	950	-	-	-	-	-	720	-	-	-	810	-	-	-	-
Nutrients																								
Ammonium (NH_4) as N **	mg/l	<0.03	2	1	0.15	0.065 - 0.175	0.117	0.065	0.60	0.24	<0.03	<0.03	<0.03	<0.03	0.93	0.41	<0.03	0.45	0.70	0.17	<0.03	<0.03	<0.03	<0.03
Ammoniacal Nitrogen (free) NH3	mg/l	<0.02	~	~	~	~	~	~	0.04	<0.01	<0.02	<0.02	<0.02	<0.02	0.06	<0.01	<0.02	0.55	0.09	<0.01	<0.02	<0.02	<0.02	<0.02
Orthophosphate as P	mg/l	0.2	~	~	~	0.035	0.03	0.075	<0.20	<0.2	<0.02	<0.02	0.029	<0.02	<0.20	<0.2	<0.02	<0.02	<0.20	<0.2	<0.02	<0.02	<0.02	<0.02
Phosphorous (P)	mg/l		~	~	~	~	~	0.035 - 0.075	<0.20	<0.2	0.014	0.018	0.039	0.024	<0.20	<0.2	0.015	0.021	<0.20	<0.2	<0.006	0.028	0.023	0.027
Nitrate as (NO3)	mg/l	0.5	~	~	~	50	25	~	26.0	22.0	49.1	4.3	30.5	33.1	40.0	42.0	37.9	33.9	36.0	41.0	38.6	43.6	38.4	39.0
Nitrite as (NO2)	mg/l	0	~	~	~	0.375	0.1	~	0.023	<0.02	0.068	<0.05	0.309	<0.05	0.023	<0.02	<0.05	<0.05	0.029	<0.02	<0.05	<0.05	<0.05	<0.05
Potassium	mg/l	0.5	~	~	~	~	5	~	**21**	**16**	**8.37**	4.55	2.36	1.52	4	3.4	3.59	4.04	1.1	1.8	2.25	2.23	2.26	1.43
Indicators																								
Chloride	mg/l	0.3	50	60	40	24 - 187.5 #	30	~	41	43	72.1	23.6	22.6	21.3	24	24	25.1	20	19	23	17.2	23.5	17.1	18.8
Fluoride	mg/l	0.05	~	~	~	~	1	0.5	0.17	0.16	<0.5	<0.5	<0.5	<0.5	0.12	0.082	<0.5	<0.5	0.12	<0.05	<0.5	<0.5	<0.5	<0.5
Metals (dissolved)																								
Aluminium	µg/l	10	~	~	~	150	200	~	<10	20	<2.9	<2.9	<2.9	<2.9	31	12	<2.9	<2.9	<10	26	<2.9	<2.9	<2.9	<2.9
Arsenic	µg/l	2.5	~	~	~	7.5	~	25	<1.0	1.1	0.81	0.55	0.42	0.30	<1.0	<1.0	0.35	0.47	<1.0	2.0	0.40	0.42	0.49	0.51
Cadmium	µg/l	0.5	~	~	~	3.75	~	~	<0.080	<0.08	0.15	<0.1	<0.1	<0.1	<0.080	<0.08	<0.1	<0.1	<0.080	0.08	<0.1	<0.1	<0.1	<0.1
Chromium	µg/l	1.5	~	~	~	37.5	30	3.4	1.10	<1.0	7.48	3.17	8.35	3.34	<1.0	<1.0	7.40	3.59	1.1	<1.0	2.98	3.57	9.17	3.85
Copper	µg/l	7	~	~	~	1500	~	30	<1.0	2.2	3.94	1.53	1.41	<0.85	<1.0	<1.0	1.94	<0.85	<1.0	<1.0	<0.85	1.10	1.23	1.06
Iron **	mg/l	20	~	~	~	~	0.2	~	<0.019	0.13	<0.019	<0.019	<0.019	<0.019	<0.02	0.02	<0.019	<0.019	0.02	**0.3**	<0.019	<0.019	<0.019	<0.019
Lead	µg/l	5	~	~	~	18.75	10	7.2	<1.0	<1.0	0.06	<0.02	0.02	0.02	<1.0	<1.0	0.02	<0.02	<1.0	1.00	<0.02	<0.02	<0.02	<0.02
Manganese	µg/l	2	~	~	~	~	50	~	**230**	31	**141**	**281**	10.1	5.01	3.4	2.4	1.4	0.82	<1.0	7.1	0.12	0.30	0.45	0.39
Mercury	µg/l	1	~	~	~	0.75	1	0.05	0.53	<0.5	<0.01	<0.01	<0.01	<0.01	<0.50	<0.5	<0.01	<0.01	0.62	1.00	<0.01	<0.01	<0.01	<0.01
Nickel	µg/l	2	~	~	~	15	20	20	<1.0	3.80	7.1	3.64	4.3	2.28	<1.0	2.10	2.05	2.28	<1.0	2.70	2.22	2.17	1.83	2.01
Selenium	µg/l	3	~	~	~	~	~	~	<1.0	2.40	1.16	0.53	1.43	1.34	1.2	2.8	1.87	1.68	1.50	5.10	1.55	1.35	1.84	1.54
Sodium	mg/l	0.5	~	~	~	150	150	~	44.0	36.0	43.0	20.3	10.6	9.69	12	9.8	12.5	11.3	9.3	53.0	9.05	11.8	9.14	9.7
Zinc	µg/l	3	~	~	~	~	100	100	<1.0	5.8	1.98	0.795	19.20	5.78	<1.0	2.6	1.28	1.07	<1.0	7.0	1.55	0.859	0.572	0.41

Notes:

1: European Communities Environmental Objectives (Groundwater) Regulations 2010; S.I. No. 9 of 2010.

2: Environmental Protection Agency (EPA), 2003. Towards Setting Guideline Values for the Protection of Groundwater in Ireland - Interim Report, EPA, Ireland

3: European Communities Environmental Objectives (Surface water) Regulations 2009; S.I. No. 272 of 2009.

Shaded denotes value exceeds groundwater regulation standards.

Bold denotes value exceeds IGV where no groundwater regulation value is available.

Underline denotes value exceeds surface water regulations

~ denotes water quality standard available

Site Specific Trigger Values are only used for reference purpose only and were not used as screening Criteria

NAC denotes no abnormal change.

N/A denotes not applicable.

¥ Denotes parameters were measured in the lab

# denotes lower value - assessment for the presence of saline/other instrusion; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution

** denotes concentrations were converted for comparison purposes

In the case of Copper the value 30µg/L applies where the water hardness exceeds 100mg/l CaCO ; Surface Water Regulation 2009 (S.I. No 272 of 2009): Alkalinity >100mg/L CaCO within CCC data 'Surface Water Trends'

In the case of Zinc the value 100µg/L applies where the water hardness exceeds 100mg/l CaCO ; Surface Water Regulation 2009 (S.I. No 272 of 2009): Alkalinity >100mg/L CaCO within CCC data 'Surface Water Trends'

Table 3: Surface Water Analytical Results

Sample Identity		**Assessment Criteria**		**SW1**			**SW2**			**SW3**			**SW4**		
Location Description				**Powerstown Stream (Upstream)**			**Powerstown Steam (adjoining site)**			**Powerstown Steam (adjoining site)**			**Powerstown Steam (Downstream)**		
Laboratory Report No.		**Surface Water Regularions 2009 (S.I. No 272 of 2009) ¹**	**Site Specific Trigger Value ²**	**252988**	**255093**	**258870**	**252988**	**255093**	**258870**	**252988**	**255093**	**258870**	**252988**	**255093**	**258870**
Sample Date				**29/11/2013**	**13/12/2013**	**28/01/2014**	**29/11/2013**	**13/12/2013**	**28/01/2014**	**29/11/2013**	**13/12/2013**	**28/01/2014**	**29/11/2013**	**13/12/2013**	**28/01/2014**
Parameters	**Unit**														
Field Measured Parameters															
Temperature	ºC	No greater than 1.5 ºC rise in ambient temperature outside the mixing zone	~	8.98	10.55	7	8.93	10.3	7	9.45	11.01	7.60	9.69	11.09	7.5
Dissolved Oxygen	%	>80 - <120	~	**64.3**	89.4	**77.70**	**77.3**	90.5	**74.3**	**61.5**	**72.5**	**75.7**	**74.7**	**78.9**	**75.8**
Dissolved Oxygen	ppm	~	~	7.54	9.88	9.37	9.05	10.05	9	7.12	7.92	9.05	8.6	8.60	9.04
Electrical Conductivity	µS/cm	~	1000	625.2	637.5	482.5	608.6	628.4	472.9	607.7	624.7	499.5	617.2	623.7	500.0
pH	pH units	6.0 - 9.0	~	7.67	8.0	7.26	7.74	8.09	7.36	7.45	7.58	7.42	7.72	7.70	7.45
Oxidation Reduction Potential	mV	~	~	125.2	61.9	68.60	123.7	67.7	68	121	57.3	68.7	157.6	60.7	64
Colour	N/A	NAC	~	Clear	Clear	Cloudy	Clear	Clear	Cloudy	Clear	Clear	Cloudy	Clear	Clear	Cloudy
Odour	N/A	~	~	None	None	None	None	None	None	None	None	None	None	None	None
Nutrients															
Ammonia (free) (N) **	mg/l N	0.065	0.5	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Potassium (K)	mg/l	~	~	2.52	2.38	3.1	2.49	2.88	3.04	2.5	2.58	3.17	2.52	2.65	3.32
Indicators															
Chloride (Cl^-)	mg/l	~	50	23.7	24.5	25.9	23.5	24.2	26.4	30	26.9	29	29.7	27.2	28.6
Sodium (Na)	mg/l	~	~	9.77	11.3	12.4	10	11.2	12.3	13.5	11.6	13.9	13.6	11.9	14.10
Total Suspended Solids (TSS)		~	~	<2	<2	4	<2	<2	6.5	<2	<2	10	<2	<2	3
Metals (dissolved)															
Iron (Fe)	mg/l	~	~	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	<0.019
Manganese (Mn)	µg/l	~	~	7.65	3.21	9.09	4.1	2.14	8.19	4.63	3.51	8.77	4.14	2.81	9.07

Notes:

1: European Communities Environmental Objectives (Surface water) Regulations 2009; S.I. No. 272 of 2009 and
as ammended S. I No 327 of 2012

2: Site Specific Trigger Levels derived from Timoney & Company, 2005 Surface water Trigger Values for Powerstown Stream

values in bold and shaded denotes that parameter exceeds relevant screening criteria

~ denotes surface water quality standard unavailable.

NAC denotes no abnormal change.

quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution

** denotes concentrations were converted for comparison purposes

^ denotes no access due to flooding

Table 3: Surface Water Analytical Results

Sample Identity		Assessment Criteria		SW5			SW6			SW7		
Location Description				Powerstown Steam (Entering the Barrow)			The Barrow (Upstream)			The Barrow (Downstream)		
Laboratory Report No.		Surface Water Regularions 2009 (S.I. No 272 of 2009) [1]	Site Specific Trigger Value [2]	252988	255093	N/A	252988	255093	N/A	252988	255093	N/A
Sample Date				29/11/2013	13/12/2013	28/01/2014	29/11/2013	13/12/2013	28/01/2014	29/11/2013	13/12/2013	28/01/2014
Parameters	**Unit**											
Field Measured Parameters												
Temperature	ºC	No greater than 1.5 ºC rise in ambient temperature outside the mixing zone	~	9.61	11.09	^	8.48	10.72	^	8.26	10.67	^
Dissolved Oxygen	%	>80 - <120	~	85.4	82.9	^	91.9	90.3	^	87	88.0	^
Dissolved Oxygen	ppm	~	~	9.9	9.04	^	10.89	9.94	^	10.36	9.69	^
Electrical Conductivity	µS/cm	~	1000	594.5	623.1	^	469.0	485.7	^	464.7	495.2	^
pH	pH units	6.0 - 9.0	~	7.9	7.8	^	8.26	8.13	^	8.16	7.95	^
Oxidation Reduction Potential	mV	~	~	140.6	63.6	^	130.3	53.5	^	90.6	86.4	^
Colour	N/A	NAC	~	Clear	Clear	^	Clear	Clear	^	Clear	Clear	^
Odour	N/A	~	~	None	None	^	None	None	^	None	None	^
Nutrients												
Ammonia (free) (N) **	mg/l N	0.065	0.5	<0.03	<0.03	^	<0.03	<0.03	^	<0.03	<0.03	^
Potassium (K)	mg/l	~	~	2.63	2.94	^	3.81	3.61	^	2.99	3.93	^
Indicators												
Chloride (Cl^-)	mg/l	~	50	29.5	27.2	^	24.2	26.8	^	24.3	26.7	^
Sodium (Na)	mg/l	~	~	13.5	12.6	^	11.4	12.50	^	11.8	13.8	^
Total Suspended Solids (TSS)		~	~	<2	<2	^	2.5	2	^	3	<2	^
Metals (dissolved)												
Iron (Fe)	mg/l	~	~	<0.019	<0.019	^	0.057	0.0266	^	0.0547	0.0267	^
Manganese (Mn)	µg/l	~	~	5.12	2.87	^	34.1	24	^	39.5	24.3	^

Notes:

1: European Communities Environmental Objectives (Surface water) Regulations 2009; S.I. No. 272 of 2009 and as ammended S. I No 327 of 2012

2: Site Specific Trigger Levels derived from Timoney & Company, 2005 Surface water Trigger Values for Powerstown Stream

values in bold and shaded denotes that parameter exceeds relevant screening criteria

~ denotes surface water quality standard unavailable.

NAC denotes no abnormal change.

quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution

** denotes concentrations were converted for comparison purposes

^ denotes no access due to flooding

APPENDIX A

Chain of Custody No: 59919

GEOTRACE - ANALYSIS REQUEST FORM AND SAMPLE CUSTODY SHEET

ALcontrol Laboratories

Unit 18a, Rosemount Business Park,
Ballycoolin, Dublin 11, Ireland
e-mail: Ireland.schedulers@alcontrol.ie
Tel: 01 8829893 Fax: 01 8829895

Client: Malone O Regan
Address: Unit 2B Richview Office park
Clonskeagh, Dublin 14
Invoice address if different
Tel: 01 260 2655 Fax:
Project/Site Name: Powerstown
Project Code: E1024
Contact Name: David Dwyer, Claire Clifford
E-mail: cclifford@morce.ie

Date Samples Despatched: 29/11/2013
Sampler: D Dwyer / J McCann
Email Schedule to: ddwyer@morce.ie jmccann@morce.ie
E-mail Results to: cclifford@morce.ie
Job Continuation - yes / no
P.O. Number:
Quote Number: 37804

Sheet 1
of 1

Report Format

Standard

Date of Sampling:	Sample Ref. ID	Depth in metres	Sample Preservation Y/N	(S)oil or (W)ater (specify if other	Sample Concentration Low Medium or High (L,M,H)	Total ammonia	Suspended solids	Chloride	Potassium	Sodium	Iron	Manganese
29/11/2013	SW 1			W		✓	✓	✓	✓	✓	✓	✓
"	SW 2			W		✓	✓	✓	✓	✓	✓	✓
"	SW 3			W		✓	✓	✓	✓	✓	✓	✓
"	SW 4			W		✓	✓	✓	✓	✓	✓	✓
"	SW 5			W		✓	✓	✓	✓	✓	✓	✓
	SW 6			W		✓	✓	✓	✓	✓	✓	✓
	SW 7			W		✓	✓	✓	✓	✓	✓	✓

Suite Name/Analysis Required

Turnaround - please tick

10 day t/a ______
5 day t/a ______
3 day t/a ______
1 day t/a ______
date results required by: ______

Time Dependant

Please Tick Box

BOD ☐

MICRO ☐

Comments / Special Instructions:
Please include any known or suspected hazards contained in the samples.

Sampler Signature

Sample Receipt (Driver/Reception)

Date: **Time:** **Temp:**

Received by: **No of coolerboxes:**

Sample Receipt (Laboratory)

Date: **Time:**

Received by: **No of coolerboxes:**

E1024/05

Chain of Custody No: 86538

GEOTRACE ANALYSIS REQUEST FORM AND SAMPLE CUSTODY SHEET

ALcontrol Laboratories

c/o Aramex, Bellinstown, Ballyboughal
Co. Dublin, Ireland

Tel: 01 8433033

Client: Malone O Regan
Address: Unit 2B Richview Office Parks
Clonskeagh Dublin 14
Invoice address if different
Tel: 01 260 2655 Fax:
Project/Site Name: Powerstown
Project Code: E1024
Contact Name: Claire Clifford
E-mail: cclifford@morce.ie

Date Samples Despatched: 13/12/13
Sampler: J McCann, O Dwyer, A.A
Email Schedule to: cclifford@morce.ie JMcCann@morce.ie
E-mail Results to: cclifford@morce.ie JMcCann@morce.ie
Job Continuation - yes / no
P.O. Number:
Quote Number: 37804

Sheet 2
of 2

Report Format

Standard ______

Date of Sampling:	Sample Ref. ID	Depth in metres	Sample Preservation Y/N	(S)oil or (W)ater (specify if other	Samples Concentration Low, Medium or High (L,M,H)	Total Ammonia	Suspended Solids	Chloride	Potassium	Sodium	Iron	Manganese
	SW 1					✓	✓	✓	✓	✓	✓	✓
	SW 2					✓	✓	✓	✓	✓	✓	✓
	SW 3					✓	✓	✓	✓	✓	✓	✓
	SW 4					✓	✓	✓	✓	✓	✓	✓
	SW 5					✓	✓	✓	✓	✓	✓	✓
	SW 6					✓	✓	✓	✓	✓	✓	✓
	SW 7					✓	✓	✓	✓	✓	✓	✓

Turnaround - please tick

7 day t/a ______
5 day t/a ______
3 day t/a ______
1 day t/a ______
date results required by:

Time Dependant

Please Tick Box

BOD ☐

MICRO ☐

Comments / Special Instructions:
Please include any known or suspected hazards contained in the samples.

Sample Receipt (Driver)

Date: **Time:** **Temp:**

Received by: **No of coolerboxes:**

Sample Receipt (Laboratory)

Date: **Time:**

Received by: **No of coolerboxes:**

Chain of Custody No: 86541

GEOTRACE ANALYSIS REQUEST FORM AND SAMPLE CUSTODY SHEET

ALcontrol Laboratories

c/o Aramex, Bellinstown, Ballyboughal
Co. Dublin, Ireland

Tel: 01 8433033

Client: Malone O'Regan
Address: Unit 2B Richview Office Park
Clonskeagh, Dublin 14
Invoice address if different
Tel: 01 260 2655 Fax:
Project/Site Name: Powerstown
Project Code: E1024
Contact Name: Claire Clifford
E-mail: cclifford@morce.ie

Date Samples Despatched: 13/12/13
Sampler: T McCann, O'Dwyer, A.A
Email Schedule to: cclifford@morce.ie, ddwyer@morce.ie
E-mail Results to: cclifford@morce.ie
Job Continuation - yes / no
P.O. Number:
Quote Number: 37804

Sheet 1 of 2

Report Format

Standard ____

Date of Sampling:	Sample Ref. ID	Depth in metres	Sample Preservation Y/N	(S)oil or (W)ater (specify if other	Samples Concentration Low, Medium or High (L,M,H)	Suite Name/Analysis Required: Ammonia, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, Iron, Potassium, Sodium, Phosphorous, Aluminium, Arsenic, Cadmium, Chromium, Copper, Mercury, Manganese, Nickel, Lead, Selenium, Zinc
13/12/13	BH1					
13/12/13	BH2					All samples to be
13/12/13	BH3					
13/12/13	GW8					Analysed for the
13/12/13	GW1					
" "	GW2					Parameters listed
" "	GW3					
" "	RLA1					Above
" "	RLA2					

Turnaround - please tick

7 day t/a ✓
5 day t/a ____
3 day t/a ____
1 day t/a ____
date results required by: ____

Time Dependant

Please Tick Box

BOD ☐

MICRO ☐

Comments / Special Instructions:
Please include any known or suspected hazards contained in the samples.

* All samples to be analysed for the parameters listed *

Sample Receipt (Driver)

Date: **Time:** **Temp:**

Received by: **No of coolerboxes:**

Sample Receipt (Laboratory)

Date: **Time:**

Received by: **No of coolerboxes:**

Chain of Custody No: 89004

GEOTRACE ANALYSIS REQUEST FORM AND SAMPLE CUSTODY SHEET

ALcontrol Laboratories

c/o Aramex, Bellinstown, Ballyboughal
Co. Dublin, Ireland

Tel: 01 8433033

Client: Malone O'Regan
Address: Unit 2B Richview office park, Clonskeagh Dublin 14
Invoice address if different
Tel: 01 260 2655 Fax:
Project/Site Name: Powerstown
Project Code: E1624
Contact Name: Claire Clifford
E-mail: cclifford@morce.ie

Date Samples Despatched: 28/01/14
Sampler: D. Dwyer J. McCann
Email Schedule to: cclifford@morce.ie ddwyer@morce.ie
E-mail Results to: cclifford@morce.ie ddwyer@morce.ie
Job Continuation - yes / no
P.O. Number:
Quote Number: 37804

Sheet 1 of 1

Report Format

Standard

Date of Sampling:	Sample Ref. ID	Depth in metres	Sample Preservation Y/N	(S)oil or (W)ater (specify if other	Samples Concentration Low, Medium or High (L,M,H)	Total Ammonia	Suspended Solids	Chloride	Potassium	Sodium	Iron	Manganese
28/01/14	Sw 1			W		✓	✓	✓	✓	✓	✓	✓
	Sw 2			W		✓	✓	✓	✓	✓	✓	✓
	Sw 3			W		✓	✓	✓	✓	✓	✓	✓
	Sw 4			W		✓	✓	✓	✓	✓	✓	✓

Suite Name/Analysis Required

Turnaround - please tick

7 day t/a ______
5 day t/a ______
3 day t/a ______
1 day t/a ______
date results required by:

Time Dependant

Please Tick Box

BOD ☐

MICRO ☐

Comments / Special Instructions:
Please include any known or suspected hazards contained in the samples.

Sample Receipt (Driver) O'Connor

Date: **Time:** **Temp:**

Received by: **No of coolerboxes:**

Sample Receipt (Laboratory)

Date: **Time:**

Received by: **No of coolerboxes:**

Chain of Custody No: 89005

GEOTRACE ANALYSIS REQUEST FORM AND SAMPLE CUSTODY SHEET

ALcontrol Laboratories

c/o Aramex, Bellinstown, Ballyboughal
Co. Dublin, Ireland

Tel: 01 8433033

Client: Malone O Regan
Address: Unit 2B Richview office park, Clonskeagh Dublin 14
Invoice address if different
Tel: 01 260 2655 Fax:
Project/Site Name: Powerstown
Project Code: E1024
Contact Name: Claire Clifford
E-mail: cclifford@morce.ie

Date Samples Despatched: 28/01/14
Sampler: D. Dwyer, J. McCann
Email Schedule to: c.clifford@morce.ie
E-mail Results to: cclifford@morce.ie, d.dwyer@morce.ie
Job Continuation - yes / no
P.O. Number:
Quote Number: 37804

Sheet 1
of 1

Report Format
Standard ________

Suite Name/Analysis Required: Ammonia, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, Iron, Potassium, Sodium, Phosphorus, Aluminium, Arsenic, Cadmium, Chromium, Copper, Mercury, Manganese, Nickel, Lead, Selenium, Zinc

Date of Sampling:	Sample Ref. ID	Depth in metres	Sample Preservation Y/N	(S)oil or (W)ater (specify if other	Samples Concentration Low, Medium or High (L,M,H)
28/01/14	RCA 1			W	
	RCA 2			W	
	GW 1			W	
	GW 2			W	
	GW 3			W	
	BH 1			W	
	BH 2			W	
	BH 3			W	
	GW 8			W	

Turnaround - please tick
7 day t/a ________
5 day t/a ________
3 day t/a ________
1 day t/a ________
date results required by: ________

Time Dependant
Please Tick Box
BOD ☐
MICRO ☐

Comments / Special Instructions:
Please include any known or suspected hazards contained in the samples.

* All Samples To be analysed for parameters listed *

Sample Receipt (Driver) CO Conlon

Date: **Time:** **Temp:**

Received by: **No of coolerboxes:**

Sample Receipt (Laboratory)

Date: **Time:**

Received by: **No of coolerboxes:**

APPENDIX B

ALcontrol Laboratories

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: mkt@alcontrol.com
Website: www.alcontrol.com

Malone O'Regan
2b Richview
Office Park
Clonskeagh
Dublin
Dublin 14

Attention: David Dwyer

CERTIFICATE OF ANALYSIS

Date:	01 May 2014
Customer:	D_MOREG_DUB
Sample Delivery Group (SDG):	131130-19
Your Reference:	E1024
Location:	POWERSTOWN
Report No:	268589

This report has been revised and directly supersedes 261440 in its entirety.

We received 7 samples on Friday November 29, 2013 and 7 of these samples were scheduled for analysis which was completed on Friday December 06, 2013. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan

Operations Manager

Alcontrol Laboratories is a trading division of ALcontrol UK Limited
Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No.

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
8507187	SW 1			29/11/2013
8507188	SW 2			29/11/2013
8507190	SW 3			29/11/2013
8507191	SW 4			29/11/2013
8507192	SW 5			29/11/2013
8507193	SW 6			29/11/2013
8507194	SW 7			29/11/2013

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

Validated

SDG:	131130-19	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268589
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261440

LIQUID

Results Legend

- X **Test**
- N **No Determination Possible**

	Lab Sample No(s)		8507187		8507188		8507190		8507191		8507192		8507193		8507194	
	Customer Sample Reference		SW 1		SW 2		SW 3		SW 4		SW 5		SW 6		SW 7	
	AGS Reference															
	Depth (m)															
	Container		500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 7		X		X		X		X		X		X		X
Anions by Kone (w)	All	NDPs: 0 Tests: 7	X		X		X		X		X		X		X	
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 7	X		X		X		X		X		X		X	
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 7	X		X		X		X		X		X		X	
Suspended Solids	All	NDPs: 0 Tests: 7	X		X		X		X		X		X		X	

Validated

CERTIFICATE OF ANALYSIS

SDG:	131130-19	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268589
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261440

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

Customer Sample R			SW 1	SW 2	SW 3	SW 4	SW 5	SW 6
Depth (m)			.	.	.	.	.	.
Sample Type			Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled			29/11/2013	29/11/2013	29/11/2013	29/11/2013	29/11/2013	29/11/2013
Sample Time			.	.	.	.	.	.
Date Received			29/11/2013	29/11/2013	29/11/2013	29/11/2013	29/11/2013	29/11/2013
SDG Ref			131130-19	131130-19	131130-19	131130-19	131130-19	131130-19
Lab Sample No.(s)			8507187	8507188	8507190	8507191	8507192	8507193
AGS Reference								
Component	**LOD/Units**	**Method**						
Suspended solids, Total	<2 mg/l	TM022	<2 #	<2 #	<2 #	<2 #	<2 #	2.5 #
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #	<0.3 #	<0.3 #	<0.3 #	<0.3 #
Manganese (diss.filt)	<0.04 µg/l	TM152	7.65 #	4.1 #	4.63 #	4.14 #	5.12 #	34.1 #
Chloride	<2 mg/l	TM184	23.7 #	23.5 #	30 #	29.7 #	29.5 #	24.2 #
Sodium (diss.filt)	<0.076 mg/l	TM228	9.77 #	10 #	13.5 #	13.6 #	13.5 #	11.4 #
Potassium (diss.filt)	<1 mg/l	TM228	2.52 #	2.49 #	2.5 #	2.52 #	2.63 #	2.81 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #	0.057 #

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG: 131130-19
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268589
Superseded Report: 261440

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

Customer Sample R	SW 7
Depth (m)	.
Sample Type	Water(GW/SW)
Date Sampled	29/11/2013
Sample Time	.
Date Received	29/11/2013
SDG Ref	131130-19
Lab Sample No.(s)	8507194
AGS Reference	

Component	LOD/Units	Method	SW 7					
Suspended solids, Total	<2 mg/l	TM022	3 #					
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2 #					
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #					
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #					
Manganese (diss.filt)	<0.04 µg/l	TM152	39.5 #					
Chloride	<2 mg/l	TM184	24.3 #					
Sodium (diss.filt)	<0.076 mg/l	TM228	11.8 #					
Potassium (diss.filt)	<1 mg/l	TM228	2.99 #					
Iron (diss.filt)	<0.019 mg/l	TM228	0.0547 #					

SDG:	131130-19	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268589
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261440

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
TM022	Method 2540D, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part120 1981;BS EN 872	Determination of total suspended solids in waters		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

CERTIFICATE OF ANALYSIS

SDG:	131130-19	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268589
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261440

Test Completion Dates

Lab Sample No(s)	8507187	8507188	8507190	8507191	8507192	8507193	8507194
Customer Sample Ref.	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7
AGS Ref.							
Depth							
Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Ammoniacal Nitrogen	05-Dec-2013	05-Dec-2013	05-Dec-2013	05-Dec-2013	05-Dec-2013	05-Dec-2013	05-Dec-2013
Anions by Kone (w)	06-Dec-2013	06-Dec-2013	06-Dec-2013	06-Dec-2013	06-Dec-2013	06-Dec-2013	06-Dec-2013
Dissolved Metals by ICP-MS	04-Dec-2013	04-Dec-2013	04-Dec-2013	04-Dec-2013	04-Dec-2013	04-Dec-2013	04-Dec-2013
Metals by iCap-OES Dissolved (W)	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013
Suspended Solids	04-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013	03-Dec-2013

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

Sample Deviations

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than : -

Trace -Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

ALcontrol Laboratories

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Malone O'Regan
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Dublin 14

Attention: David Dwyer

CERTIFICATE OF ANALYSIS

Date:	30 April 2014
Customer:	D_MOREG_DUB
Sample Delivery Group (SDG):	131214-64
Your Reference:	E1024
Location:	POWERSTOWN
Report No:	268411

We received 16 samples on Friday December 13, 2013 and 16 of these samples were scheduled for analysis which was completed on Monday December 23, 2013. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

ilac-MRA
UKAS TESTING
1291

SDG: 131214-64
Job: D_MOREG_DUB-94
Client Reference: E1024
Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer
Order Number:
Report Number: 268411
Superseded Report:

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
8593653	BH1			13/12/2013
8593654	BH2			13/12/2013
8593655	BH3			13/12/2013
8593657	GW1			13/12/2013
8593658	GW2			13/12/2013
8593659	GW3			13/12/2013
8593656	GW8			13/12/2013
8593660	RCA1			13/12/2013
8593661	RCA2			13/12/2013
8593662	SW1			13/12/2013
8593663	SW2			13/12/2013
8593664	SW3			13/12/2013
8593665	SW4			13/12/2013
8593666	SW5			13/12/2013
8593667	SW6			13/12/2013
8593668	SW7			13/12/2013

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

SDG: 131214-64
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268411
Superseded Report:

LIQUID

Results Legend

X **Test**

N **No Determination Possible**

Lab Sample No(s)			8593653		8593654		8593655		8593657		8593658		8593659		8593656		8593660		8593661		8593662		8593663		8593664		8593665		8593666		8593667		8593668	
Customer Sample Reference			BH1		BH2		BH3		GW1		GW2		GW3		GW8		RCA1		RCA2		SW1		SW2		SW3		SW4		SW5		SW6		SW7	
AGS Reference																																		
Depth (m)																																		
Container			1l Glass bottle (ALE	NaOH (ALE245)	1l Glass bottle (ALE	NaOH (ALE245)	1l Glass bottle (ALE	NaOH (ALE245)	0.5l glass bottle (AL	NaOH (ALE245)	0.5l glass bottle (AL	NaOH (ALE245)	1l Glass bottle (ALE	NaOH (ALE245)	0.5l glass bottle (AL	NaOH (ALE245)	1lplastic (ALE221)	NaOH (ALE245)	1l Glass bottle (ALE	NaOH (ALE245)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)	500ml Plastic (ALE2	H2SO4 (ALE244)
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 16	X		X		X		X		X		X		X		X		X			X		X		X		X		X		X		X
Anions by Kone (w)	All	NDPs: 0 Tests: 16	X		X		X		X		X		X		X		X		X		X		X		X		X		X		X		X	
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 16	X		X		X		X		X		X		X		X		X		X		X		X		X		X		X		X	
Fluoride	All	NDPs: 0 Tests: 9	X		X		X		X		X		X		X		X		X															
Mercury Dissolved	All	NDPs: 0 Tests: 9	X		X		X		X		X		X		X		X		X															
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 16	X		X		X		X		X		X		X		X		X		X		X		X		X		X		X		X	
Nitrite by Kone (w)	All	NDPs: 0 Tests: 9		X		X		X		X		X		X		X		X		X														
Suspended Solids	All	NDPs: 0 Tests: 7																			X		X		X		X		X		X		X	

Validated

CERTIFICATE OF ANALYSIS

SDG: 131214-64
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268411
Superseded Report:

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	BH1	BH2	BH3	GW1	GW2	GW3
		Depth (m)	.	.	.	.	.	.
		Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
		Date Sampled	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013
		Sample Time	.	.	.	.	.	.
		Date Received	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013
		SDG Ref	131214-64	131214-64	131214-64	131214-64	131214-64	131214-64
		Lab Sample No.(s)	8593653	8593654	8593655	8593657	8593658	8593659
		AGS Reference						
Component	**LOD/Units**	**Method**						
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	3.33 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #	<0.3 #	3.54 #	<0.3 #	<0.3 #
Fluoride	<0.5 mg/l	TM104	<0.5 #	1.17 #	<0.5 #	<0.5 #	<0.5 #	<0.5 #
Aluminium (diss.filt)	<2.9 µg/l	TM152	<2.9 #	<2.9 #	<2.9 #	<2.9 #	<2.9 #	<2.9 #
Arsenic (diss.filt)	<0.12 µg/l	TM152	0.324 #	0.362 #	0.951 #	0.352 #	0.812 #	0.417 #
Cadmium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #	<0.1 #	<0.1 #	0.145 #	<0.1 #
Chromium (diss.filt)	<0.22 µg/l	TM152	8.2 #	7.13 #	2.55 #	5.73 #	7.48 #	8.35 #
Copper (diss.filt)	<0.85 µg/l	TM152	1.64 #	1.82 #	1.37 #	1.77 #	3.94 #	1.41 #
Lead (diss.filt)	<0.02 µg/l	TM152	0.047 #	0.1 #	0.038 #	0.27 #	0.064 #	0.02 #
Manganese (diss.filt)	<0.04 µg/l	TM152	0.441 #	1.22 #	580 #	1.96 #	141 #	10.1 #
Nickel (diss.filt)	<0.15 µg/l	TM152	2.75 #	2.15 #	3.07 #	3 #	7.1 #	4.3 #
Phosphorus (diss.filt)	<6.3 µg/l	TM152	<6.3 #	19.7 #	<6.3 #	20.2 #	13.9 #	38.9 #
Selenium (diss.filt)	<0.39 µg/l	TM152	1.37 #	1.48 #	0.414 #	1.3 #	1.16 #	1.43 #
Zinc (diss.filt)	<0.41 µg/l	TM152	1.06 #	1.23 #	1.89 #	1.35 #	1.98 #	19.2 #
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01 #	<0.01 #	<0.01 #	<0.01 #	<0.01 #	<0.01 #
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #	<0.05 #	<0.05 #	0.068 #	0.309 #
Chloride	<2 mg/l	TM184	32.8 #	30 #	26.8 #	38.1 #	72.1 #	22.6 #
Nitrate as NO3	<0.3 mg/l	TM184	40 #	39.5 #	<0.3 #	48.3 #	49.1 #	30.5 #
Phosphate (ortho) as P	<0.02 mg/l	TM184	<0.02 #	<0.02 #	<0.02 #	<0.02 #	<0.02 #	0.029 #
Sodium (diss.filt)	<0.076 mg/l	TM228	16.4 #	15.4 #	8.65 #	20.6 #	43 #	10.6 #
Potassium (diss.filt)	<1 mg/l	TM228	2.46 #	3.7 #	1.44 #	7.1 #	8.37 #	2.36 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #

CERTIFICATE OF ANALYSIS

SDG:	131214-64	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268411
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	GW8	RCA1	RCA2	SW1	SW2	SW3
		Depth (m)	.	.	.	.	.	.
		Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
		Date Sampled	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013
		Sample Time	.	.	.	.	.	.
		Date Received	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013	13/12/2013
		SDG Ref	131214-64	131214-64	131214-64	131214-64	131214-64	131214-64
		Lab Sample No.(s)	8593656	8593660	8593661	8593662	8593663	8593664
		AGS Reference						
Component	**LOD/Units**	**Method**						
Suspended solids, Total	<2 mg/l	TM022				<2 #	<2 #	<2 #
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099				<0.2 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #	<0.3 #			
Fluoride	<0.5 mg/l	TM104	<0.5 #	<0.5 #	<0.5 #			
Aluminium (diss.filt)	<2.9 µg/l	TM152	<2.9 #	<2.9 #	<2.9 #			
Arsenic (diss.filt)	<0.12 µg/l	TM152	0.352 #	0.396 #	0.486 #			
Cadmium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #	<0.1 #			
Chromium (diss.filt)	<0.22 µg/l	TM152	7.4 #	2.98 #	9.17 #			
Copper (diss.filt)	<0.85 µg/l	TM152	1.94 #	<0.85 #	1.23 #			
Lead (diss.filt)	<0.02 µg/l	TM152	0.024 #	<0.02 #	<0.02 #			
Manganese (diss.filt)	<0.04 µg/l	TM152	1.4 #	0.115 #	0.446 #	3.21 #	2.14 #	3.51 #
Nickel (diss.filt)	<0.15 µg/l	TM152	2.05 #	2.22 #	1.83 #			
Phosphorus (diss.filt)	<6.3 µg/l	TM152	14.7 #	<6.3 #	22.7 #			
Selenium (diss.filt)	<0.39 µg/l	TM152	1.87 #	1.55 #	1.84 #			
Zinc (diss.filt)	<0.41 µg/l	TM152	1.28 #	1.55 #	0.572 #			
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01 #	<0.01 #	<0.01 #			
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #	<0.05 #			
Chloride	<2 mg/l	TM184	25.1 #	17.2 #	17.1 #	24.5 #	24.2 #	26.9 #
Nitrate as NO3	<0.3 mg/l	TM184	37.9 #	38.6 #	38.4 #			
Phosphate (ortho) as P	<0.02 mg/l	TM184	<0.02 #	<0.02 #	<0.02 #			
Sodium (diss.filt)	<0.076 mg/l	TM228	12.5 #	9.05 #	9.14 #	11.3 #	11.2 #	11.6 #
Potassium (diss.filt)	<1 mg/l	TM228	3.59 #	2.25 #	2.26 #	2.38 #	2.88 #	2.58 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #

Validated

CERTIFICATE OF ANALYSIS

SDG: 131214-64
Job: D_MOREG_DUB-94
Client Reference: E1024
Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer
Order Number:
Report Number: 268411
Superseded Report:

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	SW4	SW5	SW6	SW7		
		Depth (m)	.	.	.	.		
		Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
		Date Sampled	13/12/2013	13/12/2013	13/12/2013	13/12/2013		
		Sample Time	.	.	.	.		
		Date Received	13/12/2013	13/12/2013	13/12/2013	13/12/2013		
		SDG Ref	131214-64	131214-64	131214-64	131214-64		
		Lab Sample No.(s)	8593665	8593666	8593667	8593668		
		AGS Reference						
Component	**LOD/Units**	**Method**						
Suspended solids, Total	<2 mg/l	TM022	<2 #	<2 #	2 #	<2 #		
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #		
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #		
Manganese (diss.filt)	<0.04 µg/l	TM152	2.81 #	2.87 #	24 #	24.3 #		
Chloride	<2 mg/l	TM184	27.2 #	27.2 #	26.8 #	26.7 #		
Sodium (diss.filt)	<0.076 mg/l	TM228	11.9 #	12.6 #	12.5 #	13.8 #		
Potassium (diss.filt)	<1 mg/l	TM228	2.65 #	2.94 #	3.61 #	3.93 #		
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	0.0266 #	0.0267 #		

SDG:	131214-64	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268411
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample ¹	Surrogate Corrected
TM022	Method 2540D, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part120 1981;BS EN 872	Determination of total suspended solids in waters		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM104	Method 4500F, AWWA/APHA, 20th Ed., 1999	Determination of Fluoride using the Kone Analyser		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		

¹ Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

Test Completion Dates

Lab Sample No(s)	8593653	8593654	8593655	8593657	8593658	8593659	8593656	8593660	8593661	8593662
Customer Sample Ref.	BH1	BH2	BH3	GW1	GW2	GW3	GW8	RCA1	RCA2	SW1
AGS Ref.										
Depth										
Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Ammoniacal Nitrogen	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013
Anions by Kone (w)	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	21-Dec-2013	20-Dec-2013
Dissolved Metals by ICP-MS	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	20-Dec-2013	20-Dec-2013	23-Dec-2013	20-Dec-2013	20-Dec-2013
Fluoride	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	
Mercury Dissolved	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013	18-Dec-2013	19-Dec-2013	19-Dec-2013	
Metals by iCap-OES Dissolved (W)	17-Dec-2013	17-Dec-2013	17-Dec-2013	17-Dec-2013	17-Dec-2013	17-Dec-2013	18-Dec-2013	17-Dec-2013	17-Dec-2013	17-Dec-2013
Nitrite by Kone (w)	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	18-Dec-2013	
Suspended Solids										19-Dec-2013

Lab Sample No(s)	8593663	8593664	8593665	8593666	8593667	8593668
Customer Sample Ref.	SW2	SW3	SW4	SW5	SW6	SW7
AGS Ref.						
Depth						
Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Ammoniacal Nitrogen	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013	23-Dec-2013
Anions by Kone (w)	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013
Dissolved Metals by ICP-MS	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013	20-Dec-2013
Metals by iCap-OES Dissolved (W)	17-Dec-2013	18-Dec-2013	18-Dec-2013	17-Dec-2013	18-Dec-2013	17-Dec-2013
Suspended Solids	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013	19-Dec-2013

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors
employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

Sample Deviations

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
5	Samples exceeded holding time before presevation was performed
§	Sampled on date not provided
♦	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: -

Trace -Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

ALcontrol Laboratories

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Malone O'Regan
2b Richview
Office Park
Clonskeagh
Dublin
Dublin 14

Attention: David Dwyer

CERTIFICATE OF ANALYSIS

Date:	30 April 2014
Customer:	D_MOREG_DUB
Sample Delivery Group (SDG):	140129-43
Your Reference:	E1024
Location:	POWERSTOWN
Report No:	268412

This report has been revised and directly supersedes 261451 in its entirety.

We received 9 samples on Tuesday January 28, 2014 and 9 of these samples were scheduled for analysis which was completed on Wednesday February 05, 2014. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

1291

Alcontrol Laboratories is a trading division of ALcontrol UK Limited
Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No.

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
8760592	BH 1		0.00	28/01/2014
8760593	BH 2		0.00	28/01/2014
8760594	BH 3		0.00	28/01/2014
8760588	GW 1		0.00	28/01/2014
8760589	GW 2		0.00	28/01/2014
8760590	GW 3		0.00	28/01/2014
8760595	GW 8		0.00	28/01/2014
8760586	RCA 1		0.00	28/01/2014
8760587	RCA 2		0.00	28/01/2014

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

SDG: 140129-43
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268412
Superseded Report: 261451

LIQUID

Results Legend

X **Test**

N **No Determination Possible**

Lab Sample No(s)			8760592				8760593				8760594				8760588				8760589				8760590				8760595				8760586				8760587			
Customer Sample Reference			BH 1				BH 2				BH 3				GW 1				GW 2				GW 3				GW 8				RCA 1				RCA 2			
AGS Reference																																						
Depth (m)			0.00				0.00				0.00				0.00				0.00				0.00				0.00				0.00				0.00			
Container			1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)	1lplastic (ALE221)	Dissolved Metals Pr	H2SO4 (ALE244)	NaOH (ALE245)
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 9			X				X				X				X				X				X				X				X				X	
Anions by Kone (w)	All	NDPs: 0 Tests: 9	X				X				X				X				X				X				X				X				X			
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 9	X				X				X				X				X				X				X				X				X			
Fluoride	All	NDPs: 0 Tests: 9	X				X				X				X				X				X				X				X				X			
Mercury Dissolved	All	NDPs: 0 Tests: 9		X				X				X				X				X				X				X				X				X		
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 9	X				X				X				X				X				X				X				X				X			
Nitrite by Kone (w)	All	NDPs: 0 Tests: 9				X				X				X				X				X				X				X				X				X

Validated

CERTIFICATE OF ANALYSIS

SDG:	140129-43	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268412
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261451

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	BH 1	BH 2	BH 3	GW 1	GW 2	GW 3
		Depth (m)	0.00	0.00	0.00	0.00	0.00	0.00
		Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
		Date Sampled	28/01/2014	28/01/2014	28/01/2014	28/01/2014	28/01/2014	28/01/2014
		Sample Time	.	.	.	.	.	.
		Date Received	28/01/2014	28/01/2014	28/01/2014	28/01/2014	28/01/2014	28/01/2014
		SDG Ref	140129-43	140129-43	140129-43	140129-43	140129-43	140129-43
		Lab Sample No.(s)	8760592	8760593	8760594	8760588	8760589	8760590
		AGS Reference						
Component	**LOD/Units**	**Method**						
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	0.551 #	<0.2 #	15.3 #	<0.2 #	<0.2 #
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	0.584 #	<0.3 #	16.2 #	<0.3 #	<0.3 #
Fluoride	<0.5 mg/l	TM104	<0.5 #	<0.5 #	<0.5 #	<0.5 #	<0.5 #	<0.5 #
Aluminium (diss.filt)	<2.9 µg/l	TM152	<2.9 #	<2.9 #	<2.9 #	3.44 #	<2.9 #	<2.9 #
Arsenic (diss.filt)	<0.12 µg/l	TM152	0.274 #	0.384 #	1.23 #	0.487 #	0.546 #	0.302 #
Cadmium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #	<0.1 #	<0.1 #	<0.1 #	<0.1 #
Chromium (diss.filt)	<0.22 µg/l	TM152	3.71 #	3.59 #	3.37 #	4.9 #	3.17 #	3.34 #
Copper (diss.filt)	<0.85 µg/l	TM152	<0.85 #	<0.85 #	<0.85 #	1.83 #	1.53 #	<0.85 #
Lead (diss.filt)	<0.02 µg/l	TM152	<0.02 #	<0.02 #	0.035 #	0.278 #	<0.02 #	0.023 #
Manganese (diss.filt)	<0.04 µg/l	TM152	0.567 #	1.34 #	624 #	101 #	281 #	5.01 #
Nickel (diss.filt)	<0.15 µg/l	TM152	1.92 #	2.2 #	2.98 #	7.29 #	3.64 #	2.28 #
Phosphorus (diss.filt)	<6.3 µg/l	TM152	7.28 #	21.9 #	42.1 #	28.1 #	17.6 #	24.1 #
Selenium (diss.filt)	<0.39 µg/l	TM152	1.42 #	1.51 #	0.711 #	0.613 #	0.534 #	1.34 #
Zinc (diss.filt)	<0.41 µg/l	TM152	<0.41 #	0.933 #	1.6 #	11.4 #	0.795 #	5.78 #
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01 #	<0.01 #	<0.01 #	<0.01 #	<0.01 #	<0.01 #
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #	<0.05 #	<0.05 #	<0.05 #	<0.05 #
Chloride	<2 mg/l	TM184	23.9 #	19.7 #	24.9 #	30.7 #	23.6 #	21.3 #
Nitrate as NO3	<0.3 mg/l	TM184	35.9 #	34 #	<0.3 #	13 #	4.27 #	33.1 #
Phosphate (ortho) as P	<0.02 mg/l	TM184	<0.02 #	<0.02 #	<0.02 #	<0.02 #	<0.02 #	<0.02 #
Sodium (diss.filt)	<0.076 mg/l	TM228	13 #	11.1 #	8.17 #	29.2 #	20.3 #	9.69 #
Potassium (diss.filt)	<1 mg/l	TM228	2.13 #	3.9 #	<1 #	19.6 #	4.55 #	1.52 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.19 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #

17:13:21 30/04/2014

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	140129-43	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268412
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261451

Results Legend	
#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	GW 8	RCA 1	RCA 2			
		Depth (m)	0.00	0.00	0.00			
		Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)			
		Date Sampled	28/01/2014	28/01/2014	28/01/2014			
		Sample Time	.	.	.			
		Date Received	28/01/2014	28/01/2014	28/01/2014			
		SDG Ref	140129-43	140129-43	140129-43			
		Lab Sample No.(s)	8760595	8760586	8760587			
		AGS Reference						
Component	**LOD/Units**	**Method**						
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	0.55 #	<0.2 #	<0.2 #			
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	0.582 #	<0.3 #	<0.3 #			
Fluoride	<0.5 mg/l	TM104	<0.5 #	<0.5 #	<0.5 #			
Aluminium (diss.filt)	<2.9 µg/l	TM152	<2.9 #	<2.9 #	<2.9 #			
Arsenic (diss.filt)	<0.12 µg/l	TM152	0.465 #	0.415 #	0.507 #			
Cadmium (diss.filt)	<0.1 µg/l	TM152	<0.1 #	<0.1 #	<0.1 #			
Chromium (diss.filt)	<0.22 µg/l	TM152	3.59 #	3.57 #	3.85 #			
Copper (diss.filt)	<0.85 µg/l	TM152	<0.85 #	1.1 #	1.06 #			
Lead (diss.filt)	<0.02 µg/l	TM152	<0.02 #	<0.02 #	<0.02 #			
Manganese (diss.filt)	<0.04 µg/l	TM152	0.823 #	0.302 #	0.39 #			
Nickel (diss.filt)	<0.15 µg/l	TM152	2.28 #	2.17 #	2.01 #			
Phosphorus (diss.filt)	<6.3 µg/l	TM152	20.7 #	27.7 #	26.6 #			
Selenium (diss.filt)	<0.39 µg/l	TM152	1.68 #	1.35 #	1.54 #			
Zinc (diss.filt)	<0.41 µg/l	TM152	1.07 #	0.859 #	0.41 #			
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01 #	<0.01 #	<0.01 #			
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #	<0.05 #			
Chloride	<2 mg/l	TM184	20 #	23.5 #	18.8 #			
Nitrate as NO3	<0.3 mg/l	TM184	33.9 #	43.6 #	39 #			
Phosphate (ortho) as P	<0.02 mg/l	TM184	<0.02 #	<0.02 #	<0.02 #			
Sodium (diss.filt)	<0.076 mg/l	TM228	11.3 #	11.8 #	9.74 #			
Potassium (diss.filt)	<1 mg/l	TM228	4.04 #	2.23 #	1.43 #			
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	<0.019 #			

SDG:	140129-43	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268412
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261451

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM104	Method 4500F, AWWA/APHA, 20th Ed., 1999	Determination of Fluoride using the Kone Analyser		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		

[1] Applies to Solid samples only.   DRY indicates samples have been dried at 35°C.   NA = not applicable.

CERTIFICATE OF ANALYSIS

SDG:	140129-43	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268412
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	261451

Test Completion Dates

Lab Sample No(s)	8760592	8760593	8760594	8760588	8760589	8760590	8760595	8760586	8760587
Customer Sample Ref.	BH 1	BH 2	BH 3	GW 1	GW 2	GW 3	GW 8	RCA 1	RCA 2
AGS Ref.									
Depth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Ammoniacal Nitrogen	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	30-Jan-2014	30-Jan-2014
Anions by Kone (w)	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014	04-Feb-2014
Dissolved Metals by ICP-MS	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014
Fluoride	30-Jan-2014	30-Jan-2014	30-Jan-2014	05-Feb-2014	05-Feb-2014	05-Feb-2014	30-Jan-2014	05-Feb-2014	03-Feb-2014
Mercury Dissolved	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014
Metals by iCap-OES Dissolved (W)	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014
Nitrite by Kone (w)	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors
employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

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Asbestos Type	Common Name
Chrysotile	White Asbestos
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Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: -
Trace -Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

ALcontrol Laboratories

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Malone O'Regan
2b Richview
Office Park
Clonskeagh
Dublin
Dublin 14

Attention: David Dwyer

CERTIFICATE OF ANALYSIS

Date:	01 May 2014
Customer:	D_MOREG_DUB
Sample Delivery Group (SDG):	140129-46
Your Reference:	E1024
Location:	POWERSTOWN
Report No:	268590

We received 4 samples on Tuesday January 28, 2014 and 4 of these samples were scheduled for analysis which was completed on Wednesday February 05, 2014. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

UKAS TESTING
1291

SDG:	140129-46	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268590
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
8760744	SW 1		0.00	28/01/2014
8760747	SW 2		0.00	28/01/2014
8760749	SW 3		0.00	28/01/2014
8760752	SW 4		0.00	28/01/2014

Only received samples which have had analysis scheduled will be shown on the following pages.

Validated

CERTIFICATE OF ANALYSIS

SDG: 140129-46
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268590
Superseded Report:

LIQUID

Results Legend

- X **Test**
- N **No Determination Possible**

Lab Sample No(s)			8760744		8760747		8760749		8760752	
Customer Sample Reference			SW 1		SW 2		SW 3		SW 4	
AGS Reference										
Depth (m)			0.00		0.00		0.00		0.00	
Container			1lplastic (ALE221)	H2SO4 (ALE244)	1lplastic (ALE221)	H2SO4 (ALE244)	1lplastic (ALE221)	H2SO4 (ALE244)	1lplastic (ALE221)	H2SO4 (ALE244)
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 4		X		X		X		X
Anions by Kone (w)	All	NDPs: 0 Tests: 4	X		X		X		X	
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 4	X		X		X		X	
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 4	X		X		X		X	
Suspended Solids	All	NDPs: 0 Tests: 4	X		X		X		X	

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG: 140129-46
Job: D_MOREG_DUB-94
Client Reference: E1024

Location: POWERSTOWN
Customer: Malone O'Regan
Attention: David Dwyer

Order Number:
Report Number: 268590
Superseded Report:

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

Customer Sample R	SW 1	SW 2	SW 3	SW 4		
Depth (m)	0.00	0.00	0.00	0.00		
Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
Date Sampled	28/01/2014	28/01/2014	28/01/2014	28/01/2014		
Sample Time	.	.	.	.		
Date Received	28/01/2014	28/01/2014	28/01/2014	28/01/2014		
SDG Ref	140129-46	140129-46	140129-46	140129-46		
Lab Sample No.(s)	8760744	8760747	8760749	8760752		
AGS Reference						

Component	LOD/Units	Method	SW 1	SW 2	SW 3	SW 4		
Suspended solids, Total	<2 mg/l	TM022	4 #	6.5 #	10 #	3 #		
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #		
Ammoniacal Nitrogen as NH3	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	<0.2 #		
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3 #	<0.3 #	<0.3 #	<0.3 #		
Manganese (diss.filt)	<0.04 µg/l	TM152	9.09 #	8.19 #	8.77 #	9.07 #		
Chloride	<2 mg/l	TM184	25.9 #	26.4 #	29 #	28.6 #		
Sodium (diss.filt)	<0.076 mg/l	TM228	12.4 #	12.3 #	13.9 #	14.1 #		
Potassium (diss.filt)	<1 mg/l	TM228	3.1 #	3.04 #	3.17 #	3.32 #		
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	<0.019 #	<0.019 #	<0.019 #		

SDG:	140129-46	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268590
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
TM022	Method 2540D, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part120 1981;BS EN 872	Determination of total suspended solids in waters		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

SDG:	140129-46	**Location:**	POWERSTOWN	**Order Number:**	
Job:	D_MOREG_DUB-94	**Customer:**	Malone O'Regan	**Report Number:**	268590
Client Reference:	E1024	**Attention:**	David Dwyer	**Superseded Report:**	

Test Completion Dates

Lab Sample No(s)	8760744	8760747	8760749	8760752
Customer Sample Ref.	SW 1	SW 2	SW 3	SW 4
AGS Ref.				
Depth	0.00	0.00	0.00	0.00
Type	LIQUID	LIQUID	LIQUID	LIQUID
Ammoniacal Nitrogen	30-Jan-2014	31-Jan-2014	30-Jan-2014	31-Jan-2014
Anions by Kone (w)	04-Feb-2014	05-Feb-2014	05-Feb-2014	04-Feb-2014
Dissolved Metals by ICP-MS	31-Jan-2014	31-Jan-2014	31-Jan-2014	31-Jan-2014
Metals by iCap-OES Dissolved (W)	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014
Suspended Solids	30-Jan-2014	30-Jan-2014	30-Jan-2014	30-Jan-2014

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors
employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

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Asbestos

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The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

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Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
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Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than:
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Trace -Where only one or two asbestos fibres were identified.

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APPENDIX C

ENVIRONMETNAL RISK ASSESSMENT

Risk Assessment - Controlled Waters (P20)

Powerstown Landfill & Civic Amenity Site

Carlow County Council

May 2014

Risk Assessment - Controlled Waters (P20)

Powerstown Landfill & Civic Amenity Site
Carlow County Council

May 2014

Contents

Tables

Attachments

1.0 INTRODUCTION

A detailed environmental site assessment was undertaken by Malone O'Regan (MOR) at the Powerstown Landfill site, Co. Carlow. The Generic Quantitative Risk Assessment (GQRA) for the site identified all transport mechanisms pathways and environmental receptors which warranted further assessment in a Detailed Quantitative Risk Assessment (DQRA) for the site. This report presents the findings of the DQRA for potential environmental exposure pathways associated with the presence of contaminants in the gravel aquifer and migration of impacted groundwater offsite to the Powerstown Stream, the River Barrow and the gravel aquifer.

1.1 Project Objective

The overall objective of this report was to specifically address the risks associated with impacted groundwater at the site through the following pollutant linkages:

- Risk to the River Barrow from migration of impacted groundwater within the sand and gravel to the River Barrow.

- Risk to Powerstown Stream from migration of impacted groundwater within the sand and gravel to the Powerstown Stream.

- Risk to groundwater within both the sand and gravel aquifer and bedrock aquifer.

- Derive groundwater compliance points and values that are protective of the identified receptors.

1.2 Scope of Work

The scope of work undertaken to meet the project objectives comprised the following elements and activities:

- Review the Conceptual Site Model (CSM) based on the Tier 1 Risk Assessment and identification of plausible environmental receptors at risk through the migration of impacted groundwater down hydraulic gradient of the site.

- Develop a site specific risk assessment model to determine if there are any potential risks associated with the migration of impacted groundwater down hydraulic gradient of the site.

- Derive site specific risk-based groundwater compliance locations and values.

- Presentation of the findings of this component of the Tier 2 QRA in a comprehensive report which will support the overall Tier 2 QRA report for the site.

1.3 Limitations

No particular difficulties or limitations were encountered.

The content of this report is based on the available information provided by historic site investigation reports, desk based studies and the information obtained from analytical results of soil, groundwater, and hydrogeological testing. All work carried out in preparing this report has utilised and is based on MOR professional knowledge and understanding of the current relevant Irish and European Community standards, codes and legislation.

2.0 CONCEPTUAL SITE MODEL

The risk based approach for this assessment involved the development of a conceptual site model (CSM) to identify the potential risks and contaminant linkages for the existing site setting whereby contaminant sources, migration and transport pathways and receptors are identified. If one or more of these three elements are missing, the exposure pathway is considered incomplete and there is no risk associated with the site or activity. However, if all three elements are present and the exposure pathways are complete, the risk should be evaluated.

The revised CSM from the Generic Quantitative Risk Assessment was used as the basis for the CSM used for this assessment. The source, pathway and receptor components used for this controlled waters risk assessment are set out in the following sections.

2.1 Sources

Based on the findings of the GQRA, the following on-site source have been identified at the site:

- Ammonia and chloride are present in groundwater within the gravel aquifer located downgradient of Phase Two and Phase Three and to a lesser extend Phase One of the landfill site.

- The extent of the groundwater source area has been broadly delineated within the gravel aquifer and it is considered that the original source is landfill leachate that has migrated into the gravel aquifer beneath the site however the specific source and migration pathway into the aquifer is unknown.

- This identified sources of ammonia and chloride in the groundwater warrant further assessment and is therefore evaluated in this controlled water risk assessment using the P20 method.

2.2 Pathways

The following pathways have been considered as potential contaminant linkages between the identified contaminant sources and receptors:

- Lateral migration of the identified contaminants of potential concern (COPC) in groundwater within the gravel aquifer towards the Powerstown Stream.
- Lateral migration of the identified COPC in groundwater within the gravel aquifer towards the River Barrow.

2.3 Receptors

The following receptors have been considered for this controlled waters risk assessment:

- The Powerstown Stream, located approximately 5 meters (m) from the site boundary.
- The River Barrow, a designated Special Area of Conservation (SAC), located approximately 400m west of the site boundary.
- The regionally important gravel aquifer with a high vulnerability rating present beneath the Powerstown landfill site.

2.4 Pollutant Linkages

The following pollutant linkages have been considered for this controlled waters risk assessment:

- Migration of dissolved phase contamination downgradient in groundwater of the gravel aquifer to the Powerstown Stream.
- Migration of dissolved phase contamination downgradient in groundwater of the gravel aquifer to the River Barrow.
- Migration of dissolved phase contamination downgradient in groundwater to the offsite regionally important gravel aquifer.

3.0 METHODOLOGY

3.1 Model Selection

The UK Environment Agency's (EA) Remedial Target Worksheet v.3.1 (commonly referred to as "P20" model) was used for the purposes of this risk assessment. This worksheet calculates solutions to equations presented in the EA publication "Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination" (EA, 2006). It provides an update to earlier versions which were developed to support the framework set out in the EA document "Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources" (EA, 1999).

The P20 model can be used to predict the dissolved phase concentrations of contaminants at a compliance point from measured on-site soil or groundwater concentrations (forward modelling) or to back calculate "remedial target values" for soil or groundwater at the site that ensure that a "target value" is not exceeded at the compliance point (reverse modelling). Both approaches have been used for this assessment. For the purposes of this report the remedial target values are referred to as site specific target values (SSTVs). These are Tier 2 assessment criteria that are intended for comparison with measured groundwater concentrations at the site to allow risks to water resources from on-site sources of contamination to be more accurately characterised.

3.1.1 P20 Model - Level 1, 2 & 3

The P20 methodology is based on 3 levels of analysis for the assessment of risks from contamination in soils:

- Level 1 considers the partitioning of contaminants between soil, pore-water and vapour. Level 1 SSTV are based on achieving the target value concentrations in the pore water of the unsaturated zone.
- Level 2 considers dilution by leachate generated in the unsaturated zone mixing with groundwater flowing beneath the site. Level 2 SSTV are based on achieving the target value concentrations in groundwater below the source zone.
- Level 3 considers natural attenuation occurring within the saturated zone between the source area and the compliance point at some distance down hydraulic gradient from the source zone.

For the purposes of this report Level 3 analysis has been used for assessing risks from concentrations of contaminants in groundwater.

3.1.2 P20 Model Assumptions

The main general assumptions associated with the P20 Model are:

- The aquifer is assumed intergranular, homogeneous and isotropic, i.e. there is no lateral or vertical variation in parameter values;
- Steady state groundwater flow;
- The contaminant source can be represented as a constant term; and
- There is no attenuation of dissolved phase contaminants within the unsaturated zone.

3.2 Derivation of Site Specific Target Values (SSTVs)

The SSTVs are the estimated concentrations of contaminants on-site that would result in groundwater concentrations at the compliance location equal to a selected target value (e.g. groundwater regulation value).

$SSTV_{gw}$ (mg/l) values have been derived for comparison with measured concentrations in groundwater within the gravel aquifer, for the contaminant sources identified at the site based on several compliance distances.

This procedure has also been used as the basis for the selection of the compliance points and values.

3.3 Modelled Contaminants

A number of parameters were identified to exceed the Tier 1 screening for controlled water receptors however not all parameters were included in the P20 modelling assessment including those identified as anomalous occurrences. Following a comprehensive review of all available analytical data the COPCs considered in this controlled water assessment are:

- Ammonia; and,
- Chloride;

4.0 MODEL PARAMETER INPUT VALUES

The parameter values for the P20 Model can be divided into two types, contaminant specific and non-contaminant specific. The modelled values for non-contaminant specific parameters and contaminant specific parameters are presented in the following tables together with a justification for choice of these values. Where possible, site specific values have been used. Source areas for identified contaminant plumes are also detailed below.

4.1 Contaminant Properties and Target Values

Contaminant target values and physical-chemical properties used for the P20 modelling are shown in Table 1.

Table 4.1: Contaminant Specific Parameter Values used in P20 Model

COPC	Target Concentration Powerstown Stream	Target Concentration River Barrow (SAC)	Target Concentration Sand & Gravel Aquifer	Soil Water Partition Coefficient (Kd)	Half-life degradation
	mg/L	mg/L	mg/L	L/kg	Days
Ammonia	0.065(1)	0.065(1)	0.065 (2)	0.9 (3)	1095 (4)
Chloride	50(5)	50(5)	187.5(2)	0.0	1E+99

Notes:
1 Surface Water Regulation 2009 (SI 272 of 2009) as amended in 2012 (SI 327 of 2012)
2 Groundwater Regulation 2010 (SI 9 of 2010), as amended 2012 (SI 149 of 2012)
3 EA 2003 - NGWCLC table 4.1, Max value for clean sands and gravels
4 EA 2003 - NGWCLC table 4.2, Mid-range value for sands/gravels under aerobic conditions
5 Fehily Timoney & Co. 2005 – Powerstown Landfill Surface Water Trigger Report. Trigger Level for Powerstown Stream.

4.2 Non-Contaminant Specific Parameters

Non-contaminant properties required for the P20 Model were primarily site specific however in some instances published data were used. The parameter values used in the model and the justification for each value are presented in Table 2, together with source area details for the identified COPC.

Table 4.2: Non contaminant Specific Parameter Values used in P20 Model (SSTV$_{gw}$)

Parameter	Units	Value	Data Source/Rationale
Level 3			
Source Area	m^2	225	Source area assumed to be groundwater contamination within gravel aquifer from Phase 2 landfill in vicinity of monitoring well GW1.
Plume Width	m	15	Modelled source area in vicinity of GW1. Based on a review on all available groundwater analytical data and available landfill records.
Plume Thickness **Saturated Aquifer Thickness**	m	10	Site specific. Average gravel thickness in plume area (MOR, 2014).
Bulk density of aquifer materials	g/cm^3	1.34	Literature Value (Irish Journal of Agricultural and Food Research 44: 83–94, 2005).
Effective Porosity of aquifer materials	Fraction	0.27	Literature Value. Midrange for sand/gravel, (Fetter, 2001).
Hydraulic Gradient	Fraction	0.003	Site specific. Average gradient in plume area (MOR, 2012, 2014).
Hydraulic Conductivity	m/d	9	Site Specific Data (Slug tests, MOR 2012).

Parameter	Units	Value	Data Source/Rationale
			Representative of gravel aquifer properties of groundwater plume downgradient of the Site.
Compliance Points - Surface Water	m	400	Distance from Site Boundary (GW1) to River Barrow
		5	Distance from Site Boundary to Powerstown Stream
Compliance Points - Groundwater	m	200	Distance from Site Boundary to midway between site boundary and the River Barrow
Longitudinal dispersivity	m	Variable	Longitudinal and transverse dispersivity calculated by P20 model using Xu & Eckstein approach. Vertical dispersivity assumed negligible as plume is assumed to be mixed through saturated thickness of Gravels.
Transverse dispersivity	m	Variable	
Vertical dispersivity	m	1E-99	
Degradation option	-	Degradation option applied to pollutants in all phases	Groundwater level fluctuation will promote aerobic degradation of sorbed contamination.

5.0 RESULTS

5.1 Plume Length

The extent of the plume is the distance from the site boundary at which groundwater concentrations are predicted to meet the relevant target values set in the P20 model including groundwater threshold values and surface water quality standards.

Using the P20 model, the following plume lengths were calculated:

- Ammonia plume in excess of 0.065mg/l: 150m from downgradient onsite wells
- Chloride plume length in excess of 187.5mg/l: 25m downgradient onsite wells

The P20 model is inherently conservative the actual plume extent off-site is likely to be notably less than that modelled.

5.2 Groundwater Migration Offsite

Using the P20 model as set of site-specific target values (SSTVs) were derived that are protective of specified receptors at risk from the migration of impacted groundwater from the site at a specified compliance distance from the site. The derived SSTVs for groundwater are shown in Table 3.

Table 5.1: Derived SSTV$_{gw}$ for Surface Water Receptors

Contaminant	SSTV$_{gw}$ Powerstown Stream	SSTV$_{gw}$ for River Barrow			
	GW1/GW2	GW1	BH1/ BH2	BH3	GW8
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Ammonia	0.07	21200	5170	512	10500
Chloride	50	219	200	167	210

Table 5.2: Derived SSTV$_{gw}$ for Groundwater Receptors

Contaminant	SSTV$_{gw}$ for Gravel Aquifer			
	GW1	BH1/ BH2	BH3	GW8
	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Ammonia	62	13	0.81	28.5
Chloride	512	423	265	468

The reported concentrations for ammonia and chloride were below the applicable SSTVs for gravel aquifer receptor with the exception of couple of historical chloride results for GW1. However as the reported results were below the SSTVs for downgradient monitoring locations (i.e. BH1 and BH2) it is considered that there these SSTVs are sufficiently protective of the downgradient aquifer. Accordingly it is considered that there is no unacceptable risk for the gravel aquifer downgradient of the site.

The maximum reported groundwater concentrations of ammonia and chloride were below the SSTVs for the River Barrow and therefore it is considered that there is no unacceptable risk for the receiving water in the River Barrow.

The maximum measured groundwater concentration of ammonia and chloride exceeded the SSTV for the Powerstown Stream receptor however the maximum chloride concentration was below the SSTV. Accordingly this pollutant linkage should be further evaluated.

A 'calibration' of the P20 results has been performed in order to evaluate the level of conservatism in the P20 results for this particular hydrogeological site setting a by comparing the P20 predicted concentrations in the downgradient aquifer with measured concentrations of ammonia and chloride. As such is the P20 model is considered to have over-predicted concentrations of modelled contaminants in the downgradient aquifer compared with measured concentrations at monitoring well locations downgradient of the site. These comparisons are summarised in Table 4.

Table 5.3: Comparison of Predicted and Measured Concentrations

Contaminant	Predicted Concentration at BH1/BH2	Maximum Measured Concentration at BH1/BH2	Over-prediction Factor
	mg/L	mg/L	
Ammonia	1.87	1.1	1.7
Chloride	176	32.8	5

Therefore it is considered that the derived SSTVs for groundwater are conservative and therefore protective of the identified groundwater and surface water receptors.

5.3 Groundwater Compliance Values

The P20 model was used to derive a set of compliance values based on the SSTVs derived for specific compliance points which in this case are the groundwater monitoring wells at the downgradient site boundary. The derived compliance values are shown in Table 4.

Table 5.4: Selected Groundwater Compliance Values

Contaminant	Selected Compliance Value (mg/l)		
	BH1/ BH2 (mg/l)	BH3 (mg/l)	GW8 (mg/l)
Ammonia	13	0.8	28.5
Chloride	200	167	210

6.0 SENSITIVITY ANALYSIS

Sensitivity analysis was carried out in accordance with 'Section 8.4 Sensitivity Analysis' of EA guidance on using the P20 mode; 'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination' (EA, 2006).

6.1 Validity of Model

The P20 model uses the Ogata Banks or Domenico equations to simulate dissolved phase migration in the aquifer. These are analytical equations that predict contaminant concentration at any point in the aquifer down hydraulic gradient of a source. The equations assume that the aquifer is homogenous and that groundwater flow is isotropic, intergranular and at steady state.

6.2 Model Parameters

The influence of uncertainty in the model parameters on the model results has been tested by varying key parameters between realistic limits and observing how this affects the SSTVs for ammonia. This parameter has been chosen as it is considered to be the key COPC.

The results of the sensitivity analysis are presented with respect to the groundwater SSTVs in Table 6.

Table 6.1: Sensitivity Analysis of P20 Model for $SSTV_{gw}$

Parameter	Parameter value			Justification	$SSTV_{gw}$ (mg/L)		
	Min (1)	Max (2)	Used (3)		(1)	(2)	(3)
Bio-degradation half-life (d)	365	2190	1095	Min and max literature values represent a reasonable range	1.07E-01	7.08E-02	7.71E-02
Width of plume (m)	7	30	15	Min and max = 50% and 200% of used value	7.71E-02	7.71E-02	7.71E-02
Thickness of plume (m) / Saturated aquifer thickness (m)	5	15	10	Min and max based on Literature Values for this Gravel aquifer.	7.71E-02	7.71E-02	7.71E-02
Bulk density (g/cm^3)	1.15	1.54	1.34	Min and max literature values represent a reasonable range	7.56E-02	7.87E-02	7.71E-02
Effective porosity	0.07	0.34	0.27	Min and max literature values represent a reasonable range	7.55E-02	7.78E-02	7.71E-02
Hydraulic Gradient	1.9E-03	4.7E-03	3.0E-03	Min and max values based on site specific data	8.51E-02	7.26E-02	7.71E-02
Hydraulic Conductivity (m/d)	3.74E+00	8.22E+01	9.12E+00	Min and max values based on site specific data	9.77E-02	6.62E-02	7.71E-02
Kd (l/mg)	0.45	1.8	0.9	Min and max = 50% and 200% of used value	7.19E-02	8.83E-02	7.71E-02

Table 6 indicates that the groundwater model is sensitive to changes in a number of parameters. The parameters recording a variation greater than 25% are discussed below:

- **Bio-degradation half-life.** Decreasing this parameter to the minimum literature value results in increasing the SSTV by approximately 38%. Increasing this parameter to the maximum literature value reduces the SSTV by approximately 8%.

- **Hydraulic conductivity.** Decreasing this parameter to the minimum site data value results in increasing the SSTV by approximately 30%. Increasing this parameter to the maximum site data value reduces the SSTV by approximately 14%.

The results of this uncertainty analysis demonstrate that the $SSTV_{gw}$ are quite sensitive to bio-degradation half-life and hydraulic conductivity. However the selected bio-degradation half-life value represents the mid-range literature value for sands/gravels under aerobic conditions and is therefore considered to be suitably conservative whilst also being suitably representative of site conditions.

The hydraulic conductivity values used in the model are site specific. The value selected is an average value based on the results of in-situ permeability tests completed on a well installed across the gravel and the top of weathered bedrock in the modelled plume area, and is therefore considered to be suitably representative of the modelled aquifer conditions.

7.0 CONCLUSIONS

Based on the results of this controlled waters risk assessment that was carried out in accordance with best practice requirements including the UK Environment Agency's P20 model, it is reasonable to conclude the following:

- The receptors evaluated in this controlled water risk assessment were the Powerstown Stream and the River Barrow, located down gradient of the site, and the sand and gravel aquifer located beneath the site and down gradient of the site.

- There is no identified risk to the River Barrow, located approximately 400m down gradient of the site, associated with the identified concentrations of ammonia and chloride within the impacted groundwater migrating offsite.

- There is a potential risk to the Powerstown Stream located approximately 5m from the site, however it could not be confirmed based on the available dataset if there is a direct hydraulic connection between groundwater migrating from the site and the stream.

- There is no identified risk to the sand and gravel aquifer downgradient of the site associated with the current site condition.

- Compliance monitoring locations and values have been derived that are protective of the identified receptors and should be used to evaluate future groundwater conditions at the site.

8.0 REFERENCES

Environmental Agency (EA), 2009. Science Report SC050021/SR3: Updated technical background to the CLEA Model. EA, Bristol.

Environment Agency (EA), 2006. Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination. EA, Bristol.

Environment Agency (EA), 2003. Review of the Fate and Transport of Selected Soil Contaminants in the Soil Environment. Draft Technical Report P5- 079/TR1

Fehily Timoney & Co, 2005. Powerstown Landfill Surface Water Trigger Report.

Fetter, C.W., 2001. Applied Hydrogeology. Prentice Hall, 4th Edition.

Irish Journal of Agricultural and Food Research 44: 83–94, 2005

National Groundwater and Contaminated Land Centre (NGWCLC), 2003. Review of ammonium attenuation in soil and groundwater. Report NC/02/49

Statutory Instruments, 2009. (S.1. No. 272 of 2009): European Communities Environmental Objectives (Surface Waters) Regulations. Statutory Instruments, Ireland.

Statutory Instruments, 2012. (S.1. No. 327 of 2012): European Communities Environmental Objectives (Surface Waters) Regulations. Statutory Instruments, Ireland.

Statutory Instruments, 2010. (S.1. No. 9 of 2010): European Communities European Communities Environmental Objectives (Groundwater) Regulations. Statutory Instruments, Ireland.

Statutory Instruments, 2012. (S.1. No. 149 of 2012): European Communities European Communities Environmental Objectives (Groundwater) Regulations. Statutory Instruments, Ireland.

Attachment 1
P20 Model Outputs

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-May-14**		**Version:**	**1**
Contaminant	**Chloride**			
Target Concentration (C_T)	**187.5**	**mg/l**	**Origin of C_T:**	**Groundwater Regulations 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

Input Parameters	Variable	Value	Unit	Source
Contaminant		**Chloride**		from Level 1
Target Concentration	C_T	**1.88E+02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average Conc at GW2 (MOR CCC 2003-2014)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.50E+02	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.42E+00	m	*see options*
Transverse dispersivity	az	5.42E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.42E+00	1.50E+01	5.42E+00	m
Transverse dispersivity	**az**	5.42E-01	1.50E+00	5.42E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.50E-01	5.42E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

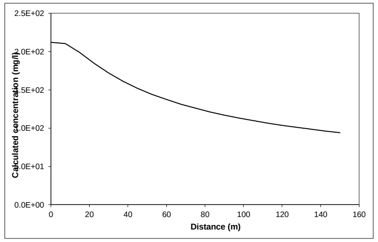
Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.40E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.25E+00**	

Remedial Targets

Remedial Target		**4.23E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**150**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**9.40E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
7.5	**2.10E+02**
15.0	**1.99E+02**
22.5	**1.85E+02**
30.0	**1.72E+02**
37.5	**1.61E+02**
45.0	**1.52E+02**
52.5	**1.44E+02**
60.0	**1.37E+02**
67.5	**1.31E+02**
75.0	**1.26E+02**
82.5	**1.21E+02**
90.0	**1.17E+02**
97.5	**1.13E+02**
105.0	**1.10E+02**
112.5	**1.07E+02**
120.0	**1.04E+02**
127.5	**1.01E+02**
135.0	**9.85E+01**
142.5	**9.62E+01**
150.0	**9.40E+01**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-May-14**		**Version:**	**1**
Contaminant	**Chloride**			
Target Concentration (C_T)	**187.5**	**mg/l**	**Origin of C_T:**	**Groundwater Regulations 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Chloride**		from Level 1
Target Concentration	C_T	**1.88E+02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average conc, GW2 2003 -2014 (MOR CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero Degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.75E+02	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.83E+00	m	*see options*
Transverse dispersivity	az	5.83E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.83E+00	1.75E+01	5.83E+00	m
Transverse dispersivity	**az**	5.83E-01	1.75E+00	5.83E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.75E-01	5.83E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

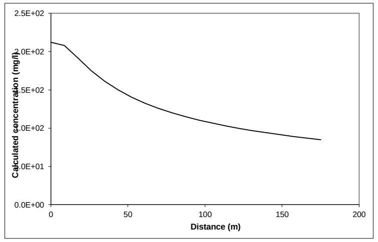
Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	8.49E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.50E+00**	

Remedial Targets

Remedial Target		**4.68E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**175**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**8.49E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
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Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
8.8	**2.08E+02**
17.5	**1.91E+02**
26.3	**1.75E+02**
35.0	**1.61E+02**
43.8	**1.50E+02**
52.5	**1.40E+02**
61.3	**1.32E+02**
70.0	**1.26E+02**
78.8	**1.20E+02**
87.5	**1.15E+02**
96.3	**1.10E+02**
105.0	**1.06E+02**
113.8	**1.03E+02**
122.5	**9.95E+01**
131.3	**9.66E+01**
140.0	**9.38E+01**
148.8	**9.13E+01**
157.5	**8.90E+01**
166.3	**8.69E+01**
175.0	**8.49E+01**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-May-14**		**Version:**	1
Contaminant	**Chloride**			
Target Concentration (C_T)	**187.5**	**mg/l**	**Origin of C_T:**	**Groundwater Regulations 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Chloride		from Level 1
Target Concentration	C_T	**1.88E+02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average Conc at GW2 (MOR CCC 2003-2014)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	2.00E+02	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	6.21E+00	m	*see options*
Transverse dispersivity	az	6.21E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

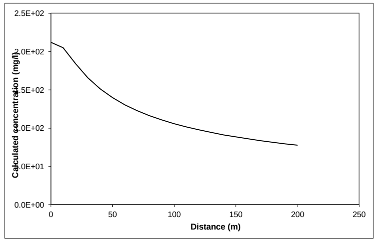
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	6.21E+00	2.00E+01	6.21E+00	m
Transverse dispersivity	**az**	6.21E-01	2.00E+00	6.21E-01	m
Vertical dispersivity	**ay**	1.00E-99	2.00E-01	6.21E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
10.0	**2.05E+02**
20.0	**1.84E+02**
30.0	**1.66E+02**
40.0	**1.51E+02**
50.0	**1.40E+02**
60.0	**1.30E+02**
70.0	**1.23E+02**
80.0	**1.16E+02**
90.0	**1.11E+02**
100.0	**1.06E+02**
110.0	**1.02E+02**
120.0	**9.78E+01**
130.0	**9.44E+01**
140.0	**9.13E+01**
150.0	**8.85E+01**
160.0	**8.60E+01**
170.0	**8.36E+01**
180.0	**8.14E+01**
190.0	**7.94E+01**
200.0	**7.76E+01**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	7.76E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.73E+00**	

Remedial Targets

Remedial Target		**5.12E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**200**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**7.76E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	1
Contaminant	**Chloride**			
Target Concentration (C_T)	**50**	**mg/l**	**Origin of C_T:**	**Site Specific SW Trigger Level, Fehilly & Co., 2005**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)	Variable	Value	Unit	Source
Contaminant		Chloride		from Level 1
Target Concentration	C_T	5.00E+01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average Conc at GW2 (MOR CCC 2003-2014)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	5.00E+00	m	*Distance from Site Boundary to Stream*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	3.50E-01	m	*see options*
Transverse dispersivity	az	3.50E-02	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.12E+02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.00E+00**	

Remedial Targets

Remedial Target		**5.00E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**5**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**2.12E+02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

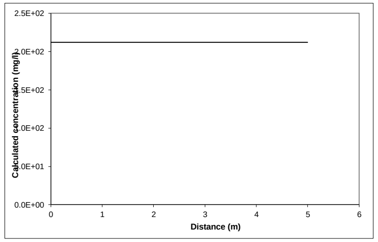
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.50E-01	5.00E-01	3.50E-01	m
Transverse dispersivity	**az**	3.50E-02	5.00E-02	3.50E-02	m
Vertical dispersivity	**ay**	1.00E-99	5.00E-03	3.50E-03	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	2.1E+02
0.3	2.12E+02
0.5	2.12E+02
0.8	2.12E+02
1.0	2.12E+02
1.3	2.12E+02
1.5	2.12E+02
1.8	2.12E+02
2.0	2.12E+02
2.3	2.12E+02
2.5	2.12E+02
2.8	2.12E+02
3.0	2.12E+02
3.3	2.12E+02
3.5	2.12E+02
3.8	2.12E+02
4.0	2.12E+02
4.3	2.12E+02
4.5	2.12E+02
4.8	2.12E+02
5.0	2.12E+02

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-May-14**		**Version:**	**1**
Contaminant	**Chloride**			
Target Concentration (C_T)	**50**	**mg/l**	**Origin of C_T:**	**Site Specific SW Trigger Level, Fehilly & Co., 2005**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Chloride**		from Level 1
Target Concentration	C_T	**5.00E+01**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average conc GW2 2003-2014 (MOR CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	3.50E+02	m	*Distance to River Barrow from BH1/BH2*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	7.91E+00	m	*see options*
Transverse dispersivity	az	7.91E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	5.30E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.00E+00**	

Remedial Targets

Remedial Target		**2.00E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**350**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**5.30E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

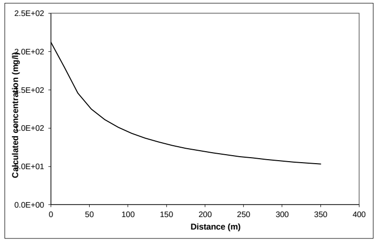
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	7.91E+00	3.50E+01	7.91E+00	m
Transverse dispersivity	**az**	7.91E-01	3.50E+00	7.91E-01	m
Vertical dispersivity	**ay**	1.00E-99	3.50E-01	7.91E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
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This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed: E1024 - Powerstown
Completed by: DL
Date: ########
Version: 1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
17.5	**1.79E+02**
35.0	**1.46E+02**
52.5	**1.25E+02**
70.0	**1.11E+02**
87.5	**1.01E+02**
105.0	**9.32E+01**
122.5	**8.69E+01**
140.0	**8.18E+01**
157.5	**7.75E+01**
175.0	**7.38E+01**
192.5	**7.05E+01**
210.0	**6.77E+01**
227.5	**6.52E+01**
245.0	**6.29E+01**
262.5	**6.09E+01**
280.0	**5.90E+01**
297.5	**5.73E+01**
315.0	**5.58E+01**
332.5	**5.44E+01**
350.0	**5.30E+01**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name: **E1024 - Powerstown**
Site Address:

Completed by: **DL**
Date: **26-May-14** **Version:** 1

Contaminant **Chloride**
Target Concentration (C_T) **50** **mg/l** **Origin of C_T:**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are autmatically copied to Level 1, 2 and 3 Worksheets.
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It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Input Parameters	Variable	Value	Unit	Source
Contaminant		**Chloride**		from Level 1
Target Concentration	**C_T**	**5.00E+01**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average conc, GW2 2003 -2014 (MOR CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero Degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	3.75E+02	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

	Variable	Value	Unit	
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	8.13E+00	m	*see options*
Transverse dispersivity	az	8.13E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	5.06E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.19E+00**	

Remedial Targets

Remedial Target		**2.10E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**375**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**5.06E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

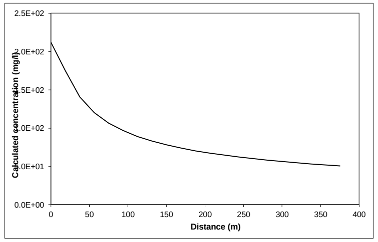
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	8.13E+00	3.75E+01	8.13E+00	m
Transverse dispersivity	**az**	8.13E-01	3.75E+00	8.13E-01	m
Vertical dispersivity	**ay**	1.00E-99	3.75E-01	8.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
18.8	**1.75E+02**
37.5	**1.41E+02**
56.3	**1.20E+02**
75.0	**1.07E+02**
93.8	**9.67E+01**
112.5	**8.92E+01**
131.3	**8.32E+01**
150.0	**7.82E+01**
168.8	**7.40E+01**
187.5	**7.05E+01**
206.3	**6.74E+01**
225.0	**6.47E+01**
243.8	**6.22E+01**
262.5	**6.01E+01**
281.3	**5.81E+01**
300.0	**5.63E+01**
318.8	**5.47E+01**
337.5	**5.32E+01**
356.3	**5.19E+01**
375.0	**5.06E+01**

Environment Agency

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-May-14**		**Version:**	**1**
Contaminant	**Chloride**			
Target Concentration (C_T)	**50**	**mg/l**	**Origin of C_T:**	**Site Specific SW Trigger Level, Fehilly & Co., 2005**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Chloride**		from Level 1
Target Concentration	C_T	**5.00E+01**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average Conc at GW2 (MOR CCC 2003-2014)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	2.70E+02	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	7.09E+00	m	*see options*
Transverse dispersivity	az	7.09E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	6.33E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.35E+00**	

Remedial Targets

Remedial Target	**1.67E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**270**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**6.33E+01**	**mg/l**	Ogata Banks
after	**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

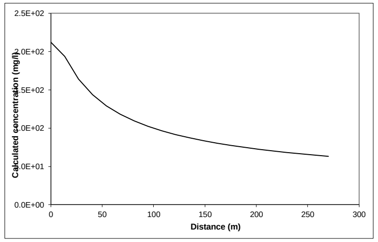
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	7.09E+00	2.70E+01	7.09E+00	m
Transverse dispersivity	**az**	7.09E-01	2.70E+00	7.09E-01	m
Vertical dispersivity	**ay**	1.00E-99	2.70E-01	7.09E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
13.5	**1.94E+02**
27.0	**1.64E+02**
40.5	**1.44E+02**
54.0	**1.29E+02**
67.5	**1.18E+02**
81.0	**1.09E+02**
94.5	**1.02E+02**
108.0	**9.66E+01**
121.5	**9.17E+01**
135.0	**8.74E+01**
148.5	**8.37E+01**
162.0	**8.04E+01**
175.5	**7.75E+01**
189.0	**7.49E+01**
202.5	**7.25E+01**
216.0	**7.03E+01**
229.5	**6.84E+01**
243.0	**6.65E+01**
256.5	**6.49E+01**
270.0	**6.33E+01**

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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Details to be completed for each assessment

Site Name: **E1024 - Powerstown**
Site Address:

Completed by: **DL**
Date: **26-Apr-14** **Version:** **1**

Contaminant **Chloride**
Target Concentration (C_T) **187.5** **mg/l** **Origin of C_T:** **Groundwater Regulations 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Chloride		from Level 1
Target Concentration	C_T	1.88E+02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average Conc at GW2 (MOR CCC 2003-2014)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	7.00E+01	m	*Arbitrary distance*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	3.64E+00	m	*see options*
Transverse dispersivity	az	3.64E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.64E+00	7.00E+00	3.64E+00	m
Transverse dispersivity	**az**	3.64E-01	7.00E-01	3.64E-01	m
Vertical dispersivity	**ay**	1.00E-99	7.00E-02	3.64E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

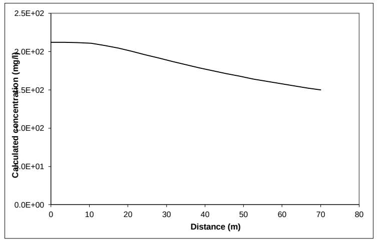
Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.50E+02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.42E+00**	

Remedial Targets

Remedial Target		**2.65E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**70**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.50E+02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
3.5	**2.12E+02**
7.0	**2.12E+02**
10.5	**2.11E+02**
14.0	**2.08E+02**
17.5	**2.04E+02**
21.0	**2.00E+02**
24.5	**1.96E+02**
28.0	**1.91E+02**
31.5	**1.87E+02**
35.0	**1.83E+02**
38.5	**1.79E+02**
42.0	**1.75E+02**
45.5	**1.71E+02**
49.0	**1.68E+02**
52.5	**1.64E+02**
56.0	**1.61E+02**
59.5	**1.58E+02**
63.0	**1.55E+02**
66.5	**1.52E+02**
70.0	**1.50E+02**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Chloride**			
Target Concentration (C_T)	**50**	**mg/l**	**Origin of C_T:**	**Site Specific SW Trigger Level, Fehilly & Co., 2005**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Chloride		from Level 1
Target Concentration	C_T	5.00E+01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.12E+02	mg/l	*Average conc GW2 2003-2014 (MOR CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Zero degradation*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	4.00E+02	m	*Distance to River Barrow from site bounda*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	8.35E+00	m	*see options*
Transverse dispersivity	az	8.35E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	8.35E+00	4.00E+01	8.35E+00	m
Transverse dispersivity	**az**	8.35E-01	4.00E+00	8.35E-01	m
Vertical dispersivity	**ay**	1.00E-99	4.00E-01	8.35E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

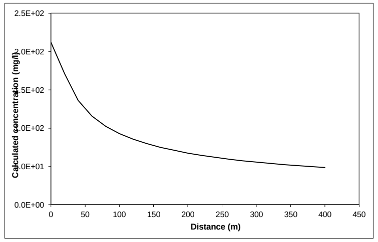
Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.00E-01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	4.84E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.38E+00**	

Remedial Targets

Remedial Target		**2.19E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**400**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**4.84E+01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**2.1E+02**
20.0	**1.71E+02**
40.0	**1.36E+02**
60.0	**1.16E+02**
80.0	**1.03E+02**
100.0	**9.29E+01**
120.0	**8.56E+01**
140.0	**7.98E+01**
160.0	**7.50E+01**
180.0	**7.10E+01**
200.0	**6.75E+01**
220.0	**6.45E+01**
240.0	**6.19E+01**
260.0	**5.96E+01**
280.0	**5.75E+01**
300.0	**5.56E+01**
320.0	**5.39E+01**
340.0	**5.24E+01**
360.0	**5.09E+01**
380.0	**4.96E+01**
400.0	**4.84E+01**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Environment Agency

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	6.50E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	4.00E+02	m	*Distance to River Barrow*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	8.35E+00	m	*see options*
Transverse dispersivity	az	8.35E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	3.35E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.26E+05**	

Remedial Targets

Remedial Target		**2.12E+04**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**400**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**3.35E-05**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc	[redacted]	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$	[redacted]	l/kg
pH value	pH	[redacted]	
acid dissociation constant	pKa	[redacted]	
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

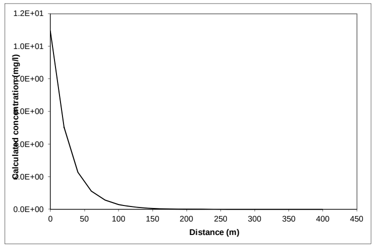
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	8.35E+00	4.00E+01	8.35E+00	m
Transverse dispersivity	**az**	8.35E-01	4.00E+00	8.35E-01	m
Vertical dispersivity	**ay**	1.00E-99	4.00E-01	8.35E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed: E1024 - Powerstown
Completed by: DL
Date: ########
Version: 1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.1E+01
20.0	5.02E+00
40.0	2.28E+00
60.0	1.11E+00
80.0	5.60E-01
100.0	2.90E-01
120.0	1.52E-01
140.0	8.11E-02
160.0	4.35E-02
180.0	2.35E-02
200.0	1.28E-02
220.0	6.96E-03
240.0	3.81E-03
260.0	2.09E-03
280.0	1.15E-03
300.0	6.37E-04
320.0	3.52E-04
340.0	1.95E-04
360.0	1.08E-04
380.0	6.03E-05
400.0	3.35E-05

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Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	**C_T**	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	5.00E+00	m	*Distance from Site Boundary to Stream*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	3.50E-01	m	*see options*
Transverse dispersivity	az	3.50E-02	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc	[redacted]	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$	[redacted]	l/kg
pH value	pH	[redacted]	
acid dissociation constant	pKa	[redacted]	
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.50E-01	5.00E-01	3.50E-01	m
Transverse dispersivity	**az**	3.50E-02	5.00E-02	3.50E-02	m
Vertical dispersivity	**ay**	1.00E-99	5.00E-03	3.50E-03	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

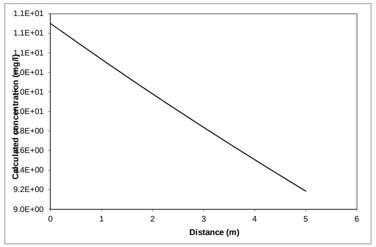
Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.19E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.19E+00**	

Remedial Targets

Remedial Target		**7.71E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**5**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**9.19E+00**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
0.3	**1.08E+01**
0.5	**1.07E+01**
0.8	**1.06E+01**
1.0	**1.05E+01**
1.3	**1.04E+01**
1.5	**1.04E+01**
1.8	**1.03E+01**
2.0	**1.02E+01**
2.3	**1.01E+01**
2.5	**1.00E+01**
2.8	**9.92E+00**
3.0	**9.84E+00**
3.3	**9.75E+00**
3.5	**9.67E+00**
3.8	**9.59E+00**
4.0	**9.51E+00**
4.3	**9.43E+00**
4.5	**9.35E+00**
4.8	**9.27E+00**
5.0	**9.19E+00**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	7.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	3.64E+00	m	*see options*
Transverse dispersivity	az	3.64E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	8.76E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.25E+01**	

Remedial Targets

Remedial Target		**8.11E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**70**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**8.76E-01**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

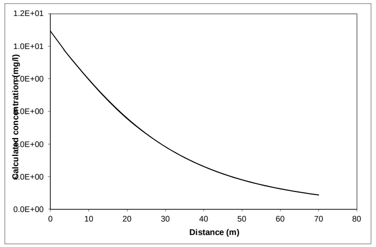
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.64E+00	7.00E+00	3.64E+00	m
Transverse dispersivity	**az**	3.64E-01	7.00E-01	3.64E-01	m
Vertical dispersivity	**ay**	1.00E-99	7.00E-02	3.64E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
3.5	**9.79E+00**
7.0	**8.78E+00**
10.5	**7.83E+00**
14.0	**6.93E+00**
17.5	**6.11E+00**
21.0	**5.37E+00**
24.5	**4.71E+00**
28.0	**4.13E+00**
31.5	**3.62E+00**
35.0	**3.17E+00**
38.5	**2.78E+00**
42.0	**2.44E+00**
45.5	**2.14E+00**
49.0	**1.88E+00**
52.5	**1.65E+00**
56.0	**1.45E+00**
59.5	**1.28E+00**
63.0	**1.13E+00**
66.5	**9.93E-01**
70.0	**8.76E-01**

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Environment Agency

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name: E1024 - Powerstown
Site Address:

Completed by: DL
Date: 26-Apr-14 **Version:** 1

Contaminant Ammonia
Target Concentration (C_T) 0.065 mg/l **Origin of C_T:** Groundwater Regs 2009 & 2012

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Input Parameters	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

Parameter	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	2.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	6.21E+00	m	*see options*
Transverse dispersivity	az	6.21E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.14E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**9.55E+02**	

Remedial Targets

Remedial Target	**6.21E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point		**200**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.14E-02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

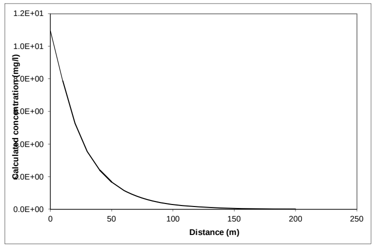
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	6.21E+00	2.00E+01	6.21E+00	m
Transverse dispersivity	**az**	6.21E-01	2.00E+00	6.21E-01	m
Vertical dispersivity	**ay**	1.00E-99	2.00E-01	6.21E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
10.0	**7.88E+00**
20.0	**5.28E+00**
30.0	**3.54E+00**
40.0	**2.41E+00**
50.0	**1.66E+00**
60.0	**1.16E+00**
70.0	**8.14E-01**
80.0	**5.75E-01**
90.0	**4.09E-01**
100.0	**2.92E-01**
110.0	**2.09E-01**
120.0	**1.50E-01**
130.0	**1.08E-01**
140.0	**7.79E-02**
150.0	**5.64E-02**
160.0	**4.09E-02**
170.0	**2.97E-02**
180.0	**2.16E-02**
190.0	**1.57E-02**
200.0	**1.14E-02**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name: E1024 - Powerstown
Site Address:

Completed by: DL
Date: 25-Apr-14 **Version:** 1

Contaminant Ammonia
Target Concentration (C_T) 0.065 mg/l **Origin of C_T:** Surface Water Regs 2012

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	days^{-1}	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	3.50E+02	m	*Distance to River Barrowfrom BH1*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	7.91E+00	m	*see options*
Transverse dispersivity	az	7.91E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.37E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**7.96E+04**	

Remedial Targets

Remedial Target		**5.17E+03**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**350**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.37E-04**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

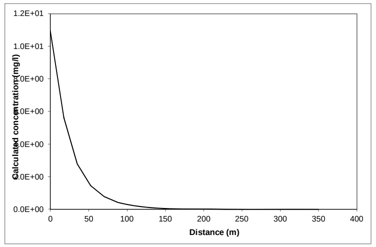
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	7.91E+00	3.50E+01	7.91E+00	m
Transverse dispersivity	**az**	7.91E-01	3.50E+00	7.91E-01	m
Vertical dispersivity	**ay**	1.00E-99	3.50E-01	7.91E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
17.5	**5.63E+00**
35.0	**2.79E+00**
52.5	**1.46E+00**
70.0	**7.90E-01**
87.5	**4.38E-01**
105.0	**2.46E-01**
122.5	**1.40E-01**
140.0	**8.04E-02**
157.5	**4.64E-02**
175.0	**2.69E-02**
192.5	**1.57E-02**
210.0	**9.19E-03**
227.5	**5.39E-03**
245.0	**3.17E-03**
262.5	**1.87E-03**
280.0	**1.11E-03**
297.5	**6.55E-04**
315.0	**3.89E-04**
332.5	**2.31E-04**
350.0	**1.37E-04**

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

Input Parameters (using pull down menu)	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.75E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.83E+00	m	*see options*
Transverse dispersivity	az	5.83E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.49E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.38E+02**	

Remedial Targets

Remedial Target	**2.85E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**175**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**2.49E-02**	**mg/l**	Ogata Banks
after	**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

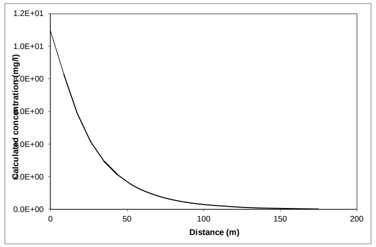
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.83E+00	1.75E+01	5.83E+00	m
Transverse dispersivity	**az**	5.83E-01	1.75E+00	5.83E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.75E-01	5.83E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.1E+01
8.8	8.27E+00
17.5	5.88E+00
26.3	4.15E+00
35.0	2.95E+00
43.8	2.12E+00
52.5	1.53E+00
61.3	1.12E+00
70.0	8.21E-01
78.8	6.05E-01
87.5	4.47E-01
96.3	3.32E-01
105.0	2.47E-01
113.8	1.84E-01
122.5	1.38E-01
131.3	1.03E-01
140.0	7.75E-02
148.8	5.83E-02
157.5	4.39E-02
166.3	3.31E-02
175.0	2.49E-02

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
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Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	6.50E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	5.00E+00	m	*Distance from Site Boundary to Stream*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	3.50E-01	m	*see options*
Transverse dispersivity	az	3.50E-02	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.19E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.19E+00**	

Remedial Targets

Remedial Target	**7.71E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**5**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**9.19E+00**	**mg/l**	Ogata Banks
after	**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

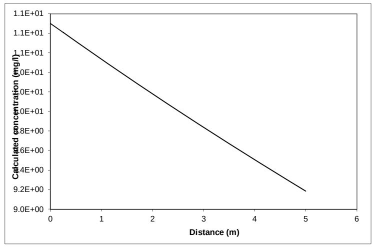
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.50E-01	5.00E-01	3.50E-01	m
Transverse dispersivity	**az**	3.50E-02	5.00E-02	3.50E-02	m
Vertical dispersivity	**ay**	1.00E-99	5.00E-03	3.50E-03	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
0.3	**1.08E+01**
0.5	**1.07E+01**
0.8	**1.06E+01**
1.0	**1.05E+01**
1.3	**1.04E+01**
1.5	**1.04E+01**
1.8	**1.03E+01**
2.0	**1.02E+01**
2.3	**1.01E+01**
2.5	**1.00E+01**
2.8	**9.92E+00**
3.0	**9.84E+00**
3.3	**9.75E+00**
3.5	**9.67E+00**
3.8	**9.59E+00**
4.0	**9.51E+00**
4.3	**9.43E+00**
4.5	**9.35E+00**
4.8	**9.27E+00**
5.0	**9.19E+00**

Environment Agency

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	4.00E+02	m	*Distance to River Barrow*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	8.35E+00	m	*see options*
Transverse dispersivity	az	8.35E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	3.35E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.26E+05**	

Remedial Targets

Remedial Target	**2.12E+04**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**400**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**3.35E-05**	**mg/l**	Ogata Banks
after	**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc	[redacted]	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$	[redacted]	l/kg
pH value	pH	[redacted]	
acid dissociation constant	pKa	[redacted]	
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

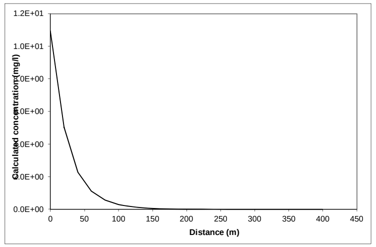
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	8.35E+00	4.00E+01	8.35E+00	m
Transverse dispersivity	**az**	8.35E-01	4.00E+00	8.35E-01	m
Vertical dispersivity	**ay**	1.00E-99	4.00E-01	8.35E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
20.0	**5.02E+00**
40.0	**2.28E+00**
60.0	**1.11E+00**
80.0	**5.60E-01**
100.0	**2.90E-01**
120.0	**1.52E-01**
140.0	**8.11E-02**
160.0	**4.35E-02**
180.0	**2.35E-02**
200.0	**1.28E-02**
220.0	**6.96E-03**
240.0	**3.81E-03**
260.0	**2.09E-03**
280.0	**1.15E-03**
300.0	**6.37E-04**
320.0	**3.52E-04**
340.0	**1.95E-04**
360.0	**1.08E-04**
380.0	**6.03E-05**
400.0	**3.35E-05**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	3.50E+02	m	*Distance to River Barrowfrom BH1*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	7.91E+00	m	*see options*
Transverse dispersivity	az	7.91E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.37E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**7.96E+04**	

Remedial Targets

Remedial Target	**5.17E+03**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point		**350**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.37E-04**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

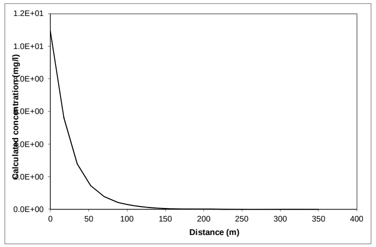
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	7.91E+00	3.50E+01	7.91E+00	m
Transverse dispersivity	**az**	7.91E-01	3.50E+00	7.91E-01	m
Vertical dispersivity	**ay**	1.00E-99	3.50E-01	7.91E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed: E1024 - Powerstown
Completed by: DL
Date: ########
Version: 1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
17.5	**5.63E+00**
35.0	**2.79E+00**
52.5	**1.46E+00**
70.0	**7.90E-01**
87.5	**4.38E-01**
105.0	**2.46E-01**
122.5	**1.40E-01**
140.0	**8.04E-02**
157.5	**4.64E-02**
175.0	**2.69E-02**
192.5	**1.57E-02**
210.0	**9.19E-03**
227.5	**5.39E-03**
245.0	**3.17E-03**
262.5	**1.87E-03**
280.0	**1.11E-03**
297.5	**6.55E-04**
315.0	**3.89E-04**
332.5	**2.31E-04**
350.0	**1.37E-04**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Input Parameters (using pull down menu)	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	2.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*

Parameters values determined from options

Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	6.21E+00	m	*see options*
Transverse dispersivity	az	6.21E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.14E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**9.55E+02**	

Remedial Targets

Remedial Target		**6.21E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**200**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.14E-02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

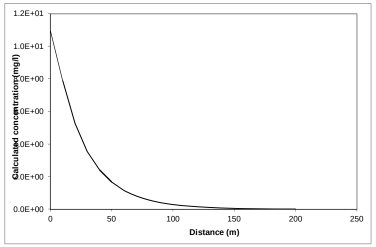
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	6.21E+00	2.00E+01	6.21E+00	m
Transverse dispersivity	**az**	6.21E-01	2.00E+00	6.21E-01	m
Vertical dispersivity	**ay**	1.00E-99	2.00E-01	6.21E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
10.0	**7.88E+00**
20.0	**5.28E+00**
30.0	**3.54E+00**
40.0	**2.41E+00**
50.0	**1.66E+00**
60.0	**1.16E+00**
70.0	**8.14E-01**
80.0	**5.75E-01**
90.0	**4.09E-01**
100.0	**2.92E-01**
110.0	**2.09E-01**
120.0	**1.50E-01**
130.0	**1.08E-01**
140.0	**7.79E-02**
150.0	**5.64E-02**
160.0	**4.09E-02**
170.0	**2.97E-02**
180.0	**2.16E-02**
190.0	**1.57E-02**
200.0	**1.14E-02**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Environment Agency

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Input Parameters (using pull down menu)	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	6.50E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.50E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.42E+00	m	*see options*
Transverse dispersivity	az	5.42E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc	[redacted]	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$	[redacted]	l/kg
pH value	pH	[redacted]	
acid dissociation constant	pKa	[redacted]	
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.42E+00	1.50E+01	5.42E+00	m
Transverse dispersivity	**az**	5.42E-01	1.50E+00	5.42E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.50E-01	5.42E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

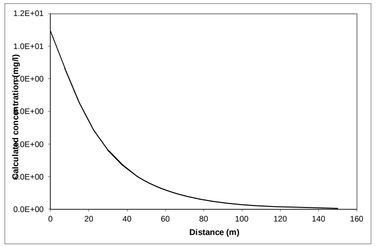
Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	5.55E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.97E+02**	

Remedial Targets

Remedial Target		**1.28E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**150**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**5.55E-02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.1E+01
7.5	8.66E+00
15.0	6.54E+00
22.5	4.87E+00
30.0	3.63E+00
37.5	2.72E+00
45.0	2.05E+00
52.5	1.55E+00
60.0	1.18E+00
67.5	9.05E-01
75.0	6.95E-01
82.5	5.35E-01
90.0	4.13E-01
97.5	3.19E-01
105.0	2.48E-01
112.5	1.92E-01
120.0	1.50E-01
127.5	1.17E-01
135.0	9.09E-02
142.5	7.10E-02
150.0	5.55E-02

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	**Source of parameter value**
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	7.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	3.64E+00	m	*see options*
Transverse dispersivity	az	3.64E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	8.76E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.25E+01**	

Remedial Targets

Remedial Target	**8.11E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**70**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**8.76E-01**	**mg/l**	Ogata Banks
after	**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

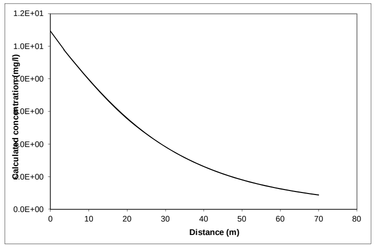
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.64E+00	7.00E+00	3.64E+00	m
Transverse dispersivity	**az**	3.64E-01	7.00E-01	3.64E-01	m
Vertical dispersivity	**ay**	1.00E-99	7.00E-02	3.64E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
3.5	**9.79E+00**
7.0	**8.78E+00**
10.5	**7.83E+00**
14.0	**6.93E+00**
17.5	**6.11E+00**
21.0	**5.37E+00**
24.5	**4.71E+00**
28.0	**4.13E+00**
31.5	**3.62E+00**
35.0	**3.17E+00**
38.5	**2.78E+00**
42.0	**2.44E+00**
45.5	**2.14E+00**
49.0	**1.88E+00**
52.5	**1.65E+00**
56.0	**1.45E+00**
59.5	**1.28E+00**
63.0	**1.13E+00**
66.5	**9.93E-01**
70.0	**8.76E-01**

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name: E1024 - Powerstown
Site Address:

Completed by: DL
Date: 26-Apr-14 **Version:** 1

Contaminant Ammonia
Target Concentration (C_T) 0.065 mg/l **Origin of C_T:** Groundwater Regs 2009 & 2012

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	days^{-1}	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.75E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.83E+00	m	*see options*
Transverse dispersivity	az	5.83E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.49E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.38E+02**	

Remedial Targets

Remedial Target		**2.85E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**175**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**2.49E-02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

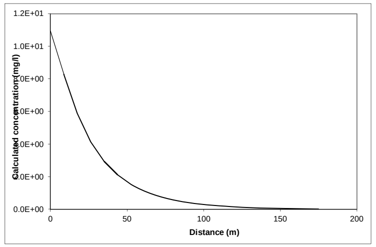
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.83E+00	1.75E+01	5.83E+00	m
Transverse dispersivity	**az**	5.83E-01	1.75E+00	5.83E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.75E-01	5.83E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	1.1E+01
8.8	8.27E+00
17.5	5.88E+00
26.3	4.15E+00
35.0	2.95E+00
43.8	2.12E+00
52.5	1.53E+00
61.3	1.12E+00
70.0	8.21E-01
78.8	6.05E-01
87.5	4.47E-01
96.3	3.32E-01
105.0	2.47E-01
113.8	1.84E-01
122.5	1.38E-01
131.3	1.03E-01
140.0	7.75E-02
148.8	5.83E-02
157.5	4.39E-02
166.3	3.31E-02
175.0	2.49E-02

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**26-Apr-14**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Groundwater Regs 2009 & 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
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Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Ammonia**		from Level 1
Target Concentration	C_T	**6.50E-02**	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived valu**

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	1.50E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	5.42E+00	m	*see options*
Transverse dispersivity	az	5.42E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	5.55E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.97E+02**	

Remedial Targets

Remedial Target	**1.28E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			

Distance to compliance point		**150**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**5.55E-02**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

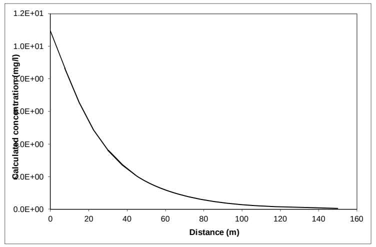
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.42E+00	1.50E+01	5.42E+00	m
Transverse dispersivity	**az**	5.42E-01	1.50E+00	5.42E-01	m
Vertical dispersivity	**ay**	1.00E-99	1.50E-01	5.42E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.1E+01**
7.5	**8.66E+00**
15.0	**6.54E+00**
22.5	**4.87E+00**
30.0	**3.63E+00**
37.5	**2.72E+00**
45.0	**2.05E+00**
52.5	**1.55E+00**
60.0	**1.18E+00**
67.5	**9.05E-01**
75.0	**6.95E-01**
82.5	**5.35E-01**
90.0	**4.13E-01**
97.5	**3.19E-01**
105.0	**2.48E-01**
112.5	**1.92E-01**
120.0	**1.50E-01**
127.5	**1.17E-01**
135.0	**9.09E-02**
142.5	**7.10E-02**
150.0	**5.55E-02**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions)

Details to be completed for each assessment

Site Name:	**E1024 - Powerstown**			
Site Address:				
Completed by:	**DL**			
Date:	**25-Apr-14**		**Version:**	1
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.065**	**mg/l**	**Origin of C_T:**	**Surface Water Regs 2012**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Environment Agency

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	6.50E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — **Equations in HRA publication**

Approach for simulating vertical dispersion: **Simulate vertical dispersion in 1 direction**

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to pollutants in all phases (e.g. field derived value**

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.09E+01	mg/l	*Average conc, GW1 - 2009 -2014 (MOR & CCC Data)*
Half life for degradation of contaminant in water	$t_{1/2}$	1.10E+03	days	*Mid range value EA table 4.2, pg 27 NC/0*
Calculated decay rate	λ	6.33E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.50E+01	m	*Site specific - Modelled plume width*
Plume thickness at source	Sy	1.00E+01	m	*Site specific (average)*
Saturated aquifer thickness	da	1.00E+01	m	*Site specific (average)*
Bulk density of aquifer materials	ρ	1.34E+00	g/cm^3	*Irish Journal Agri & Food Research 2005, irish gravel*
Effective porosity of aquifer	n	2.70E-01	fraction	*Midrange Literature value for sand/gravel, Fetter, 2001, table 3.4, pg75*
Hydraulic gradient	i	3.00E-03	fraction	*Ave gradient in plume area (MOR 2014)*
Hydraulic conductivity of aquifer	K	9.00E+00	m/d	*Site Specific Data (Slug tests, MOR 2012)*
Distance to compliance point	x	3.75E+02	m	*Distance to River Barrow*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*conservative approach*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*conservative approach*
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	8.13E+00	m	*see options*
Transverse dispersivity	az	8.13E-01	m	*see options*
Vertical dispersivity	ay	1.00E-99	m	*see options*

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.00E-01	m/d
Retardation factor	Rf	5.47E+00	fraction
Decay rate used	λ	6.33E-04	d^{-1}
Rate of contaminant flow due to retardation	u	1.83E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	6.76E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.61E+05**	

Remedial Targets

Remedial Target		**1.05E+04**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**375**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**6.76E-05**	**mg/l**	Ogata Banks
after		**1.0E+99**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

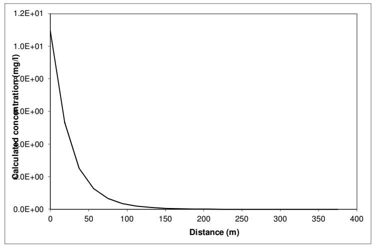
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	8.13E+00	3.75E+01	8.13E+00	m
Transverse dispersivity	**az**	8.13E-01	3.75E+00	8.13E-01	m
Vertical dispersivity	**ay**	1.00E-99	3.75E-01	8.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

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with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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Site being assessed:	E1024 - Powerstown
Completed by:	DL
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.1E+01
18.8	5.32E+00
37.5	2.52E+00
56.3	1.27E+00
75.0	6.65E-01
93.8	3.56E-01
112.5	1.93E-01
131.3	1.06E-01
150.0	5.90E-02
168.8	3.29E-02
187.5	1.85E-02
206.3	1.04E-02
225.0	5.90E-03
243.8	3.35E-03
262.5	1.91E-03
281.3	1.09E-03
300.0	6.23E-04
318.8	3.57E-04
337.5	2.05E-04
356.3	1.18E-04
375.0	6.76E-05

ATTACHMENT I.4 BASELINE REPORT

STAGES 1-5 INTERIM REPORT

CARLOW COUNTY COUNCIL

NOVEMBER 2014

CARLOW
COUNTY COUNCIL
COMHAIRLE CHONTAE CHEATHARLOCHA

FEHILY
TIMONEY
& COMPANY

ATTACHMENT I.4 BASELINE REPORT

STAGES 1-5 INTERIM REPORT

REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT

User is Responsible for Checking the Revision Status of This Document

Rev. Nr.	Description of Changes	Prepared by:	Checked by:	Approved by:	Date:
0	Final Issue	TR/MG	NM NM	BG	19.11.2014

Client: Carlow County Council

Keywords: groundwater, soil sampling, Article 22(1) of Directive 2010/75/EU on industrial emissions (IED), IE licence review application form

Abstract: This baseline report forms part of the response to Attachment I.4 for the IE licence review application for Powerstown Landfill and Recycling Facility which is owned and operated by Carlow County Council. It is being prepared in accordance with the requirements of Article 22(2) of Directive 2010/75/EU on industrial emissions (IED). The purpose of the report is to determine the state of contamination of soil and groundwater at the time the report is drawn up in order that a quantified comparison may be made to the state of the site upon the permanent cessation of the IE activity.

At the time of submission of this interim report, Stages 1-5 have been completed and CCC intends to carry out a site investigation to sample soil downgradient of Phase 1. Following sampling of soil, analysis of samples and interpretation of results, a completed baseline report will be submitted to the Agency.

TABLE OF CONTENTS

PAGE

LIST OF APPENDICES

LIST OF TABLES

EXECUTIVE SUMMARY

This baseline report will form the response to Attachment I.4 for the IE licence review application for Powerstown Landfill and Recycling Facility (W0025-03), Carlow. It is being prepared in accordance with the requirements of Article 22(2) of Directive 2010/75/EU on industrial emissions (IED).

The purpose of the report is to determine the state of soil and groundwater contamination at the time the report is drawn up in order that a quantified comparison may be made to the state of the site upon the permanent cessation of the industrial emissions (IE) activity.

The facility is operated under an Industrial Emission Licence (EPA Licence Ref No W0025-03). It is a non-hazardous landfill and a recycling centre. Section I of the IE licence application form on *Existing Environment and Impact of the Activity* seeks a baseline report, where the activity involves the use, production or release of relevant hazardous substances and having regards to the possibility of soil and groundwater contamination.

The Commission produced guidance on the content of the baseline report in May 2014, *European Commission Guidance concerning baseline reports under Article 22(2) of Directive 2010/75/EU on industrial emissions*. This baseline report has been prepared in accordance with the Guidance.

Stages 1-3 has been completed and identified the need for a baseline report, based on the risk of leachate leaking from the unlined portion of the landfill. Leachate has the potential to contain substances that are hazardous to soil and groundwater.

Stages 4-5 are substantially complete. They examine the site history and the environmental setting. There are no recorded incidents of contamination of soil or groundwater. However, groundwater monitoring indicates potential contamination by leachate downgradient of Phase 1, the unlined portion of the site. The indicated pollution is identified by the presence of ammonia.

Stage 5 will be completed by a review of the groundwater dataset for List I substances to determine whether there is any evidence of hazardous substances in the groundwater. It is intended to carry out Stage 7, the site investigation and to submit a final version of this baseline report in Q1 2014. The site investigation will consist of soil sampling with analysis for List I substances. Stage 8 will comprise a summary of each stage of the baseline report.

1 REQUIREMENT FOR A BASELINE REPORT (STAGES 1 & 2)

This section includes:

- Stage 1: A list of hazardous substances used, produced or released
- Stage 2: A list of ‘relevant hazardous substances’ used, produced or released

As part of the IE licence review application, a table of raw materials used and generated at the site was compiled. These tables, (Table G.1.(i) and Table G.1.(ii)) provided the starting point for compiling a list of relevant hazardous substances. A master list was compiled and as each stage of the baseline report was carried out, substances were highlighted as hazardous (yellow) or non-hazardous (grey).

1.1 Stage 1: Hazardous Substances

Hazardous substances are defined as being:

> *“Substances or mixtures as defined in Article 3 of Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures”.*

Article 3 of the same Regulations defines:

> *“A substance or a mixture fulfilling the criteria relating to physical hazards, health hazards or environmental hazards, laid down in Parts 2 to 5 of Annex I is hazardous and shall be classified in relation to the respective hazard classes provided for in that Annex”.*

With these definitions in mind, a list of all process related raw materials, intermediates, products etc., which are used or generated on site are included in Table 2.1.

Table 1.1: Identification of Hazardous Substances

	Material/Substance	Active Ingredient
1	Diesel	
2	Petrol	
3	Kerosene Heating Oil	
4	Leachate	
5	K-Othrine	
6	Raco Grain	Difenaconum
7	Raco Paste	Difenaconum
8	BioKill	Permethrin
9	Ambush	Cypermethrin
10	Defy	Prosulfocarb
11	Roundup	Glyphosphate
12	Nitric Acid	
13	Sodium Persulphate	

1.2 Stage 2: Relevant Hazardous Substances

Article 3(18) of the IED Directive defines ‘relevant hazardous substances’ as meaning *“substances or mixtures defined within Article 3 of Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation) which, as a result of their hazardousness, mobility, persistence and biodegradability (as well as other characteristics), are capable of contaminating soil or groundwater and are used, produced and/or released by the installation”.*

Table A.2 is a list of relevant hazardous substances used at Powerstown Landfill and Recycling Facility. This list was created by eliminating substances which are deemed non-hazardous to soil and groundwater, or highlighting substances which are hazardous to either soil or groundwater using the following steps:

(Please note that the list of hazardous and relevant hazardous substances was prepared electronically. Substances that were ‘eliminated’ from the investigation, were not deleted, but shaded in grey and noted so that they can be filtered out of the table if required.

1.2.1 Step 1 Identification of hazardous substances to groundwater.

This list was compiled using Table G.1 (ii) from the licence application as it identifies those substances that are hazardous to groundwater as determined by the EPA[1] in accordance with the European Community Environmental Objectives Groundwater Regulations 2010 (S.I. No. 9 of 2010). The EPA classification of hazardous and non-hazardous substances to groundwater is not exhaustive, therefore, a number of the substances on the list are either ‘not determined’ or are ‘N/A’ as they do not appear in the EPA document. Therefore only substances which are defined as non-hazardous to groundwater, can be eliminated from the list.

Leachate as a substance is not included in the EPA document referenced above. However, there is the possibility that some hazardous substances may be present in leachate and it cannot be eliminated.

1.2.2 Step 2 Identification of hazardous substances to soil.

In accordance with the European Communities (Classification, Packaging and Labelling of Dangerous Preparations) Regulations 2004 (S.I. No. 62 of 2004 as amended by S.I. No. 13 of 2008), risk phrases are assigned to dangerous substances. Risk phrase, R56 denotes ‘Toxic to soil organisms.’ The list of substances used at Powerstown was filtered for R56. There are no substances on the list that are toxic to soil organisms.

1.2.3 Step 2 Identification of Physical State, Storage and Conveyance on Site.

All of the substances included on the list are either liquid or solid. The storage locations and methods of handling and transport on site were identified in order to determine significant risks to soil or groundwater.

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[1] Classification of Hazardous and Non-Hazardous Substances in Groundwater, EPA 2010

For the purposes of this Baseline report it is only substances that have been identified as being a theoretical pollution risk to groundwater and soils that have been taken forward for consideration in Stage 3. Table 1.2 is a list of relevant hazardous substances. Substances which are hazardous to soil or groundwater are highlighted in yellow, those that are non-hazardous are highlighted in grey.

Table 1.2: Identification of Relevant Hazardous Substances

Ref No. /Code	Material/ Substance	Comment	Hazardous/Non-Hazardous	EC EO Groundwater) Regulations 2010		R56
				Hazardous	Non-hazardous	Toxic to soil organisms
Stages in Baseline Investigation			Stage 1	Stage 2		Stage 2
1	Diesel	Diesel Fuel Machines	Yes	Yes		No
	Diesel	Diesel Generator	Yes	Yes		No
2	Petrol	Petrol	Yes	Yes		No No No
3	Kerosene Heating Oil	Kerosene Heating Oil	Yes	Yes		No
4	Leachate	Leachate	No	Note 1		
5	K-Othrine	K-Othrine	Yes	Yes		No
6	Raco Grain	Active ingredient Difenaconum	Incomplete data but is not water soluble.	N/A		No
7	Raco Paste	Active ingredient Difenaconum	Incomplete data but is not water soluble.	N/A		No
8	BioKill	Active ingredient, Permethrin	Yes	Yes		No
9	Ambush	Active ingredient, Cypermethrin	Yes	Yes		No
10	Defy	Active Ingredient Prosulfocarb	Yes	Yes		No
11	Roundup	Active Ingredient Glyphosphate	Yes		Yes	No
12	Nitric Acid	Nitric Acid	Yes	ND		No
13	Sodium Persulphate	Sodium Persulphate	No data	ND		No

2 STAGE 3: IDENTIFICATION OF POTENTIAL POLLUTION RISK

Each substance brought forward from Stage 2 was considered in the context of the site to determine whether circumstances exist which may result in the release of the substance in sufficient quantities to represent a pollution risk either as a result of a single emission or as a result of accumulation from multiple emissions.

The relevant hazardous substances identified in Table 1.2 were investigated to identify the possibility for soil or groundwater contamination at the facility. This filter produced Table 2.1 which identified the relevant hazardous substances that represent a potential pollution risk on the site based on the likelihood of releases of such substances occurring. The following steps were taken:

Step 1: Determination of quantity stored or conveyed on site and whether that quantity has pollution potential.

Step 2: The storage and conveyance method for each substance was noted.

Step 3: The presence and integrity of containment mechanisms, nature and condition of site surfacing, location of drains, services or other potential conduits for migration.

2.1.1 Measures in Place to Mitigate Impacts to Soil or Groundwater

There are no direct discharges to groundwater from the facility.

The facility operates an Accident Prevention and Emergency Response Plan to further aid the mitigation process.

Leachate has been identified as a relevant hazardous substance at Powerstown for the following reasons:

1. It has the potential to contain substances which are hazardous to groundwater and soil; and
2. It is present on site in an unlined portion of the landfill.

Table 2.1 indicates storage locations and transport systems used on site.

Table 2.1: Storage and Transport of Materials/Substances

	Substance	Storage Condition/Location	Segregation System	Transport System Used on Site
1	Diesel (Plant)	Not stored on site. Diesel tanker comes to site to fill plant machinery in refuelling area. Refuelling area drains to leachate collection system.	Yes	Diesel tanker
2	Diesel (Generator)	Small diesel tank/drums stored on site in a bunded area in administration car park.	Yes	Drums not transported. Diesel drums topped up by site staff using jerry cans.
3	Petrol	Stored in portable petrol container inside storage (shipping) container.	Yes	Petrol container transported by vehicle.
4	Kerosene Heating Oil	Bunded oil tank	Yes	Delivered by oil tanker, conveyed by pipe to administration building.

	Substance	Storage Condition / Location	Segregation System	Transport System Used on Site
5	Leachate	Lined Leachate Lagoon & Bunded Leachate Storage Tank	Yes Leachate management system in place	HDPE pipe to lagoon and tank, tanker from tank to gate.
6	K-Othrine	These substances are stored on site in very low volumes, in a storage (shipping container). Staff decant substances as required on slab (with drainage to leachate system).	Yes, all substances are stored in the containers in which they are purchased.	Deliveries by vehicle. Transfer around site, on foot or by vehicle as required.
7	Raco Grain			
8	Raco Paste			
9	BioKill			
10	Ambush			
11	Defy			
12	Roundup			
13	Nitric Acid			
14	Sodium Persulphate			

Table 2.3 shows the outcome of Stage 3 of the baseline report. Based on the volume of material stored on site, the manner in which is it stored and handling and transportation, a risk significance was determined for each substance.

Table 2.2: Storage and Transport of Materials/Substances

Ref No. /Code	Material/ Substance	Comment	Hazardous /Non-Hazardous	EC EO Groundwater) Regulations 2010		R56	Amount	Annual	Significant Risk by Volume Used, Storage and Handling	Nature of Use	R - Phrase
				Hazardous	Non-hazardous	Toxic to soil organisms	Stored (tonnes)	Usage (tonnes)			
Stages in Baseline Investigation			Stage 1	Stage 2		Stage 2	Stage 3	Stage 3	Stage 3	Stage 3	
1	Diesel	Diesel Fuel Machines	Yes	Yes		No	0	55	No	Site machinery	R40, R51/53
	Diesel	Diesel Generator	Yes	Yes		No	1	2	No	Site generator	R40, R51/53
2	Petrol	Lawnmower	Yes	Yes		No	0.1	0.5	No	Lawnmower	R11, R12, R19, R22, R26/27/28, R33, R36/38
						No					R45, R46, R48/20, R48/23/24/25, R51/53
						No					R62, R65, R66, R67
3	Kerosene Heating Oil	Kerosene Heating Oil	Yes	Yes		No	1	2	No	Central Heating	R10, R38, R51/53, R65
4	Leachate	Leachate	No	Note 1			710	15,000	Yes	Landfill byproduct	
5	K-Othrine	K-Othrine	Yes	Yes		No	0	0.1	No	Insecticide	R23/24/25, R34, R40, R43, R50/53
6	Raco Grain	Active ingredient Difenaconum	Incomplete data but is not water soluble.	N/A		No	0	0.1		Rat Poison	R28, R48/25, R50/53, R83
7	Raco Paste	Active ingredient Difenaconum	Incomplete data but is not water soluble.	N/A		No	0	0.1		Rat Poison	R28, R48/25, R50/53, R83
8	BioKill	Active ingredient, Permethrin	Yes	Yes		No	0.02	0.1	No	Insecticide	R22, R50, R53, R36/38

Ref No. /Code	Material / Substance	Comment	Hazardous / Non-Hazardous	EC EO Groundwater) Regulations 2010		R56	Amount	Annual	Significant Risk by Volume Used, Storage and Handling	Nature of Use	R - Phrase
				Hazardous	Non-hazardous	Toxic to soil organisms	Stored (tonnes)	Usage (tonnes)			
Stages in Baseline Investigation			Stage 1	Stage 2		Stage 2	Stage 3	Stage 3	Stage 3	Stage 3	
9	Ambush	Active ingredient, Cyper-methrin	Yes	Yes		No	0.02	0.1	No	Insecticide	R22, R43, R45, R46, R65
10	Defy	Active ingredient Prosulfocarb	Yes	Yes		No	0.05	0.2	No	Surfactant	R37, R36/38
11	Roundup	Active ingredient Gly-phosphate	Yes		Yes	No	0.02	0.2	No	Herbicide	R36/38, R52/53
12	Nitric Acid	Nitric Acid	Yes	ND		No	0	0.005	No	Reagent	R8, R35
13	Sodium Persulphate	Sodium Persulphate	No data	ND		No	0	0.005	No	Reagent	R22, R36/37/38, R42/43, R8

3 STAGES 4 & 5: SITE HISTORY AND ENVIONMENTAL SETTING

3.1 Stage 4: Site History

The landfill has been developed in three phases; Phase 1 is unlined and operated on the principal of dilute and disperse. It was operational from 1975 to 1990. Phase 2 is made up of Cells 1-13. Cells 1-6 are lined with a single HDPE liner and Cells 7-13 are lined with a single HDPE liner and engineered clay. Phase 2 was operational from 1991 to 2006. Phase 3 (cells 15-18) is fully engineered in accordance with the requirements of the Landfill Directive (99/31/EC). It commenced waste acceptance in 2007 and remains active. (There is no Cell 14.)

The facility has been in operation since 1975 and is licensed (W0025-03) to accept 40,000 tonnes per annum of waste. Phases 1 and 2 of the landfill have been permanently capped, Cells 15 and 16 are filled and have an intermediate cap. Cell 17 is being filled and Cell 18 has been constructed but remains unfilled to-date. Drawing No. LW14-120-02-001 Rev A in Appendix 1 shows the site layout and infrastructure.

The recycling centre is open to the general public and provides for the recovery of glass, paper, cardboard, metal and household hazardous waste amongst others.

Powerstown Landfill and Recycling Facility is located in a rural agricultural setting in the townland of Powerstown approximately 8 km south of Carlow Town and 7 km north of Bagenalstown in County Carlow. The site is defined by a local road (L3045) to the south and west, the M9 motorway to the west & north, Powerstown Stream to the north and agricultural landscape to the east and north. The landfill occupies a total area of approximately 24 ha (including buffer zone) and lies approximately 50-60 mOD. The facility is located close to Junction No. 6 on the M9 Motorway. A location map is included in Appendix 1.

Two quarries exist along the L3045 which runs along the south of Powerstown landfill. One of these quarries abuts the boundary of Phase 1 of the facility A second quarry is located further east on this road. The wider area includes a number of other quarries to the south and east as well as improved grassland used for grazing and silage making. Hedgerows typically form the field boundaries and consist of linear strips of shrubs with occasional trees.

Topographically, the Powerstown facility lies almost equidistant between Gallows Hill (approximately 300 mOD) 6 km to the west and a peak to the east (195 mOD) in the townland of Graiguralug. The landscape to the south and north is similar to that of the Powerstown facility. The construction of the M9 motorway along with Junction 6 in the immediate vicinity of the site has significantly altered the local landscape.

The greater landscape is characterised by fertile gently undulating pasturelands with a dense hedgerow grid defining field boundaries, copses of mature trees and small rural roads. Forestry plantations are located along Gallows Hill adding to the man-made nature of the landscape.

The surrounding landscape is dotted with farmsteads, individual dwellings and a number of archaeological sites and monuments of interest. The River Barrow is the predominant surface water feature in the landscape meandering in a north south direction to the west of the site. This river is a European designated site. A number of tributaries flow to the river from the areas of high ground to the east and west of the site including Powerstown Stream, to which the Powerstown facility drains to.

Powerstown landfill is located within 10 km of five designated sites. A full site synopses for these designated sites is provided in Appendix 7.2 of the accompanying EIS to the IE licence review application.

The closest designated site is the River Barrow and River Nore SAC. This SAC is located 300 m from the outlet point of the on-site surface water attenuation pond. The site drains into three waterbody catchments, which in turn drain to the River Barrow and its associated SAC. Powerstown Stream, which is a tributary of the River Barrow, flows west along the northern boundary of the site.

Cloghristick Wood pNHA is 0.31 km to the northwest, which is upstream of any drainage from the site. All other designated sites are located over 5 km from the proposed development site and are upstream of site drainage.

A Natura Impact Statement was also completed to examine potential impacts arising from the proposed development on Natura 2000 sites.

This accompanies the IE licence review application. It determined that the landfill is not resulting in any loss or fragmentation of habitats for which the SAC is designated and that it is not causing significant disturbance to or affecting the population density of any of the species for which the SAC is designated.

3.1.1 Incidents on site – hazardous substances

There have been no one-off incidents involving emissions of hazardous substances to groundwater or soil.

Groundwater monitoring downgradient of the landfill indicates that there is some contamination by leachate from the unlined portion of the landfill (Phase 1). This has been the subject of a Tier 3 Groundwater assessment (May 2013).

3.1.2 Existing Data on Groundwater and Soil

There is a groundwater dataset for the site compiled though licence compliance monitoring. There is no relevant soil monitoring data.

Groundwater monitoring has been carried out quarterly in accordance with the licence at a number of groundwater wells. There are currently 12 groundwater wells. Monitoring of the following parameters is conducted; pH, Conductivity, Dissolved Oxygen, Ammonia, Chloride, Cyanide, Metals, Fluoride, Mercury, Sulphate, Total Phosphorous, Total Organic Nitrogen and Total Organic Chloride. The groundwater samples are screened annually for List I/II substances.

Analysis of groundwater trends for List I substances to be completed as part of Stage 7, but write up to be included here.

3.2 Stage 5: Environmental Setting

3.2.1 Soils

The soils association of the area is described from the *General Soil Map of Ireland*. There is one soil association at the site. This soil is classified as a grey-brown podzolic soil and an association of the Athy Complex. The parent material of this soil consists of calcareous, fluvio-glacial coarse gravels and sands of Weichsel Age, composed mainly of limestone, with a small proportion of sandstone, schist, shale and occasional conglomerate. Alluvial deposits also occur along Powerstown Stream and the River Barrow.

Grey brown podzolics comprise 70% of the Athy Complex association and brown earths occupy 20% of the association. Both have a wide use-range, from farm, fruit and vegetable crops to pasture land. Due to their coarse texture and very friable consistency, they are easily tilled.

The quaternary geology of the landfill area comprises unconsolidated deposits, most of which were laid down during and immediately following the last glaciation. During the various investigations carried out over the years at the Powerstown Facility, 5 m to 15 m of sands and gravel overly the thin layer of lodgement till over the area of the landfill.

3.2.2 Bedrock

The GSI database for the area shows that the site is underlain by the Milford and Ballysteen Formations. These are Dinantian dolomitised limestones. Both formations dip to the east at approximately 10°, the Milford Formation resting on top of the Ballysteen Formation.

The lower part of the Ballysteen Formation consists of well-bedded, relatively clean calcarenitic limestones, which pass gradationally up into finer-grained and more muddy limestones. Dolomitisation has taken place.

The Milford Formation is classified by the GSI from a sequence encountered in a 275 m-deep borehole drilled at Milford (1.5 km north-northwest of Powerstown landfill).

Descriptions from this borehole indicate that the bedrock is a uniform, shale-free poorly bedded, medium-grey dolomite with scattered crinoid debris and that the boundary with the underlying Ballysteen Formation is gradational.

3.2.3 Hydrogeology

The major aquifer in the Lower Carboniferous strata of the Barrow Lowlands is dolomitised limestone and it is classified as a Regionally Important Aquifer (Rkd) by the GSI. Groundwater enters Powerstown landfill via fissure flow in the bedrock and through the permeable fluvio-glacial gravel overburden. Flow direction is generally to the west towards the River Barrow, but with a northern component discharging to the Powerstown Stream.

The horizontal gradients of the water tables underlying the site are as follows (as recorded by the FTC site investigation of Phase 3):

- For the three bedrock boreholes (RCA1, RCB1 and RCC1), the horizontal gradient is approximately 0.015
- For the two overburden wells (RCA2 and RCB2), the gradient is approximately 0.25.

The overburden encountered at the site consisted of sand and gravel with cobbles. Thickness encountered in boreholes varied from 3.6 to 15 m. The underlying bedrock consisted of dolomitised limestone. A layer of discontinuous boulder clay overlying the bedrock confines the bedrock aquifer locally to the south of Phase 3.

An aquifer classification map is included in Appendix 1. A groundwater flow map is included in Appendix 1.

3.2.4 Groundwater Vulnerability

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. The factors used in assessing groundwater vulnerability include subsoil type and thickness, and recharge type. The GSI procedure whereby groundwater protection is assessed is outlined in the EPA-GSI publication 'Groundwater Protection Schemes' (DELG/EPA/GSI, 1999). The procedure proposes a matrix, which relates vulnerability, source and resource such that a particular site is given a Response (R) to specific activities. However, in the construction of phase 3 of the landfill, the sand/gravel was removed to the water table, therefore increasing the vulnerability of the site to 'Extreme.'

Extensive consultation took place with the EPA during the statutory consent process for Phase 3 and it was agreed with the Agency that a double lining system be installed in Phase 3 of Powerstown landfill. This lining system provides protection to the aquifer five times above that required by the Landfill Directive for non-hazardous landfills.

4 STAGE 6: SITE CHARACTERISATION

To be completed

5 STAGE 7: SITE INVESTIGATION

To be completed

6 STAGE 8: SUMMARY OF FINDINGS

To be completed

Appendix 1

Maps/Drawings

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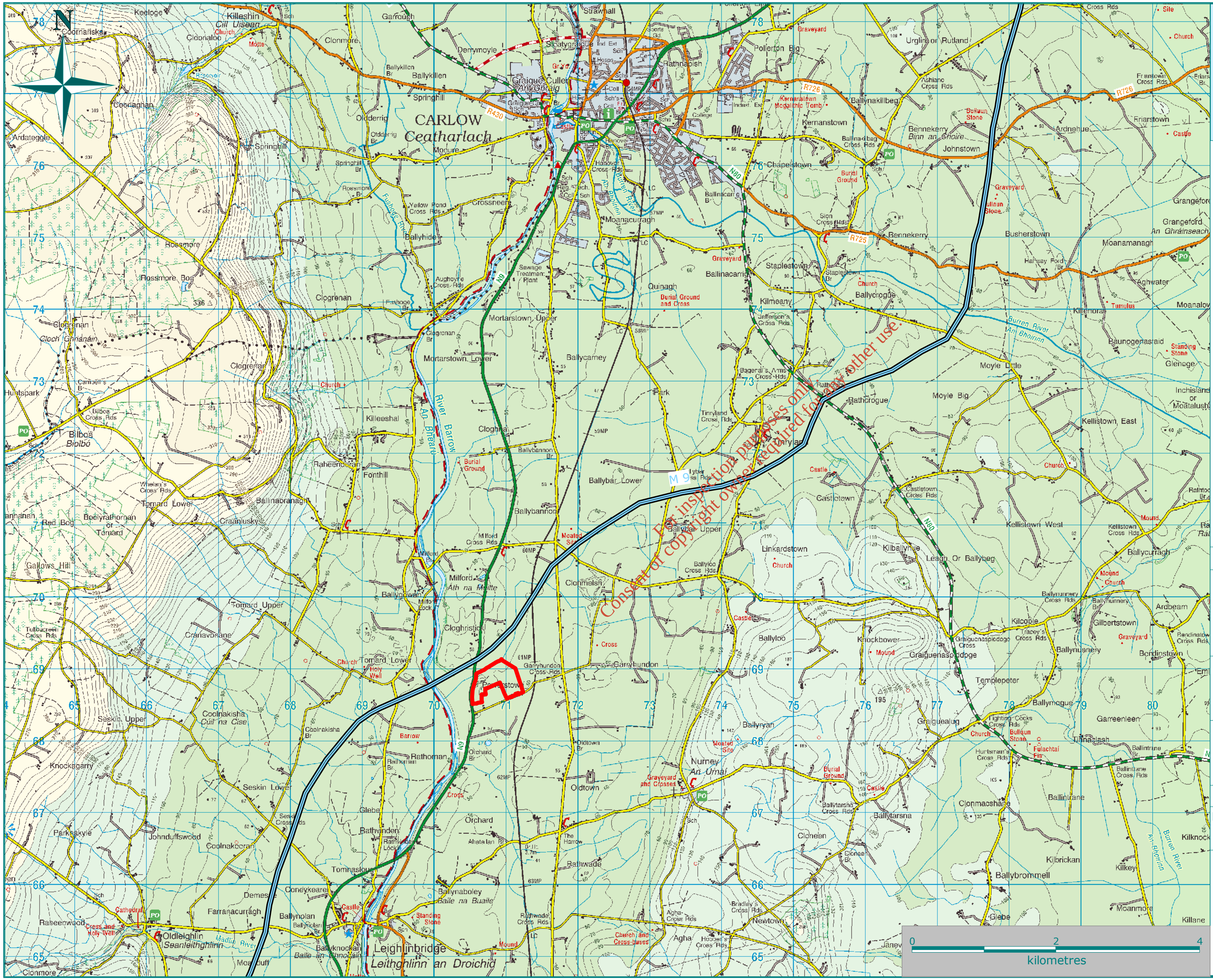
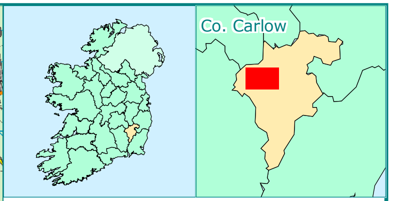
LW11-120-03_Figure 1.1_Site Location Map_Rev A





Legend

🟥 site boundary

Date 23/08/2011

Name of Client

Carlow County Council

Name of Job

EIS for Continued Use of Powerstown Landfill

Title of Figure

Site Location Map

Scales Used 1 : 75,000 @ A4

Figure No. 1.1

Rev A

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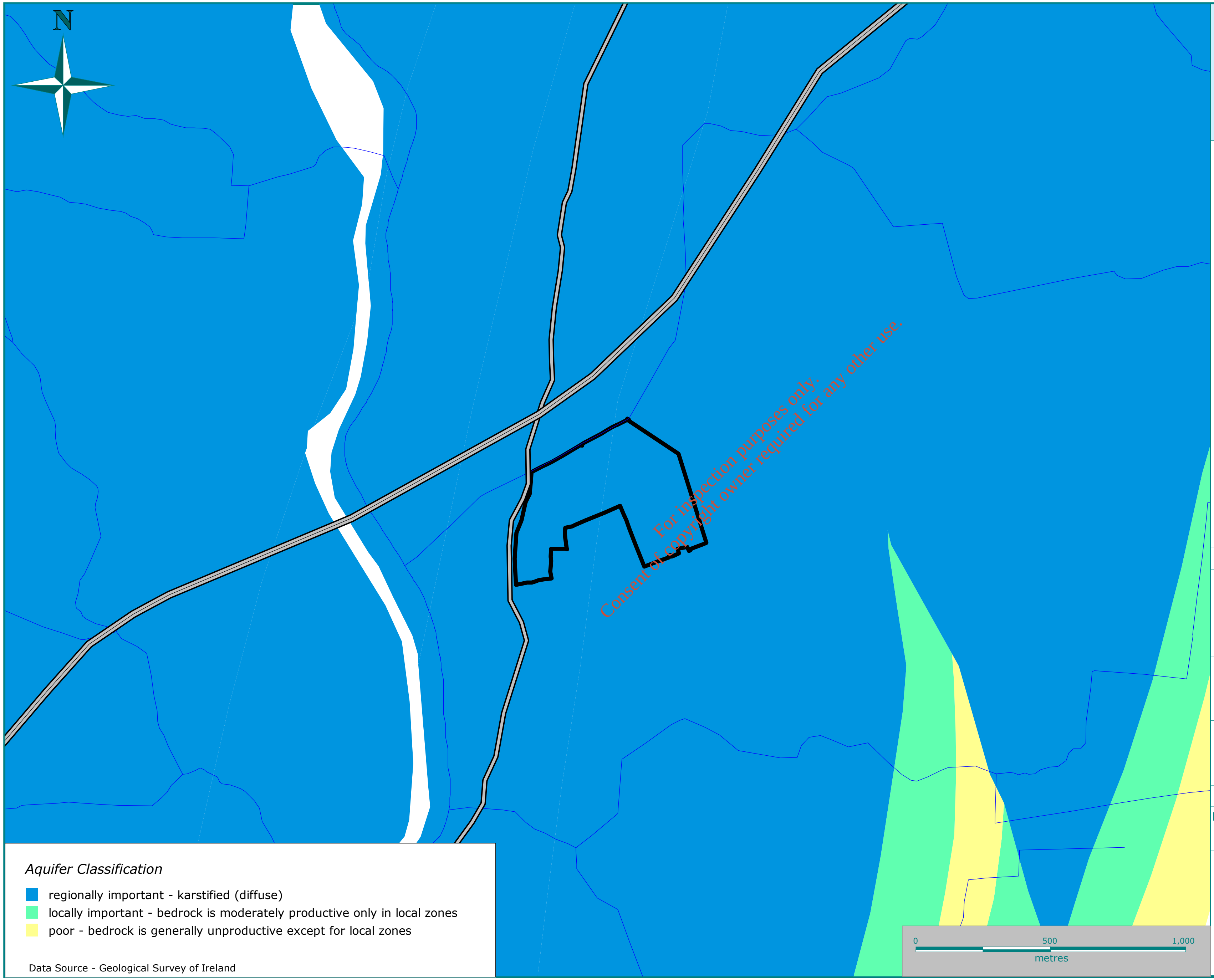
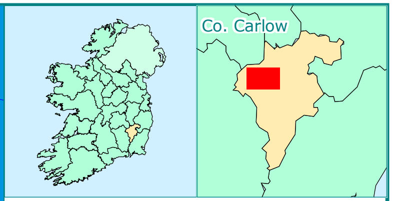
LW11-120-03_Figure 13.3_Aquifer Classification Map_Rev A



Aquifer Classification

- 🟦 regionally important - karstified (diffuse)
- 🟩 locally important - bedrock is moderately productive only in local zones
- 🟨 poor - bedrock is generally unproductive except for local zones

Data Source - Geological Survey of Ireland



Legend

▭ site boundary

Date	23/08/2011
Name of Client	Carlow County Council
Name of Job	EIS for Continued Use of Powerstown Landfill
Title of Figure	Aquifer Classification Map
Scales Used	1 : 20,000 @ A4
Figure No.	13.3
Rev	A

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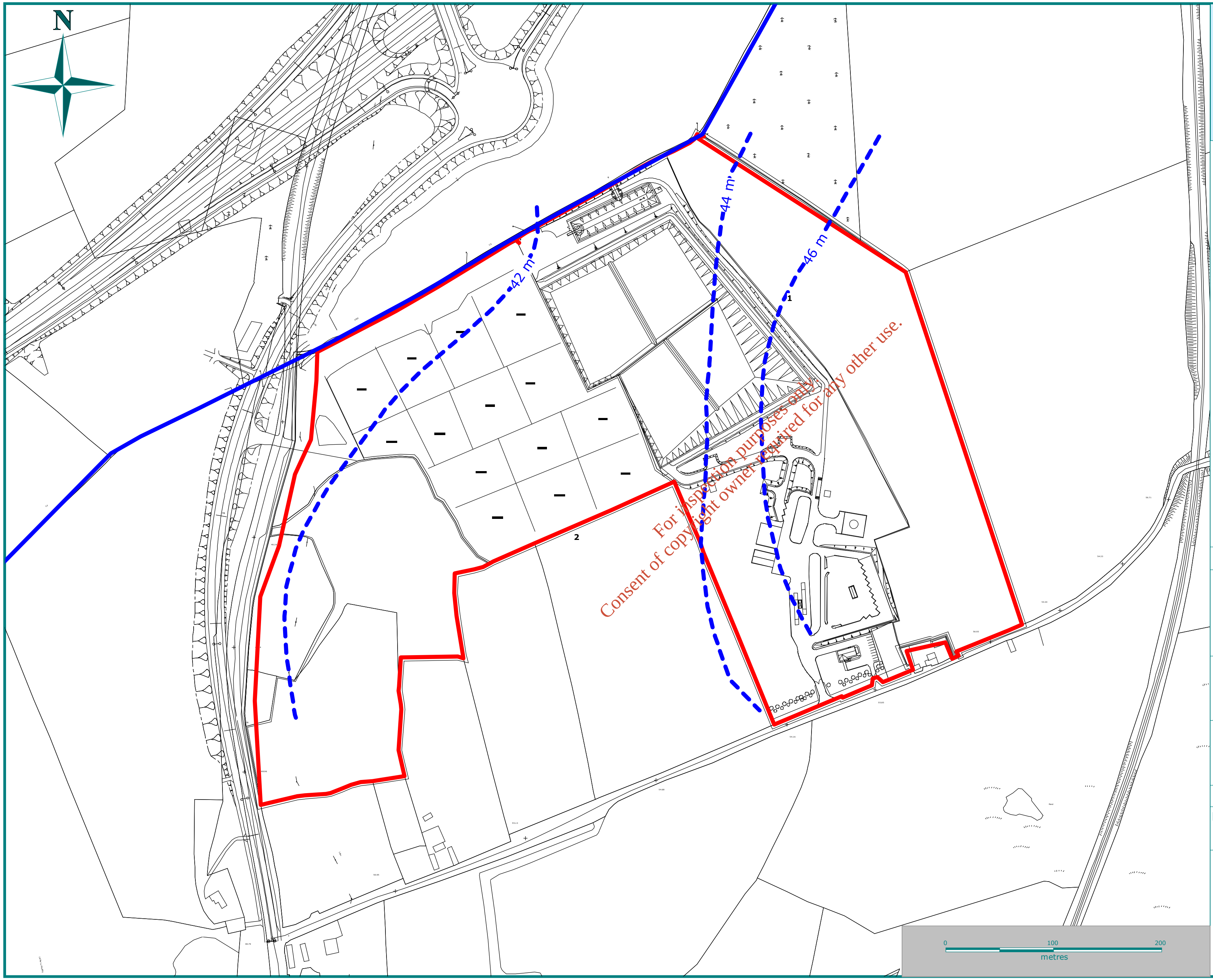

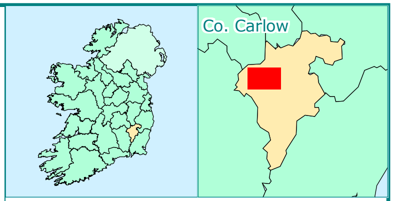

Legend

- ▭ site boundary
- - - - line of equal groundwater elevation (m OD)
- — stream

Date	23/08/2011

Name of Client

Carlow County Council

Name of Job

EIS for Continued Use
of Powerstown Landfill

Title of Figure

Groundwater Contour Map

Scales Used	1 : 5,000 @ A4	
Figure No.	13.4	Rev A

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Appendix J

(Documents in support of Attachment J)

Emergency Response Plan

POWERSTOWN LANDFILL COUNTY CARLOW

INDUSTRIAL EMISSIONS LICENCE REF. NO. W0025-03

AUGUST 2014

EMERGENCY RESPONSE PLAN

TABLE OF CONTENTS

1. GENERAL INFORMATION

The site operates under a Industrial Emissions Licence (Register No. W0025-03) issued by the Environmental Protection Agency. This licence was issued on 19th of October 2009 in accordance with the Waste Management Acts, 1996 to 2013, and defines the terms by which Powerstown Landfill can operate. This licence permits Carlow Local Authorities to carry out waste disposal and recovery activities (as defined by the licence and under twelve conditions stipulated within the licence).

Condition 9 of the waste licence stipulates contingency arrangements that must be in place at the site.

"The licensee shall maintain a written Emergency Response Procedure. The Procedure shall address any emergency situations which may originate on the facility and shall include provision for minimizing the effects of any emergency on the environment. This shall include a risk assessment to determine the requirements at the facility for fire fighting and firewater retention facilities. The licencee shall consult the Fire Authority during this assessment. The Emergency Response Procedure shall be reviewed annually and updated as necessary".

Condition 9.4 of the Waste Licence defines emergencies. These are listed as follows:

- *All significant spillages occurring at the facility shall be treated as an emergency and immediately cleaned up and dealt with so as to alleviate their effects.*
- *No waste shall be burned within the boundaries of the facility. A fire at the facility shall be treated as an emergency and immediate action shall be taken to extinguish it and notify the appropriate authorities.*
- *In the event that monitoring of local wells indicates that the facility is having a significant adverse effect on the quantity and/or quality of the water supply this shall be treated as an emergency and the licencee shall provide an alternative supply of water to those affected.*
- *In the event that monitoring of the side slopes of the facility indicate that there may be a risk of slope failure this will be treated as an emergency.*

A number of other emergency scenarios have been included, in addition to the waste licence stipulations.

This Emergency Response Plan (ERP) reflects current site activities, best practice guidelines and relevant health and safety legislation. This document supersedes earlier versions of the Emergency Response Procedures issued for the facility.

Carlow County Council has also prepared an Environmental Liabilities Risk Assessment (ELRA) document. The document contains a detailed risk assessment of the following environmental risks. Some of these risks constitute emergencies and are addressed in the relevant Emergency Response Procedures.

Landfill fire in waste cells	Release of fugitive air emissions
Landfill fire in waste cells	Damage to basal liner, contamination of groundwater and/or soil
Active cell filling operations	Damage to basal liner, contamination of groundwater and/or soil
Failure of flare	Escape of landfill gas, explosion
Failure of gas collection system	Escape of landfill gas
Migration of landfill gas	Accumulation of landfill gas in structures
Leachate escape from unlined cells	Contamination of groundwater and/or soil
Failure of leachate tanks	Contamination of groundwater, soil or surface water

Overflow of leachate from cells	Contamination of groundwater, soil or surface water
Leachate breakout due to liner failure	Contamination of groundwater and/or soil
Leak during leachate tankering onsite	Contamination of groundwater, soil or surface water
Leak during leachate tankering offsite	Contamination of groundwater, soil or surface water
Failure of leachate collection infrastructure	Contamination of groundwater, soil or surface water
No capping in place	Increase in leachate generation, fugitive emissions
Degradation of capping	Increase in leachate generation, fugitive emissions
Breach of capping system	Increase in leachate generation, fugitive emissions
Fuel spillage during machinery fuelling operations from tanker	Contamination of groundwater, soil or surface water
Fuel spillage from Administration Building tank	Contamination of groundwater, soil or surface water
Weather conditions	Flooding causing uncontrolled surface water discharge

1.1. Management Structure

The landfill management structure is set out in the landfill Safety Statement, Appendix 1 Management Structure. Duties and responsibilities are as follows, as applicable to the Emergency Response Plan.

Landfill Manager: Pat Connolly

- Ensure that the Emergency Response Plan is maintained up-to-date
- Ensure the identification of hazards
- Ensure the assessment of risks
- Decide on necessary controls/precautions and approve risk control measures
- Ensure communication of emergency response procedures to landfill staff
- In the event of an emergency, arrange to implement the procedure.
- Arrange for investigations of all emergencies and incidents

Assistant Landfill Manager: Mary Walsh

- Ensure that the Emergency Response Plan is maintained up-to-date
- Ensure the identification of hazards
- Ensure the assessment of risks
- Decide on necessary controls/precautions and approve risk control measures
- Ensure communication of emergency response procedures to landfill staff
- In the event of an emergency, arrange to implement the procedure.
- Arrange for investigations of all emergencies and incidents

Site Foreman: John Nolan

- Understand and have a copy of the Emergency Response Plan
- Ensure the identification of hazards
- Ensure the assessment of risks
- Monitor site activities day-to-day for the possibility of emergencies.
- Ensure communication of emergency response procedures to landfill staff

- In the event of an emergency, immediately contact the Landfill Manager.
- In the event of an emergency, arrange to implement the procedure.
- Arrange for investigations of all emergencies and incidents

1.2. Emergency Response Procedures

Emergency Response Procedures have been developed for a number of scenarios, in order to address the types of emergencies which may arise at the landfill.

ERP - 001 Response to Electrical Power Failure.
ERP - 002 Response to Mechanical Plant Failure
ERP - 003 Response to Fire
ERP - 004 Response to Explosion
ERP - 005 Response to Adverse Weather Conditions or Industrial Disputes
ERP - 006 Procedure for Dealing with Hot or Burning Loads
ERP - 007 Exposure to Hazardous Substances
ERP - 008 Response to Landfill Gas
ERP - 009 Response to Accidents and Notifiable Injury
ERP - 010 Procedure for Dealing with Uncontained Spillage/Leakage
ERP - 011 Flooding
ERP - 012 Exceedance of Emission Limit Values (ELV)
ERP - 013 Response to Gas Flare Equipment Cut-Out
ERP - 014 Response to Potential Slope Collapse

1.3. Environmental Policy

Carlow County Council is committed to conducting all activities so that they have a minimal effect on the environment. In the event of an emergency situation occurring at the facility, the procedures outlined in this ERP document will be adhered to, to minimize any potential impacts.
As part of the Environmental Management Programme, in compliance with the Agency's licence requirements, all levels of management are committed to implementing and maintaining the ERP. The main objectives of the Council are:

- A commitment to comply with the Waste Licence and all relevant environmental legislation and approved code of practice
- To reduce negative environmental impacts by continually developing and modifying all procedures
- To provide adequate training and awareness to all employees with regard to minimising environmental risks
- To ensure that management and all personnel working on the site are familiar with the conditions of the waste licence, the content of the Environmental Management Plan and the ERP.

2. OVERVIEW OF EMERGENCY SITUATIONS

The purpose of the ERP is to set out procedures to be followed during emergency situations to minimise the potential adverse impacts that an emergency situation may have on the heath and safety of staff at the facility or on the environment.

2.1. Emergency Review

In the event of an emergency, the landfill manager will carry out a review of the operational practices in order to determine the factors contributing to the event. Any revisions required will be documented and issued to the appropriate personnel
.
Should any emergencies occur, the landfill manager will evaluate the situation in a logical sequence to:

- Identify the problem
- Determine staffing needs
- Assess the likely downtime resulting from the problem
- Provide notification of waste diversion and later notification of commencement of activities.
- Review the procedure following the return to normal operations.

2.1.1. Identify the Problem

In the event of a mechanical breakdown at the facility, the landfill manager will be informed. Arrangements will be made for the prompt repair of the machine or for replacement equipment to be mobilised if repair work will be prolonged.

In the event of a loss of power, The EPA and relevant authorities will be informed. A back-up system will automatically provide power to the weighbridge and the weighbridge system will operate as normal.

In cases of industrial dispute, management from Carlow County Council will hold discussions with all parties involved to resolve disagreements thus diverting potential future shutdowns.

In the event of a fire occurring on the site, the landfill manager will follow the emergency procedures given in Section 3. The landfill manager will assess the situation and determine if the facility (or some sections) is unable to operate because of the extent of the fire.

Adverse weather cannot be mitigated. In the event of extreme weather conditions, the landfill manager will assess the need for closedown, and divert waste accordingly. If waste diversion is necessary, the manager will follow the procedures for Notification of Waste Diversion.

These emergencies are discussed in greater detail in the following sections.

2.1.2. Determine Staffing Needs

In the event of an emergency at the site, the manager will determine whether the cause can be remedied with in-house staff or if a specialist contractor is required.

Emergency contact details are provided at the end of this report. Specialist contractors are also listed and key responsibilities of emergency personnel are also included.

2.1.3. Assess Down-time

In consultation with on-site personnel or specialist contractors, the manager will make an assessment of the facility down-time. In the event of a power failure, the electrical contractor or the ESB will be contacted to determine the duration of the downtime.

Downtime will be difficult to assess in the case of an industrial dispute, or adverse weather conditions. In these cases, the manager will prepare for a prolonged downtime.

2.1.4. Notification of Waste Diversion

If prolonged down-time is anticipated, the manager will notify the following personnel that waste is to be diverted: -

- Carlow County Council – Director of Services
- Members of the public through local media
- Regular waste carriers
- The Environmental Protection Agency.

The weighbridge clerk will in turn inform the drivers of all waste collection vehicles as they enter the facility of the situation and will divert each to the alternative disposal site.
The landfill manager will make arrangements with an alternative facility to accept diverted waste.

2.1.5. Recommencement of Activities

When operations have recommenced, the manager will notify the following:

- Carlow County Council – Director of Services
- The Environmental Protection Agency
- The managers of the alternative disposal sites
- The public
- All waste carriers.

3. EMERGENCY PROCEDURES

3.1.1. ERP - 001 Response to Electrical Power Failure

Pre-Notified Power Interruption
The Electricity Supply Board (ESB) may issue a notification at any time that power at the facility is to be interrupted. In the event that notification is received, and further details are not provided, the landfill manager, or other agreed person, will contact the ESB to clarify the extent and date(s) of the interruption. Relevant contact details are provided at the end of this procedure.

In event of an unannounced power interruption, the emergency backup generator will be started and will provide continuous power to the site for the duration of the interruption.
The manager or other agreed person will contact the ESB to confirm an outage has occurred and determine its estimated duration before investigating site equipment faults.
If there is a fault with the site equipment, the manager will arrange any necessary corrective actions.

3.1.2. ERP - 002 Response to Mechanical Plant Failure

This procedure applies to all instances where mechanical plant failure occurs.

A. Identification of Problem

A number of items of plant and machinery are used on site to facilitate delivery, recording and disposal of waste. These include the following:-

- Weighbridge decks and ancillary items
- Rough terrain vehicles
- Track mounted excavators including excavator with hydraulic grab attachment
- 37 tonne compactor machine

The landfill manager will ensure that arrangements are made for the prompt repair of the machinery or for replacement to be mobilised if repair work will not be completed immediately.
In the event of a shut-down/malfunction of the weighbridge, whatever the cause, the weighbridge attendant will notify the landfill manager immediately and all incoming waste deliveries will be manually recorded. Vehicles not involved in the delivery of waste will not be affected during this time.

B. Determination of Labour/Resource Needs

The landfill manager or other agreed person will determine whether the problem can be rectified using in-house staff or if specialist outside contractors are required.

C. Assessment of Down-Time

The manager will make an assessment of down-time in consultation with the on-site personnel or specialist contractors, if appropriate.

D. Notification of Waste Diversion

If a prolonged down-time is anticipated, the manager will notify the persons listed below at the earliest practicable time that waste is to be diverted from the landfill.

- Carlow County Council Environmental Section
- The EPA as required by the Waste Licence conditions.
- The Weighbridge Attendant who will notify drivers entering the facility of the situation.

E. Recommencement of Waste Disposal Activities

Once the problem has been rectified and is possible to re-commence the acceptance and landfilling of waste, the landfill manager will notify the appropriate persons.

3.1.3. ERP - 003 Response to Fire

Carlow County Council has developed a fire safety programme to:
- guard against outbreak of fire
- ensure the safety of persons on site

The fire safety programme incorporates arrangements for:

- The instruction and training of staff on fire prevention practices
- Providing adequate means of escape in all buildings on site
- Provision, inspection and maintenance of fire protection equipment.

Fire poses a potential hazard in the site offices / buildings and within the landfilled waste body. The compaction of the waste reduces the potential for fire within the landfill. The administration building is fitted with a fire alarm system, 2 hand-held carbon dioxide extinguishers, and 2 hand held dry powder extinguishers. Carbon dioxide extinguishers are also located at the weighbridge. Dry powder extinguishers are located at the civic amenity site, at the waste reception area. Landfill machinery each has an extinguisher on-board. There is also a fire hydrant on-site located adjacent to the civic amenity site.

Any member of staff upon discovering a fire will raise the alarm. All employees, contractors etc will cease operations immediately then proceed to the designated assembly area as quickly possible without risk of injury to their selves or other parties.

On hearing an alarm all personnel must evacuate the offices. All vehicles must be parked away from the fire and clear of all gates and doorways which may obstruct the passage for the emergency services. The landfill manager will ensure that all employees and visitors are accounted for.

Fire Control

It is site policy that all employees will receive basic instruction in the proper use of on-site fire-fighting equipment. However, this equipment is only to be used when an escape route is available to the user, when the user is trained in the use of this equipment and where the fire is at a stage where it can be controlled. All site staff are trained in the use of a fire extinguisher.

Fire within the Waste

A fire on the surface of the waste, or within the waste, should, if it is safe to do so, be tackled as follows:
Using available mobile plant, (bucket or blade), the fire should be smothered with inert material working from the outside edge of the fire towards the centre. Under no circumstances should a machine be driven into the centre of the fire, as this will endanger both driver and machine. If the fire is not completely extinguished and continues to burn below the surface the material should be isolated. The smoldering material is to be dug out and spread on top of inert material, after which it should again be smothered. A careful watch should be kept to ensure that all burning material has been fully and permanently extinguished. Access to the immediate waste area should be restricted. Under no circumstances should further waste be deposited until authorised by the landfill manager.

Minor Fires on other areas of the site, including buildings or machinery, should be dealt with according to the relative scale of the fire. Personnel should use on-site fire extinguishers to tackle minor fires.

Major Fires The emergency services should be alerted. Personnel should not attempt to tackle major fires in site buildings or equipment unless trained and equipped to do so.

Notification The landfill manager will ensure that the emergency Fire Services have been notified if the fire cannot be controlled on site.

Once the emergency Fire Services arrive at the site, the landfill manager or other agreed person will direct them to the location of the fire and will also provide them with information regarding any potential dangers (i.e. location of fire accelerants, areas where landfill gas may be present, locations of excavations etc.). The landfill manager will ensure that the firewater runoff control measures are in place and operating properly so that firewater runoff does not pose a threat to the environment.

In the event of a fire occurring on-site the landfill manager will notify the Environmental Protection Agency in accordance with the Waste Licence conditions.

Fire Risk Assessment
See Appendix A for the fire risk assessment.

Damage Assessment
Once the Fire Services have extinguished the fire and made the area safe, the landfill manager will assess the damage with the appropriate technical assistance and support. A fire within the landfill may result in damage to the lining and/or leachate collection systems. Should this occur, the landfill manager will contact specialist contractors to implement corrective actions. The Environmental Protection Agency will be informed of the outcome of any such assessments in accordance with the Waste Licence.

3.1.4. ERP - 004 Response to Explosion

Explosion on landfills is attributable to the build-up and ignition of landfill gas from a spark or naked flame. Due to the nature of landfilling activities and potential migration of landfill gas, explosions can occur at any number of locations on site where Methane levels are between 5% v/v and 15% v/v.

A detailed Explosion Protection Document has been prepared for the site. This document is contained in Appendix 11 of the Safety Statement for Powerstown Landfill. The document has been compiled in accordance with the ATEX Regulations and deals specifically with policies and practices relating to explosive atmospheres.

A detailed examination of the onsite risks due to landfill gas explosion is contained in the document “Hazardous Area Classification, Risk Assessment”.

Both of the above documents should be read in conjunction with the present report.

3.1.5. ERP - 005 Response to Adverse Weather Conditions or Industrial Disputes

Adverse Weather
The landfill manager will make an assessment of the expected down time based on weather forecasts and will notify appropriate persons of the inability to accept waste, if necessary.

Industrial Disputes
In the event of an industrial dispute, appropriate industrial relations procedures will be initiated. All waste will be redirected to other landfills for the duration of the dispute.
.

3.2.1. ERP - 006 Procedure for Dealing with Hot or Burning Loads

If a load is found to be hot or burning upon inspection, it will be refused admission to the site.
Details of the load (name, registration number, type of land, site of origin) will be recorded in the appropriate register retained in the site office.
If the load has gained entry to the site, prior to discovery of the status of the load, it will be directed to the quarantine area where the material can be extinguished. These loads must never be placed close to areas of the site which are lined in case of heat damage to liner.

If the load has been deposited at the landfill it should be spread in a controlled manner and covered with inert material. This should always be carried out by working from the edges of the load inwards toward the centre. Machines must never be driven through burning material.
Details of the load and location of deposition will be recorded in the appropriate register retained in the site office.
In certain circumstances it may be necessary to call the emergency services. In addition, the EPA will be notified.
A careful watch will be kept to ensure that all burning material has been fully and permanently extinguished.

3.2.2. ERP - 007 Exposure to Hazardous Substances

Hazardous materials that are stored on site include:
Cleaning agents, degreasers
Pesticides for rodent and fly control
Diesel / Petrol
Chemicals for Surface Water TOC Analyser

Material safety data sheets for each substance, detailing their composition and risks are filed in the site office.
All materials are kept in a controlled lock up facility.

3.2.3. ERP - 008 Response to Landfill Gas

The site offices were previously a dwelling and are a permanent building situated at the landfill entrance. The weighbridge office is of portacabin-type construction. Air can flow freely beneath this structure and so the risk of landfill gas ingress is negligible.
Service ducts are potential pathways for landfill gas migration. There are permanent landfill gas monitors installed in the site office, and weighbridge office.

Landfill Gas Migration

A portable gas detection unit is used to monitor gas levels at monitoring locations on site, at the site buildings and at neighbouring properties. Elevated gas readings are reported to the EPA and are used to decide as to whether an emergency response should be put in hand.
In the event that significant quantities of landfill gas are found at any critical locations which could impact on the human health then the following sequence of events will be initiated.

Plan 1 (for buildings adjacent to the landfill)
If the concentration of methane and carbon dioxide in any room exceed 1% volume and 1.5% respectively the building shall be evacuated immediately and ventilated. The emergency services

contacted. In the event of an emergency occurrence outside normal working hours, on-call staff should be notified.
If safe to enter the building, appropriate PPE shall be worn and gas samples taken to establish the source of the gas

Plan 2
Should routine gas monitoring indicate a potential hazard or should an emergency call be received, the EPA, local Gardai and the environmental services section of Carlow County Council are to be informed.
The Health and Safety Authority are to be notified within 7 days when the following concentrations are found and are attributable to landfill gas;

- Methane at concentrations in excess of 1.0% v/v within buildings
- Carbon dioxide at concentrations in excess of 1.5% v/v within buildings

These plans are in accordance with guidelines on landfill gas contained in Waste Management Paper No. 27 (UK Department of Environment).

3.2.4. ERP - 009 Response to Accidents and Notifiable Injury

Activities conducted at the site could pose a risk to workers' health and safety. First aid kits are available at the civic amenity area, the waste reception area, in the weighbridge office and in the site offices.
Risk assessments for various site activities and the general safety precautions in place are described in the Site Safety Statement, which is maintained in the site office. Contractors engaged in work at the site are also required to submit a Safety Statement to Carlow County Council.
The emergency response will depend on the type of accident. In any event, management should ensure that first aid is administered immediately and that the injured person will be taken to doctor / hospital for professional medical attention if required, and if movement is possible. If the injured person cannot be moved due to the circumstances and/or the extent of injury, the appropriate emergency services will be notified without delay.
The immediate area should be kept clear to provide access for the emergency services.
An Accident Report Form will be completed. If a notifiable injury or dangerous occurrence has taken place, this must be reported to the Health and Safety Advisor who in turn notifies the HSA. If practicable the area in which the incident took place should remain undisturbed until any investigations into the circumstances are complete.

Procedures for Dealing with a Notifiable Injury
Immediately report the incident to the landfill manager or in his/her absence, his/her appointed deputy to the site office.
If there is a risk of further injury, the injured person should be moved to safety and basic first aid administered by a competent person.
If immediate medical assistance and/or emergency services are called for, ensure that the exact location is given. The immediate area should be kept clear to provide access for the emergency services.
All injuries and relevant notes are recorded in the Incident Report Forms in the Health and Safety folders.
Next of kin or family of the injured person(s) are notified and if required, their transport to hospital is arranged.
The incident is reported to the Health and Safety Advisor who in turn notifies the Health and Safety

Authority and the environmental services section of Carlow County Council as soon as is practicable.

Accident Investigation

Any accident resulting in injury, exposure, illness or property damage must be reported immediately to the landfill manager. The scene of the incident should not be disturbed more than is necessary, at least until it has been inspected by the landfill manager or his/her deputy. An accident report form shall be completed by the employee and reviewed by the health and safety representative. Corrective actions (if any) should be addressed.

A near-miss incident is defined as an occurrence other than normal procedure or practice that has the potential for causing injury, exposure, illness or property damage. Reporting and investigation of these incidents minimises the possible of repeat occurrences.
Near-miss incidents are to be reported on accident report forms and as such shall be treated as accidents.

Records of injuries and incidents should be maintained in a record file which is stored in the site office. Follow-up actions will also be recorded.

As well as establishing the source and cause of the incident, the accident investigation should include comment on how it could have been prevented, and recommendations on how a recurrence could be avoided. Alterations to procedures and working practices should then be made accordingly.

An employee exposure/injury incident report form should be completed along with the following steps:
All information about the incident and what led up to it is gathered. This should include photographic records and sketches of the accident scene, and statement by the injured person(s) and witnesses.

The incident report form is completed by the facilities manager and verified by Carlow County Councils Health and Safety Advisor before being sent to the Health and Safety Authority (HSA).
If the HSA are to inspect site and location of accident, the accident scene should be sealed off, unless action is required to prevent exposure to further serious risks.

The County Council shall notify relevant insurance companies of the event.

Note: The preceding instructions and procedures do not in any way supersede or take precedence over the legal and contractual requirements which relate to the operation of Powerstown Landfill Site.

3.3.1. ERP - 010 Procedure for Dealing with Uncontained Spillage/Leakage

The greatest potential for spill incidents is from leachate management. Leachate generated at the site is collected in leachate sumps, a leachate holding tank and a leachate lagoon. Leachate is removed from site by suitable haulage tankers and transported to Mortarstown wastewater treatment plant for final disposal. In the event of a spillage of leachate during transport to the wastewater treatment plant or during the filling operation, the driver of the tanker will notify the landfill manager, who in turn will notify the Agency. The landfill manager will notify the appropriate specialists if deemed necessary. The manager will proceed to the spill location and assess the impact of the spillage on nearby groundwater sources, surface water sources and drinking water sources. Procedures will be put in place to ensure that activities leading to the spill will not reoccur.

Leakage of leachate into surface water and/or groundwater would be detected by the surface water/groundwater monitoring programmes and measures would be taken immediately to locate and repair the damage.

Although the potential spillages of leachate pose the biggest environmental threat, all spillages of any material of greater than 100 litres will be treated as an emergency. All spillages will be contained and immediately cleaned up by absorbent material (small spillages). All cleanup material will be disposed of correctly after use. Personal protective equipment including protective eyewear and clothing are made available to workers involved in clean up of spills.

Spillage or Leakage of Oil or Diesel
Minor quantities of diesel and oil are kept on site. In the event of any spillages, the material will be contained and absorbent materials used to clean up any residual spillage.

3.3.2. ERP - 011 Flooding

Every effort must be made to prevent the flood:

- causing pollution to watercourses
- leaving the site's boundary and entering neighbouring land
- entering the working cell
- any cell containing waste; and/or
- entering gas/leachate wells.

Barriers to contain the flood shall be constructed using machinery and inert cohesive material. A mobile pump will be utilised as required, however, due consideration will be given to siting the outflow and any potential problems which could arise. Care will be taken to ensure any contaminated water is contained.

If efforts to contain the flood fail, the fire services will be called to provide assistance.
As soon as is practicable after the emergency the EPA should be notified and the environment section of Carlow County Council.
The incident will be reported on the site's incident log and emergency report form.

3.3.3. ERP - 012 Exceedance of Emission Limit Values (ELV)

The landfill manager is responsible for overseeing the Environmental Monitoring Programme at the site. In the event of an exceedence, the landfill manager will investigate the cause and source of the exceedences. Corrective measures will be put in place to prevent or minimise the risks associated with the exceedance. The landfill manager will verify that the remediation measures put in place are effective through re-sampling and monitoring. To verify the laboratory results a second sample may be taken and analysed. A fast turnaround time will be requested from the laboratory, if a drinking water supply well is impacted. If the exceedence is verified, the landfill manager will inform the Agency of the results of the re-sampling.

Landfill gas measurements are taken at a number of licensed monitoring points. In the event of elevated levels of landfill gas being detected the appropriate emergency response measures will be taken as outlined in ERP 008.

The following general procedure is to be followed in all cases.

- If a direct reading is obtained from an instrument, and is above the trigger level, re-check the equipment calibration and/or ensure that the instrument used is within the certified calibration period.
- Carry out re-sampling to verify the result. If the result is confirmed, notify the landfill manager.
- Record the date, time and place of the exceedence. Carry out an investigation to identify the nature, source and cause of the exceedence and associated emissions if any.
- Isolate the source of the emissions of identified.
- Evaluate any environmental pollution that has occurred.
- Identify and implement measures to minimise the exceedence and its effects on the environment.
- Identify and implement measures to avoid recurrence of the incident.
- Identify and implement any other appropriate corrective action.
- Report the event to the EPA as required under the Waste Licence.

3.3.4. ERP - 013 Response to Gas Flare Equipment Cut-Out

This procedure relates to unintended cut-out/operational failure of the landfill gas collection / combustion equipment. It does not apply in cases where the equipment has been intentionally shut down to facilitate work such as maintenance or connection of additional landfill gas collection infrastructure.

Cut-Out During Site Working Hours (When Site Staff Are Present)

This event will be detected immediately by a member of staff who will notify the landfill manager. The date and time of the event will be noted. An attempt will be made immediately to re-start the equipment in the normal manner. If attempts to re-start are unsuccessful, an investigation to identify the cause of the breakdown will be carried out immediately. The problem will be rectified using site-held spares where possible. If re-start by site staff is not possible, the manufacturer or a suitable contractor will be consulted immediately for advice and assistance. A maintenance / inspection visit will be arranged promptly (same day where possible) to identify and implement a course of corrective action. An incident notification will be forwarded to the EPA, informing them of the occurrence. Corrective actions will be put in place to restore normal operation at the earliest opportunity.

Cut-Out outside Site Working Hours (When Site Staff Are Not Present)

In the event that the flare cuts out outside operating hours, a member of landfill staff is immediately alerted through an automatic alarm system. The person will travel to the facility where the flare will be re-started where possible.

The date and time of a cut-out will be recorded in the gas flare log book.

If re-start by site staff is not possible, the manufacturer or a suitable contractor will be consulted at the earliest opportunity for advice and assistance. A maintenance / inspection visit will be arranged promptly (same day where possible) to identify and implement a course of corrective action.

If the flare will be out of operation overnight, the landfill manager will prepare an incident notification for submission to the EPA, informing them of the occurrence.

Corrective actions will be put in place to restore normal operation at the earliest opportunity.

3.3.5. ERP - 014 Response to Potential Slope Collapse

Priorities in this incidence are to make the slope safe and to prevent the slope failing. Water should be in so far as possible prevented from flowing over the slope in danger of failure. A chartered geotechnical engineer will make an assessment of the slope and advise on a course of action to make the slope safe. Access to the immediate area will be restricted, if necessary.

4. COMMUNICATIONS

All relevant telephone contact names and numbers in the event of an emergency are listed below.

Ambulance:	999 or 112
Fire Brigade:	999 or 059 91 31144
Carlow Gardaí:	059 91 31505
Kilkenny Hospital:	056 778500
Caredoc Carlow:	1850 334999
Parish Priest:	
Fr. Lawlor:	059 97 21463
(Fr. Tom Little)	059 91 31559
Dr. Conway:	059 91 43247
Fisheries Board:	052 23971
EPA:	053 9160600
HSA:	01 6620400
Carlow County Council:	059 91 70300
ESB	1850 372 757

Appendix K

(Documents in support of Attachment K)

Closure Restoration and Aftercare Plan (Re-submitted for EPA Approval August 2014)

Environmental Liabilities Risk Assessment Report (ELRA Report August 2014)

POWERSTOWN LANDFILL

CLOSURE PLAN
AND
RESTORATION/AFTERCARE PLAN
AUGUST 2014

Prepared by Pat Connolly SEE
Landfill Manager
Carlow County Council

Checked by Jerry Crowley A/ SEO
Carlow County Council

Tuesday, 23 September 2014

CONTENTS

PART 1 CLOSURE PLAN

PART 2 RESTORATION/AFTERCARE PLAN

PART 3 COST SUMMARY

MAPS

MONITORING LOCATIONS: GAS

MONITORING LOCATIONS: NON-GAS

SITE LOCATION MAP

SITE LAYOUT MAP

FINAL CONTOURS

PART 1, CLOSURE PLAN

A. CLOSURE PLAN SUMMARY

1. Activity Details

- Name: Carlow County Council
- Address: Powerstown, County Carlow County Council
- Licence Number: Industrial Emissions Licence W0025-03
- Activities Licensed:

Disposal Activities

Class 1:	*Deposit on, in or under land (including landfill): The activity is limited to the disposal of non-hazardous waste at the facility.*
Class 4:	*Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons: This activity is limited to the storage of leachate/ collected surface water in lagoon(s)/ retention ponds.*
Class 5:	*Specially engineered landfill, including placement into lined discrete cells which are capped and isolated from one another and the environment: This activity is limited to the disposal of non-hazardous waste into lined cells.*
Class 6:	*Biological treatment not referred to elsewhere in this Schedule which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: This activity is limited to the biological treatment of wastewater generated on site.*
Class 7	*Physico-chemical treatments not referred to elsewhere in this Schedule (including evaporation, drying and calcination) which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: The activity is limited to the removal of grit from leachate in the leachate lagoon(s).*
Class 13:	*Storage prior to submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where the waste concerned is produced: This activity is limited to the storage of waste in receptacles and designated areas prior to disposal on or off site.*

Recovery Activities

Class 2:	*Recycling or reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes): This activity is limited to the composting of green waste from households and the collection of wastes at the civic waste facility.*
Class 3	*Recycling or reclamation of metals and metal compounds: This activity is limited to the collection of wastes at the civic waste facility.*
Class 4:	*Recycling or reclamation of other inorganic materials: This activity is limited to the collection of waste at the civic waste facility and re-use of construction and demolition waste at the facility as capping or on site road material.*
Class 9:	*Use of any waste principally as a fuel or other means to generate energy: This activity is limited to the use of landfill gas for the generation of electricity/ energy.*
Class 11:	*Use of waste obtained from any activity referred to in a preceding paragraph of this Schedule. This activity is limited to the use of compost generated on site in restoration works.*
Class 13:	*Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on*

the premises where such waste is produced. This activity is limited to the storage of waste in receptacles and designated areas prior to recovery on or off site.

- RBME Category: A1, Operations Year 2013

2. Report Preparation

This report was prepared by Carlow County Council staff in the Water and Environmental Section.

3. Comparison with Previous Plans

Table 1

Year	Plan Cost	Financial Provision	FP Expiry Date
2011	4,673,901	Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration and aftercare of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs and restoration and aftercare works at Powerstown Landfill for the duration of the waste licence.	n/a
2014	7,415,618	Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration and aftercare of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs and restoration and aftercare works at Powerstown Landfill for the duration of the waste licence, including the aftercare period. The average landfill expenditure requirement over a 32-year period is 231,738 per annum. This cost will be included in the Environmental Services annual budget, currently circa €7,325,000.	n/a

4. Overview of the Plan

The Closure and Restoration/Aftercare Plan was prepared in accordance with Conditions 4 and 12 of the facility waste licence. The methodology used follows the Agency publication "Guidance on Assessing and Costing Environmental Liabilities", 2014.

5. Scoping

Scoping has determined that the landfill will have long-term environmental liabilities. As such, a Closure Plan and Restoration/Aftercare Plan have been prepared.

6. Cost Summary

The total closure and restoration/aftercare costs have been calculated at € 7,415,618 (including contingency, VAT and adjusted for inflation).

7. Financial Provision

Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration and aftercare of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs and restoration and aftercare works at Powerstown Landfill for the duration of the waste licence, including the aftercare period.

The average landfill expenditure requirement over a 32-year period is 231,738 per annum. This cost will be included in the Environmental Services annual budget, currently circa €7,325,000.

8. Review

The Plan will be reviewed annually.

B. CLOSURE PLAN INTRODUCTION

1. Site Description

Powerstown Landfill is a municipal landfill and civic amenity site owned and operated by Carlow County Council. The site covers approximately 23.9 ha in the townland of Powerstown, located adjacent to the N9 Kilkenny to Carlow road. The facility is approximately 4Km north of Leighlinbridge and approximately 6km south of Carlow Town. The site boundaries include the Powerstown Stream, a tributary of the River Barrow, to the north, the N9 roadway to the west, a third class road which is used to access the site to the south and agricultural lands to the east. The landfill is currently licensed, under W0025-03, to accept waste at an annual rate of 40,000 tonnes. The current estimated remaining capacity is 100,000 m3 (July 2014).

The estimated closure date is July 2017, based on current licenced waste intake.

Cells 15 and 16 were filled to the final waste profile in July 2014, current waste filling is in Cell 17.

2. Commencement of Operations

The landfill facility has been developed in three phases:

- Phase one consisting of the old uncontained landfill to the south-west of the site covering an area of approximately 2.5 ha. This landfill was filled from 1976 to 1990 and is permanently capped.

- Phase Two consisting of the engineering landfill cells 1 to 13, which were filled, after the closure of the old landfill, from 1990 until August 2006. Cells 1-5 were permanently capped in 2002. Cells 6-13 to the east of the site were permanently capped during 2008.

- Phase Three consists of four engineered landfill cells (Cells 15-18), currently being filled with municipal waste.

The EPA issued a waste licence in March 2000 and it has since been reviewed twice.

Planning permission was issued by An Bord Planeala in 2012 for the continued operation of the landfill until 2018. This allows for a waste intake of 50,000 tonnes/annum. It is proposed to apply for a Licence Review in the near future to increase the waste intake to this figure.

3. Classes of Activities Licensed

Disposal Activities

Class 1:	*Deposit on, in or under land (including landfill): The activity is limited to the disposal of non-hazardous waste at the facility.*
Class 4:	*Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons: This activity is limited to the storage of leachate/ collected surface water in lagoon(s)/ retention ponds.*
Class 5:	*Specially engineered landfill, including placement into lined discrete cells which are capped and isolated from one another and the environment: This activity is limited to the disposal of non-hazardous waste into lined cells.*
Class 6:	*Biological treatment not referred to elsewhere in this Schedule which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: This activity is limited to the biological treatment of wastewater generated on site.*
Class 7	*Physico-chemical treatments not referred to elsewhere in this Schedule (including evaporation, drying and calcination) which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: The activity is limited to the removal of grit from leachate in the leachate lagoon(s).*
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Recovery Activities

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Class 13:	*Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where such waste is produced. This activity is limited to the storage of waste in receptacles and designated areas prior to recovery on or off site.*

4. Licence Requirements

This Closure and Restoration/Aftercare Plan includes the proposed closure, restoration and aftercare of the landfill facility. It is anticipated that the Civic Amenity Site will continue to function. Condition 12 of the waste licence requires the following:

12.2 Financial Provision for Closure, Restoration and Aftercare
12.2.1 The licensee shall maintain a fund, or provide a written guarantee, that is adequate to assure the Agency that the licensee is at all times financially capable of implementing the Restoration and Aftercare Plan required by Condition 4. The type of fund established and means of its release/recovery shall be agreed by the Agency prior to its establishment.
12.2.2 Any fund established shall be maintained in an amount always sufficient to underwrite the current Restoration and Aftercare Plan.
12.2.3 The licensee shall revise the cost of restoration and aftercare annually and any details of the necessary adjustments to the fund or guarantee must, within two weeks of the revision, be forwarded to the Agency for its agreement. Any adjustment agreed by the Agency shall be effected within four weeks of said written agreement.
12.2.4 Unless otherwise agreed any revision to the fund shall be computed using the following formula:-
Cost = (ECOST x WPI) + CiCC
Cost = Revised restoration and aftercare cost
ECOST= Existing restoration and aftercare cost
WPI = Appropriate Wholesale Price Index [Capital Goods, Building & Construction (i.e. Materials & Wages) Index], as published by the Central Statistics Office, for the year since last closure calculation/revision.
CiCC = Change in compliance costs as a result of change in site conditions, changes in law, regulations, regulatory authority charges, or other significant changes.

12.3 Environmental Liabilities
12.3.1 The licensee shall as part of the AER, provide an annual statement as to the measures taken or adopted at the site in relation to the prevention of environmental damage, and the financial provisions in place in relation to the underwriting of costs for remedial actions following anticipated events (including closure) or accidents/incidents, as may be associated with the carrying on of the activity.
12.3.2 The licensee shall arrange for the completion, by an independent and appropriately qualified consultant, of a comprehensive and fully costed Environmental Liabilities Risk Assessment (ELRA) to address the liabilities from past and present activities. A report on this assessment shall be submitted to the Agency for agreement within twelve months of date of grant of this licence. The ELRA shall be reviewed as necessary to reflect any significant change on site, and in any case every three years following initial agreement.
The results of the review shall be notified as part of the AER.
12.3.3 As part of the measures identified in Condition 12.3.1, the licensee shall, to the satisfaction of the Agency, make financial provision to cover any liabilities associated with operation (including closure and aftercare) of the facility not already covered by Condition 12.2. The amount of indemnity held shall be reviewed and revised as necessary, but at least annually. Proof of renewal or revision of such financial indemnity shall be included in the annual 'Statement of Measures' report identified in Condition 12.3.1.

This report has been prepared to satisfy condition 12.3, following 2014 EPA published methodology. The Plan will focus on the planned and anticipated liabilities associated with closure and restoration/aftercare and the required financial provisions required for these liabilities.

C. SITE EVALUATION

1. Operator Performance

Carlow County Council maintains an Environmental Management System (EMS) which complies with Condition 2.3 of the waste licence which requires that:

'The licensee shall maintain an Environmental Management System. The EMS shall be updated on an annual basis with amendments being submitted to the Agency for its agreement.'

The EMS contains the following components and was last updated in February 2014.

- Schedule of Environmental Objectives and Targets
- Landfill Environmental Management Plan
- Corrective Action Procedures
- Awareness Training Programme

There following environmental complaints were received in relation to the facility in 2013:
- Flies (8)

The following notifiable incidents occurred in 2013:
- Groundwater trigger level exceeded (4)
- Flare shutdown (1)
- Perimeter gas well trigger level exceeded (10)
- VOC diffuse surface emission trigger level exceeded (1)
- Surface water lagoon outlet ELV exceeded (1)

Following EPA audit inspections the following non-compliances were noted in 2013:

- None

Monitoring takes place at the following locations in accordance with licence conditions.

- Landfill gas perimeter boreholes
- Upstream and downstream groundwater boreholes
- Perimeter dust locations
- Perimeter noise locations
- Upstream and downstream surface water locations and storage lagoon
- Leachate storage tanks and lagoon
- VOC on waste surfaces
- Flare inlet and outlet

2. Environmental Pathways and Sensitivity

The quaternary geology of the landfill area comprises unconsolidated deposits, most of which were laid down during and immediately following the last glaciation. During the various investigations carried out over the years at the Powerstown Facility, 5 m to 15 m of sands and gravel overlie the thin layer of lodgement till over the area of the landfill. The GSI database for the area shows that the site is underlain by the Milford and Ballysteen Formations. These are Dinantian dolomitised limestones. Both formations dip to the east at approximately 10%, the Milford Formation resting on top of the Ballysteen Formation. The lower part of the Ballysteen Formation consists of well-bedded, relatively clean calcarenitic limestones, which pass gradationally up into finer-grained and more muddy limestones.

The major aquifer in the Lower Carboniferous strata of the Barrow Lowlands is dolomitised limestone and it is classified as a Regionally Important Aquifer by the GSI. Groundwater enters Powerstown landfill via fissure flow in the bedrock and through the permeable fluvio-glacial gravel overburden. Aquifer flow direction is generally to the west towards the River Barrow, but with a northern component discharging to the Powerstown Stream.

There is one surface water emission point to the Powerstown Stream, which in turn enters the River Barrow. The River Barrow is part of the River Barrow and River Nore SAC. Monitoring of the Powerstown Stream does not indicate any significant decrease in water quality downstream of the landfill. Groundwater monitoring results indicate that there may be diffuse leachate contamination from the unlined landfill, in the area to the west of the site. A Tier 3 Groundwater Risk Assessment, in order to ascertain the effect of the unlined landfill area on groundwater to the west of the facility, was completed in 2014. A copy has been sent to the Agency for comment.

The Risk Assessment concluded that there was no risk to the groundwater within the underlying gravel aquifer at a distance of 200m downgradient of the site associated with current site condition and offsite migration of impacted groundwater. It also concluded that further monitoring of the Powerstown stream be carried out over a 12 month period. This has now commenced.

A Natura Impact Statement was carried out in 2011, as part of the planning process, which concluded that:

As no negative impacts on the Qualifying Interests of SAC 002162 were detected, it can be stated with full confidence that the Powerstown Landfill is not contributing to any significant cumulative impacts on Conservation Status of the Qualifying Interests of the SAC and is not affecting the sites Conservation Objectives and that no mitigation measures, additional to those already in place, are necessary. The engineering controls at the site, outlined in section 2, will operate to prevent accidental spillages. These are summarised as follows:

- *Direction of all surface water run-off to the surface water attenuation pond*
- *Continuous monitoring of the surface water pond and automatic cut-off controls when exceedances are detected*
- *Oil interceptor facilities at the surface water attenuation pond*
- *Collection of leachate in cells 1-18 and transfer to storage facilities.*

3. Activity Processes and Activities

The site consists of an engineered landfill facility which accepts non-hazardous waste. Waste from the public is directed to a skip area, which is then transported to the active cells by tractor. Waste from contractors is delivered directly to the active cell. Waste is placed in the cell using a compactor and excavator.

As stated previously, the landfill consists of three phases:

- Phase 1 is an unlined landfill area which closed in 1992. This area is provided with an engineered cap.
- Phase 2 is a lined landfill area which closed in 2006. This area is provided with an engineered cap.
- Phase 3 is a lined landfill area which is now in operation.

All phases of the landfill contain a gas collection infrastructure which connects to a closed flare.

Phases 2 and 3 contain a leachate collection infrastructure which connects to leachate storage tanks.

A civic amenity facility is also contained within the landfill for domestic waste.

4. Inventory of Buildings, Equipment and Plant

- Phase 1, unlined landfill
- Phase 2, lined landfill
- Phase 3, lined landfill
- Leachate lagoon: 310 m^3
- Leachate tank: 400 m^3
- Surface water lagoon: 1600 m^3
- Leachate pumps
- Gas collection infrastructure
- Gas flare
- Public skip area
- Waste quarantine area
- Metal recycling area
- Timber/Green waste recycling area
- Civic Amenity area
- Administration building
- Weighbridge
- Wheelwash
- Compactor, excavator, tractor/trailers

5. Ìnventory of Raw Materials, Products and Waste

- Waste for disposal (2013)

Table 2

Type	Total tonnes
Municipal Waste	18182.20
Unauthorised Site Clean Up	205.88
Clean Up Areas)	498.06
Clean Out (Housing)	86.60
Fly Tipping	467.20
Garden Park	571.54
Litterbins	310.48
Street Cleaning Residues	790.20
Filter Sand	5.56
Screenings	342.14
Treated Sludge	279.46
Drain Cleaning	70.90
Alum Sludge (KKCC)	503.64
Total Disposed	**22314**

- Waste for recovery (2013)

Table 3

Batteries (Car)	8.26
Batteries (Household)	0.00
Bottle banks	73.14
Cardboard	74.18
Flat Glass	34.98
Flourescent Lights	0.60
Food Waste	29.86
Green Waste	269.02
Gypsum	7.74
Light Bulbs (Filament)	0.26
Oil Filters	0.82
Paint Cans	13.32
Paper / Mags	122.58
Plastic Bottles	51.48
Plastic Wrapping	11.00
Scrapmetal	112.54
Tetrapac	0.00
Textiles	6.90
Timber	125.16
Tyres	1.14
Waste Cooking Oil	2.46
Waste Engine Oil	5.04
WEEE	195.98
Total Recovered	**1146**

- Leachate removed from site: 10,600 (2013)

- Landfill Gas: 1,406,000 m^3 (2013)

Storage capacities on site are as follows:

- Total landfill waste capacity: 685,000 m^3 (100,000 m^3 remaining July 2014)

- Leachate Lagoon:

- Leachate Tank:

- Surface Water Lagoon:

D. CLOSURE TASKS AND PROGRAMMES

It is anticipated that the landfill will close on expiry of the current planning permission in August 2018. Tasks and programmes are set out below, but do not include for closure of the Civic Amenity facility. It is intended that Cells 15 and 16 will have been capped before final closure. Cells 15-18 will be filled in July 2017 and this date is used for costing purposes.

Note: this date for cessation of waste filling may vary, based on market conditions and the outcome of the licence review.

Capping of Cells 15 and 16 will take place in July 2016, while waste operations are still ongoing.

Capping of Cells 17 and 18 will take place in July 2019, two years after the final profiles are reached.

1. Cessation of Waste Acceptance at the Landfill.

Waste acceptance for disposal will cease in July 2017. Waste recovery at the Civic Amenity site will continue. A topographical survey and slope stability survey will be undertaken on completion of landfilling.

2. Decommissioning of Equipment and Infrastructure

- The public skip area will be decommissioned and all equipment removed.

- The following machinery will be removed: compactor, excavator, dump truck and skips, trailers, sweeper, water tanker.

- The waste quarantine area will be cleared.

- All infrastructure relating to the landfill gas, leachate collection and surface water collection systems will be retained.

- There will be no required demolition.

- The Civic Amenity site and Administration building will be retained.

- The weighbridge will be retained

- A study will be carried out of baseline environmental status in order to determine the required level of environmental monitoring
- There will be no requirement for contaminated land removal.

3. Active Cells Temporary Capping

Carry out placement of interim capping to top and side slopes of Cells 17 and 18 pending final capping.

4. Final capping of Cells 17 and 18

Final capping will be carried out 24 months after waste filling has ceased, July 2019.
These works are covered in the Restoration/Aftercare section.

Closure operations will take place over a 24 month period.

E. CRITERIA FOR SUCCESSFUL CLOSURE

The following criteria have been established for successful closure of the landfill.

- Plant safely decontaminated using standard procedures and authorised contractors.
- Relevant records relating to waste and materials management retained throughout the closure process.
- Successful verification of baseline groundwater and surface water conditions in order to establish required monitoring programmes.
- Completion of waste profiles to final and stable profiles, in accordance with licence conditions.
- Sufficient funds available to cover full closure costs
- Environmental management system in place.

F. CLOSURE PLAN VALIDATION

Upon completion of the implementation of the Closure Plan, Carlow County Council will conduct a Validation Audit in order to demonstrate to the EPA that the Plan has been implemented. The qualification and experience of the independent auditor will be provided and agreed with the EPA prior to the validation commencing. The scope of the validation audit will be agreed in advance with the EPA and following approval, the chosen independent auditor will complete the validation audit. The completed Validation Audit report will be submitted to the EPA for approval.

G. CLOSURE PLAN COSTING

Estimated costs are set out in Table 4 below and cover the period from July 2017-July 2019 (from the cessation of waste acceptance to completion of final capping).

Table 4 (July 2017-July 2019)

Task	Quantity	Unit	Cost	Source
Decommission public skip area	1	item	3,000	Estimated
Remove mobile machinery	1	item	0	
Clear waste quarantine area	1	item	2,000	Estimated
Topographical Survey	2	item	3,000	Recently tendered rates
Slope Stability Study	2	item	3,000	Recently tendered rates
Carry out study of baseline environmental conditions, including baseline monitoring of groundwater and surface water.	1	item	10,000	Recently tendered rates
Validation Audit	1	item	5,000	Estimated
Final capping Cells 15 and 16 (note 1)	17,000	M^2	595,000	EPA guidance note
Temporary capping cells 17 and 18	16,000	M^2	50,000	Recently tendered rates
Final capping Cells 17 and 18	16,000	M^2	560,000	EPA guidance note
Leachate Removal	16,340	M^3 (3-10)	50,654	Tendered rates
Leachate Disposal	16,340	M^3 (2-44)	39,869	Water Service
Leachate system upkeep	2	per annum	10,000	Present costs
Landfill gas management	2	per annum	32,000	EPA guidance note
Surface Water system upkeep	2	Per annum	5,000	Current rates
Security	2	per annum	30,000	Current rates
Pest Control	2	Per annum	6,000	Current rates
Site management	2	per annum	200,000	Estimated
Site administration	2	per annum	10,000	Estimated
Utilities	2	per annum	30,000	Estimated
Monitoring and reporting (note 2)	2	per annum	70,000	Current rates incl regional lab costs
Licence fees	2	per annum	60,000	Current rates
Contingency (10%)			177,452	EPA guidance note
Total			**1,951,975**	

Note 1: works to be carried out in 2016.
Note 2: includes cost of environmental technician on site

H. REVIEW AND COSTING

The Closure Plan will be reviewed annually and the EPA will be notified of any amendments.

PART 2. RESTORATION/AFTERCARE PLAN

I. RESTORATION TASKS AND PROGRAMME

The landfill will be restored in accordance with the EPA landfill manuals on “Restoration and Aftercare”, “Landfill Site Design” and Industrial Emissions licence W0025-03.. Specific tasks are as follows:

Note: Final capping will have been completed as part of the Closure Plan, to the final licenced profiles.

- Seeding and planting within cells 15-18: After the completion of the landfilling operations and capping the area will be grassed to reflect the surrounding landscape. Due regard will be given to the EPA publication ‘Landfill Manuals- Landfill Restoration and Aftercare’

- Landscaping over the entire landfill.

- Examination of surface water drainage requirements and status. Carry out upgrades where required.

- Examination of the landfill gas collection system and status. Carry out upgrades where required.

- Examination of the landfill gas flare and status. Carry out any required maintenance works.

- Examination of the leachate collection system and status. Carry out upgrades where required.

- Carry out an ecological survey of the site. Update the Appropriate Assessment Screening, relating to the impact on the River Barrow and River Nore SAC.

- It is estimated that these tasks will be completed within 12 months of closure.

J. AFTERCARE TASKS AND PROGRAMMES

An aftercare period of 30 years is used for financial costing, in accordance with EPA recommendations. Specific tasks are as follows:

- Landfill gas infrastructure operation and maintenance: maintenance of gas collection pipework, boreholes, manifolds, knock-out pots and valves.

- Landfill gas flare operation and maintenance: The landfill gas flare will be maintained under contract by a specialist company. Regular maintenance, testing and monitoring will be carried out to ensure the flare is working correctly. In the event that a malfunction of the flare is detected, the contractor will be contacted and required to rectify the fault without delay. In accordance with the EPA publication ‘Landfill Manuals- Landfill Restoration and Aftercare’, once gas extraction is exhausted, the gas compound will be decommissioned and all redundant equipment removed by a specialist contractor

- Leachate network operation and maintenance: Leachate will be managed in accordance with condition 5.15 of waste licence W0025- 03 and the onsite leachate handling procedure until no more leachate is generated. The existing SCADA will facilitate the remote monitoring of the depth of leachate within the cells and the remote / automatic activation of the leachate pumps. For each leachate monitoring borehole not connected to the SCADA, cell levels will be monitored monthly to ensure that they do not exceed 1 metre. Storage lagoons/ tanks will be visually inspected regularly to ensure that a sufficient free area is maintained. The operation of the pumps will also be inspected on a regular basis. Leachate will continue to be removed on a regular basis by enclosed tankers for treatment to the Mortarstown Waste Water Treatment Plant (or other designated plant such as Tullow or Bagenalstown).

- Air monitoring: dust and noise monitoring will not be required after closure. VOC odour monitoring will be carried out annually by an independent external consultant. The independent assessment involves the use of a continuous kinematic VOC/GPS to detect areas of potential landfill gas leakages from the site.

- Landfill gas monitoring will be carried out as per W0025-03, Condition 8.

- Groundwater monitoring will be carried out as per W0025-03, Condition 8.

- Surface water infrastructure: The effectiveness of the drainage system will be monitored and any remedial works to the drainage layer or surface water collection system will be carried out where required. All drainage ditches and outfalls carrying run-off from the site will be regularly checked to ensure that effective surface water flows are being maintained. Any depressions created through settlement will be re-profiled to ensure surface water run-off.

- Surface water monitoring will be carried out as per W0025-03, Condition 8.

- Landscaping

- Pest control

- Site security

- Staff resourcing

- Storage integrity: In accordance with conditions 3.11 and 5.16 of the licence, all lagoon structures on
  the facility, the existing leachate tank and the diesel bund will be integrity tested every three years by an independent and qualified chartered engineer until such time that they are no longer in use.

- Calibration and maintenance: All treatment/ abatement and emission control equipment (including the SCADA) will be calibrated and maintained, in accordance with condition 5.16 of the licence and the
  instructions issued by the manufacturer/supplier/ installer.

- On-going assessment of environmental risks

- Site surveys: A topographical survey will also be required on an annual basis to assess the settling behaviour of the level of the landfill body. In addition, stability assessment will be necessary to assess the structural integrity of the landfill body.

K. CRITERIA FOR SUCCESSFUL RESTORATION/AFTERCARE

The following criteria have been established for the successful restoration and aftercare of the landfill.

- Sufficient funds available to cover full Restoration/Aftercare costs
- Environmental Management System in place.
- Landscaping is completed to the appropriate agreed future land use for the site.
- Monitoring parameters for groundwater, surface water, leachate, landfill gas and odour will settle to acceptable levels 30 years after official closure.
- Reporting of all monitoring carried out in accordance with the licence and liaison with the EPA.
- Landfill settlement has reduced to non- detectable levels.
- Amount of landfill gas produced is no longer sufficient to require a gas flare. Decommissioning of the gas management will then be undertaken.
- Leachate is no longer generated. Decommissioning of the leachate management system will then be undertaken.
- A documented and fully costed validation report to include a certificate of completion for the Restoration/Aftercare Plan.

L. RESTORATION/AFTERCARE PLAN VALIDATION

Upon completion of the implementation of the Restoration/Aftercare Plan, Carlow County Council will conduct a Validation Audit in order to demonstrate to the EPA that the Plan has been implemented. The qualification and experience of the independent auditor will be provided and agreed with the EPA prior to the validation commencing. The scope of the validation audit will be agreed in advance with the EPA and following approval, the chosen independent auditor will complete the validation audit. The completed Validation Audit report will be submitted to the EPA for approval.

M. RESTORATION/AFTERCARE PLAN COSTING

Estimated costs are set out in Table 5 below.

Table 5, Restoration Costs

Task	Quantity	Unit	Cost	Source
Cells 15-18 seeding and planting	5	day	2,500	Recently tendered rates
Surface waste system review and upkeep	1	item	10,000	Recently tendered rates
Landscaping	10	day	5,000	Recently tendered rates

Leachate system review and upkeep	1	item	10,000	Recently tendered rates
Landfill gas waste system review and upkeep	1	item	10,000	Recently tendered rates
Landfill gas flare waste system review and upkeep	1	item	10,000	Recently tendered rates
Ecological survey of the site	1	item	1,000	Recently tendered rates
Contingency			5,000	
Total for Restoration			**51,000**	

Table 6, Aftercare Costs (including inflation)

The detailed Aftercare costs are set out in the attached Excel spreadsheet and are estimated at €5,412,643 over a 30 year period.

N. REVIEW AND UPDATE

The Plan will be reviewed annually and the EPA will be notified of any amendments.

PART 3 COST SUMMARY

O. CONTINGENCY

There is inherent uncertainty in costing closure and restoration/aftercare due to the complexities involved and lack of knowledge of the circumstances that will pertain at the time of closure. Therefore, the final costing should include a level of contingency. The contingency is a specific provision for unplanned or unforeseeable items (e.g. mobilisation issues due to weather conditions, changes due to incomplete design information, changes in regulatory requirements) and provides an additional level of confidence in relation to the costing. A contingency of 10% has been included in all Plan calculations.

P. INFLATION

Closure and restoration/aftercare costs have been calculated and presented in today’s costs, i.e. the costing at the time of the assessment. However, as the aftercare costs will be incurred over a significant number of years after this initial costing is carried out and the financial provision put in place, the initial costs should be adjusted to account for future inflation. An inflation rate of 2.0% has been used. This is estimated only as it is not possible to forecast accurately, changes in costs, over the 30 year period.

Q. COST TOTAL

Table 7, Total Cost

Operation	**Total Cost**
Closure	1,951,975
Restoration	51,000
Aftercare	5,412,643
Total	**7,415,618**

MAPS

NOTES

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LEGEND

● PERIMETER GAS

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No.	Date		Amendment / Issue	App
A	xx/xx/xx		xxxxxxxxxxxxxxxxx	J.C.

CARLOW COUNTY COUNCIL

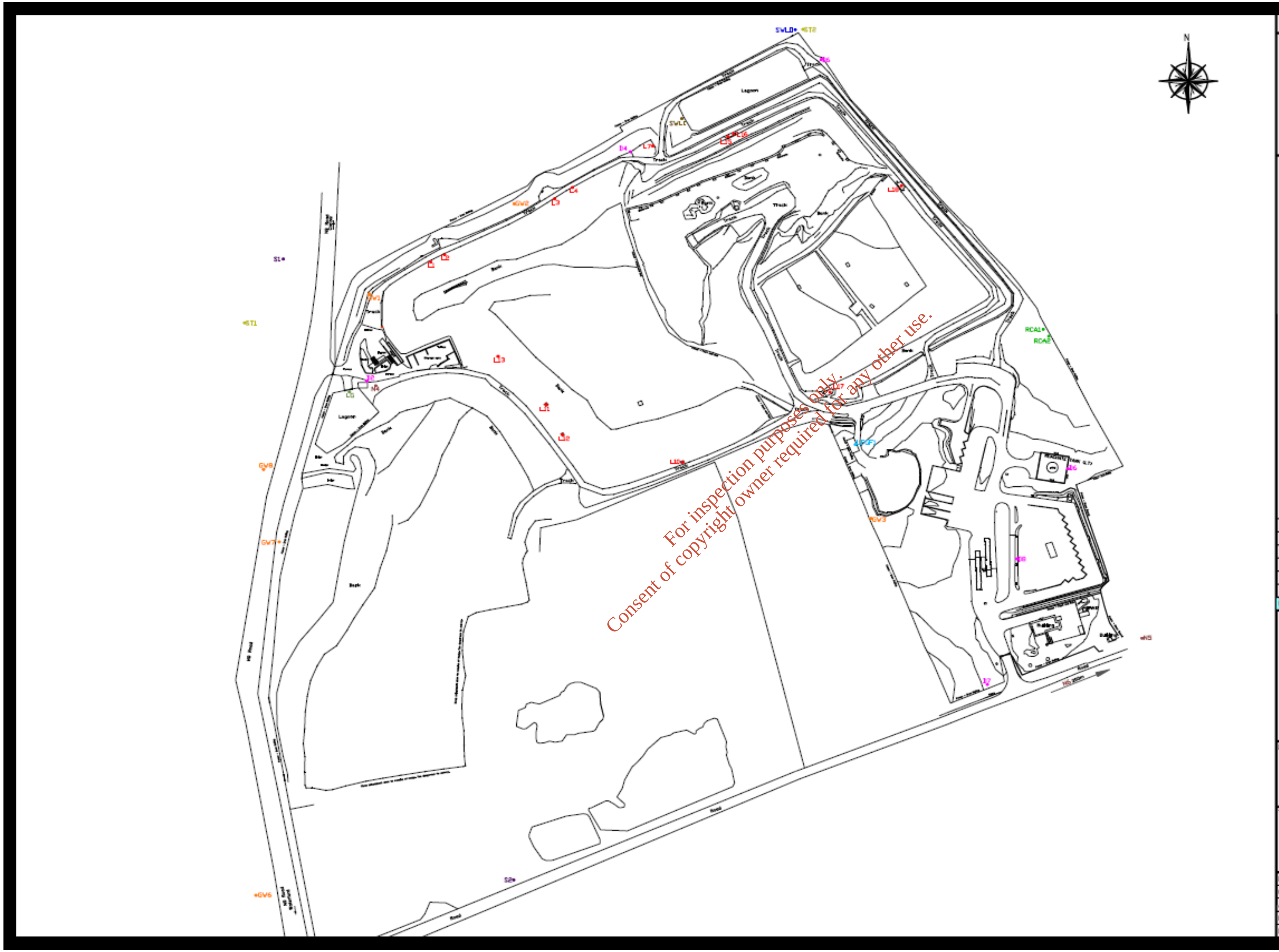
Director Of Services: John Carley
The Assembly Rooms, 40 Dublin Street, Carlow
Phone: [illegible] Fax: [illegible]
Email: [illegible]

Carlow Local Authorities, A EFQ Accredited Company

Project:
POWERSTOWN
LANDFILL

Title:
PERIMETER
GAS
MONITORING

Drawn by:	S.K.	Job No:	XXXXXXXXXXXXXX
Checked by:	P.C.	Dwr Loc:	XXXXXXXXXXXXXX
Approved by:	P.C.	Dwg. No: XXXX	Rev: A
Scale:	1/1,250		
Date:	29/07/2011		



NOTES

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LEGEND

- ● GROUND WATER (GW)
- ● GROUND WATER (RCA)
- ● NEW LOCATION OF FLARE (LFGF1)
- ● NOISE (N)
- ● NOISE (S)
- ● SURFACE WATER POINT (ST)
- ● OUTLET FROM SURFACE WATER LAGOON (SWLO)
- ● DUST (D)
- ● LEACHATE (L)
- ● LEACHATE LAGOON (LG)
- ● INLET TO SURFACE WATER LAGOON (SWLI)

A	xx/xx/xx		xxxxxxxxxxxxxxxx	J.C.
No.	Date		Amendment / Issue	App.

CARLOW COUNTY COUNCIL

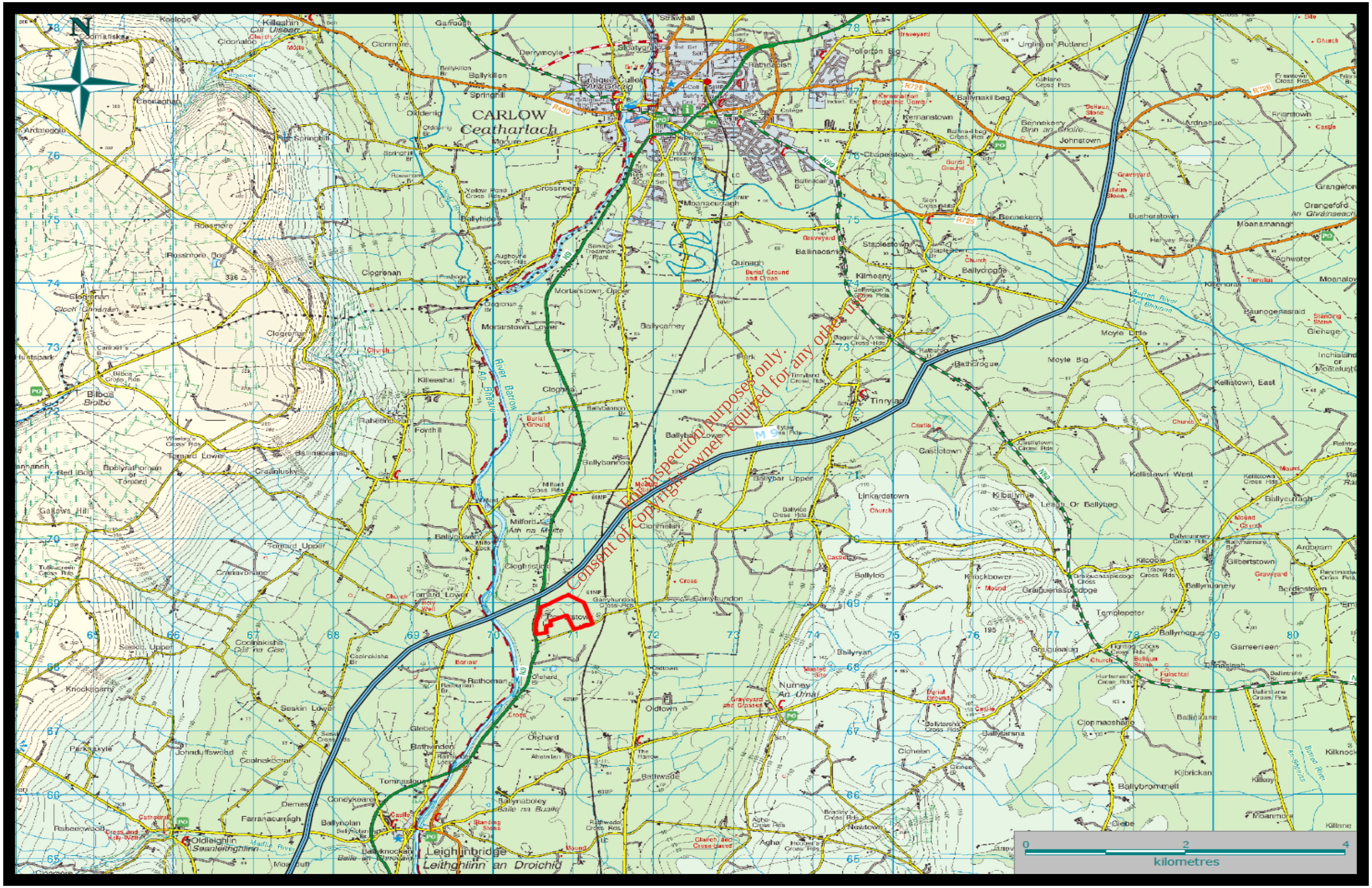
Director Of Services: John Carley
The Assembly Rooms, 40 Dublin Street, Carlow
Phone: [illegible] Fax: [illegible]
Email: [illegible]

Carlow Local Authorities, A EPD Accredited Company

Project:
POWERSTOWN LANDFILL

Title:
LANDFILL MONITORING NON-GAS

Drawn by:	S.K.	Job No:	XXXXXXXXXXXXXX
Checked by:	P.C.	Drw Loc:	XXXXXXXXXXXXXX
Approved by:	P.C.	Drg. No: XXXX	Rev: A
Scale:	1/1,250		
Date:	29/01/2011		


N
CARLOW
Ceatharlach
Leighlinbridge
Leithghlinn an Droichid
Oldleighlin
Seanleithghlinn
Milford
Áth na Muilte
Nurney
An Urnaí
Bagenalstown
Tinryland
Ballinacarrig
Castletown
Kellistown West
Linkardstown
Knockbower
Templepeter
Ballyryan
Ballynaboley
Baile na Buaile
River Barrow
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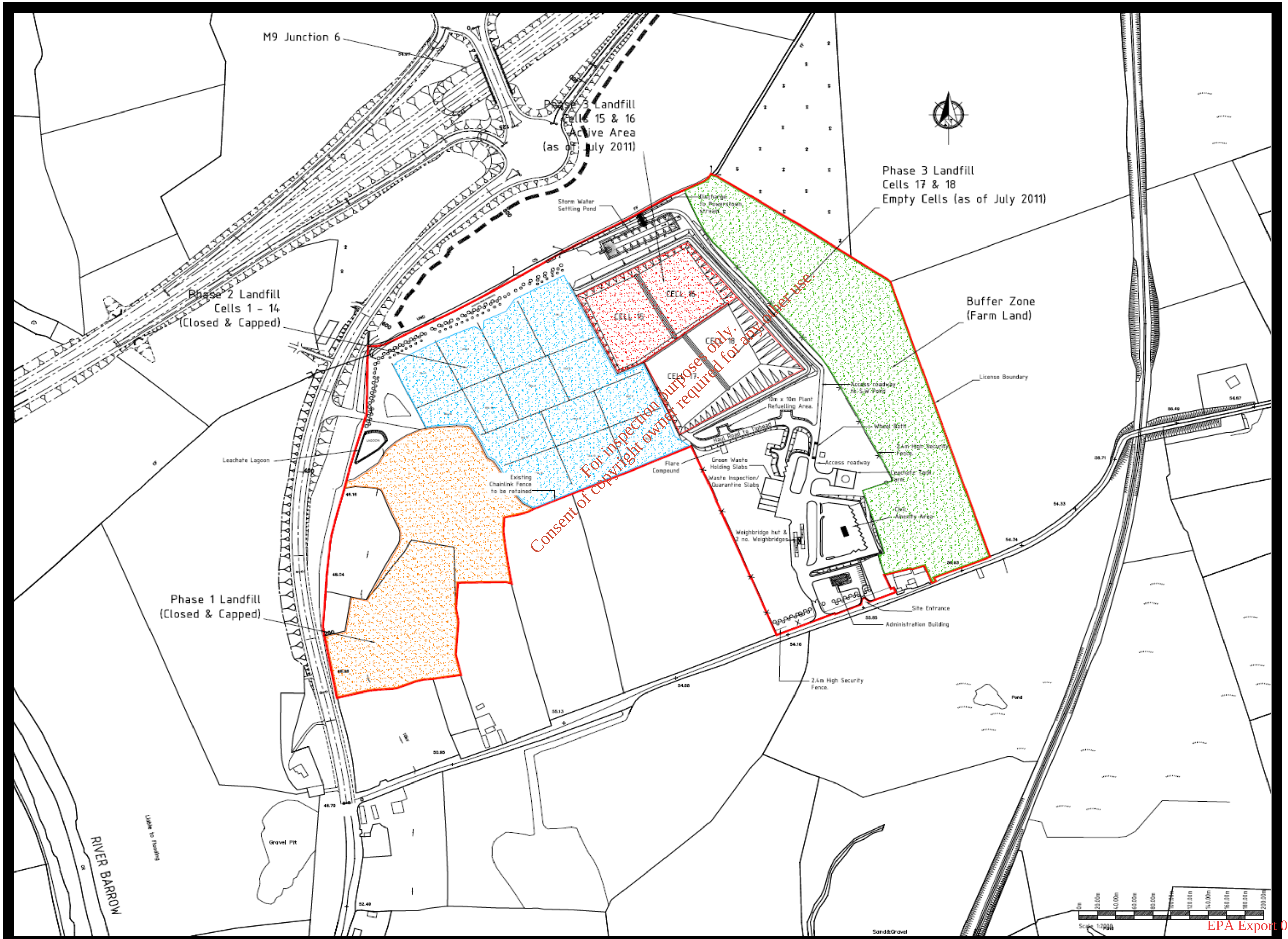
M9 Junction 6
Phase 3 Landfill
Cells 15 & 16
Active Area
(as of July 2011)
Storm Water
Settling Pond
Discharge
to Powerstown
stream
Phase 3 Landfill
Cells 17 & 18
Empty Cells (as of July 2011)
Phase 2 Landfill
Cells 1 - 14
(Closed & Capped)
CELL 15
CELL 16
CELL 17
CELL 18
Buffer Zone
(Farm Land)
License Boundary
Access roadway
to S.W Pond
10m x 10m Plant
Refuelling Area.
Haul Road to Tiphead
Wheel Bath
2.4m High Security
Fence.
Access roadway
Leachate Tank
Farm
Civic
Amenity Area
Leachate Lagoon
LAGOON
Existing
Chainlink Fence
to be retained
Flare
Compound
Green Waste
Holding Slabs
Waste Inspection/
Quarantine Slabs
Weighbridge hut &
2 no. Weighbridges
Site Entrance
Administration Building
2.4m High Security
Fence.
Phase 1 Landfill
(Closed & Capped)
Pond
Gravel Pit
Liable to Flooding
RIVER BARROW
Sand&Gravel
Scale 1:2000
0m
20.00m
40.00m
60.00m
80.00m
100.00m
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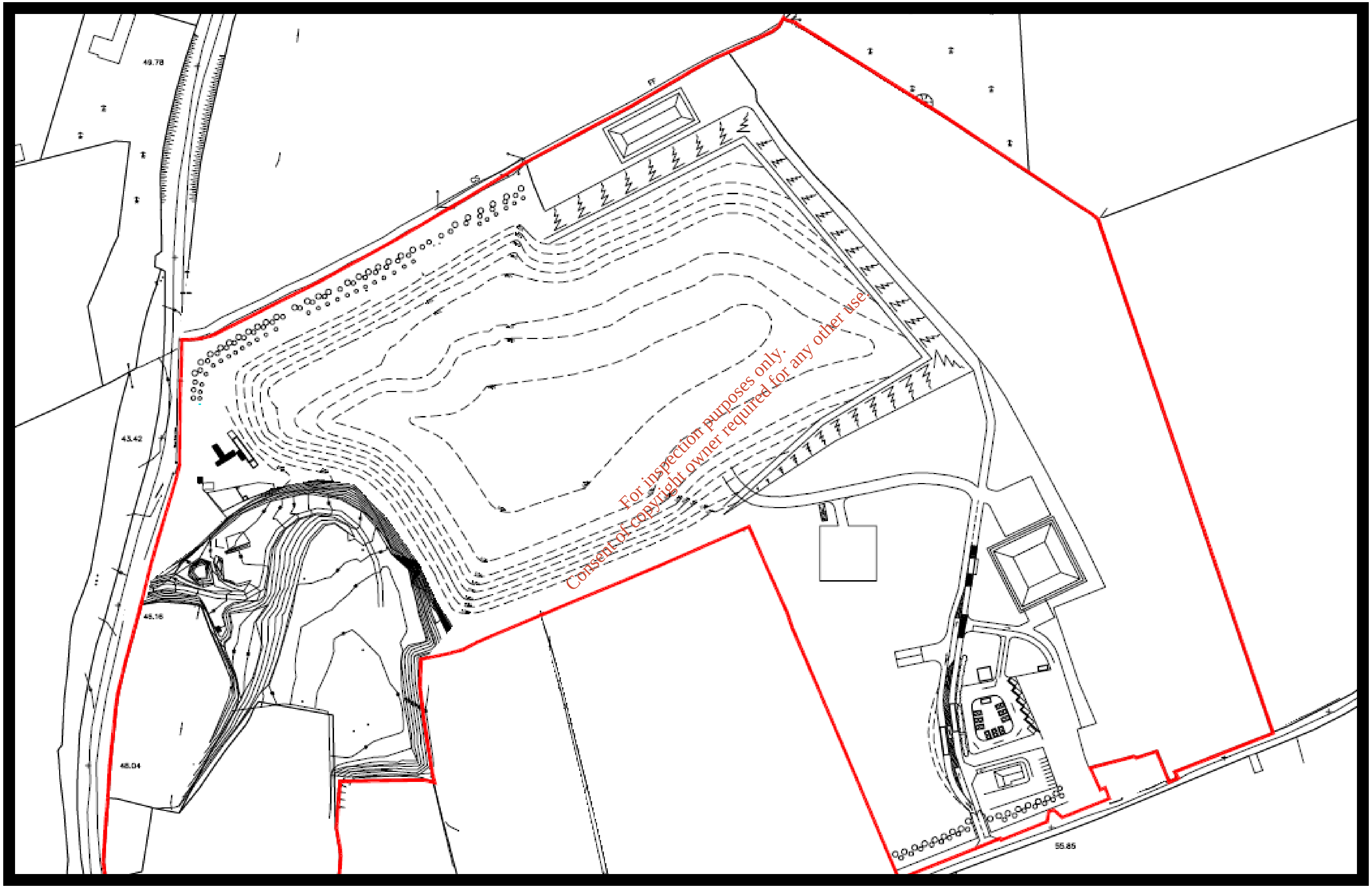
140.00m
160.00m
180.00m
200.00m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55.85

POWERSTOWN LANDFILL

ENVIRONMENTAL LIABILITIES RISK ASSESSMENT REPORT (ELRA) AUGUST 2014

Prepared by Pat Connolly SEE
Landfill Manager
Carlow County Council

Checked by Jerry Crowley SEO
Carlow County Council

Monday, 18 August 2014

CONTENTS

A. ELRA REPORT SUMMARY

B. INTRODUCTION

C. SCOPING

D. RISK IDENTIFICATION

E. RISK ANALYSIS

F. RISK EVALUATION

G. RISK TREATMENT

H. WORST CASE SCENARIO

I. QUANTIFICATION AND COSTING

J. CONCLUSION

MAPS

MONITORING LOCATIONS: GAS
MONITORING LOCATIONS: NON-GAS
SITE LOCATION MAP
SITE LAYOUT MAP

A. ELRA REPORT SUMMARY

1. Activity Details

- Name: Carlow County Council
- Address: Powerstown, County Carlow
- Industrial Emissions Licence Number:W0025-03
- Activities Licensed:

Disposal Activities

Class 1:	*Deposit on, in or under land (including landfill): The activity is limited to the disposal of non-hazardous waste at the facility.*
Class 4:	*Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons: This activity is limited to the storage of leachate/ collected surface water in lagoon(s)/ retention ponds.*
Class 5:	*Specially engineered landfill, including placement into lined discrete cells which are capped and isolated from one another and the environment: This activity is limited to the disposal of non-hazardous waste into lined cells.*
Class 6:	*Biological treatment not referred to elsewhere in this Schedule which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: This activity is limited to the biological treatment of wastewater generated on site.*
Class 7	*Physico-chemical treatments not referred to elsewhere in this Schedule (including evaporation, drying and calcination) which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: The activity is limited to the removal of grit from leachate in the leachate lagoon(s).*
Class 13:	*Storage prior to submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where the waste concerned is produced: This activity is limited to the storage of waste in receptacles and designated areas prior to disposal on or off site.*

Recovery Activities

Class 2:	*Recycling or reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes): This activity is limited to the composting of green waste from households and the collection of wastes at the civic waste facility.*
Class 3	*Recycling or reclamation of metals and metal compounds: This activity is limited to the collection of wastes at the civic waste facility.*
Class 4:	*Recycling or reclamation of other inorganic materials: This activity is limited to the collection of waste at the civic waste facility and re-use of construction and demolition waste at the facility as capping or on site road material.*
Class 9:	*Use of any waste principally as a fuel or other means to generate energy: This activity is limited to the use of landfill gas for the generation of electricity/ energy.*
Class 11:	*Use of waste obtained from any activity referred to in a preceding paragraph of this Schedule. This activity is limited to the use of compost generated on site in restoration works.*
Class 13:	*Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where such waste is produced. This activity is limited to the storage of waste in receptacles and designated areas prior to recovery on or off site.*

- RBME Category: A1, Year 2013 operations.

2. Report Preparation

This report was prepared by Carlow County Council staff in the Water and Environmental Section.

3. Comparison with Previous Reports

Table 1

Year	Worst case Scenario Cost	Financial Provision	FP Expiry Date
2011	138,631	Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration and aftercare of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs, restoration and aftercare works and environmental liabilities at Powerstown Landfill for the duration of the waste licence, including the aftercare period.	n/a
2014	1,595,200	Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration, aftercare and environmental liabilities of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs, restoration and aftercare works and environmental liabilities at Powerstown Landfill for the duration of the waste licence, including the aftercare period.	n/a

4. Overview of the Report

The ELRA Report was prepared in accordance with Condition 12 of the facility Industrial Emissions licence. The methodology used follows the Agency publication “Guidance on Assessing and Costing Environmental Liabilities” (2014).

5. Financial Provision

The financial liability is based on the worst case scenario. This is the maximum liability that may be incurred and is calculated at €1,595,200. The worst case scenario is considered to be a large scale fire in a waste cell, which will result in the release of hazardous compounds to air and also result in widespread liner damage in the cell base.

Carlow County Council, as a local authority, has made the necessary provisions, for the development, management, restoration and aftercare of Powerstown Waste Management Facility. Carlow County Council is committed to the ongoing provision of funding for all site development works, environmental monitoring costs, restoration and aftercare works and environmental liabilities at Powerstown Landfill for the duration of the waste licence, including the aftercare period.

B. INTRODUCTION

1. Site Description

Powerstown Landfill is a municipal landfill and civic amenity site owned and operated by Carlow County Council. The site covers approximately 23.9 ha in the townland of Powerstown, located adjacent to the N9 Kilkenny to Carlow road. The facility is approximately 4Km north of Leighlinbridge and approximately 6km south of Carlow Town. The site boundaries include the Powerstown Stream, a tributary of the River Barrow, to the north, the N9 roadway to the west, a third class road which is used to access the site to the south and agricultural lands to the east. The landfill is currently licensed, under W0025-03, to accept waste at an annual rate of 40,000 tonnes. The current estimated remaining capacity is 100,000 m3 (July 2014).

2. Commencement of Operations

The landfill facility has been developed in three phases:

- Phase one consisting of the old uncontained landfill to the south of the site covering an area of approximately 2.5 ha. This landfill was filled from 1976 to 1990 and is permanently capped.

- Phase Two consisting of the engineering landfill cells 1 to 13, which were filled since the closure of the old landfill since 1990 until August 2006. Cells 1-5 were permanently capped in 2002. Cells 6-13 to the east of the site were permanently capped during 2008.

- Phase Three consists of four engineered landfill cells (Cells 15-18), currently being filled with municipal waste.

The EPA issued a waste licence in March 2000 and it has since been reviewed twice.

Planning permission was issued by An Bord Planeala in 2012 for the continued operation of the landfill until 2018.

3. Classes of Activities Licensed

Disposal Activities

Class 1:	*Deposit on, in or under land (including landfill): The activity is limited to the disposal of non-hazardous waste at the facility.*
Class 4:	*Surface impoundment, including placement of liquid or sludge discards into pits, ponds or lagoons: This activity is limited to the storage of leachate/ collected surface water in lagoon(s)/ retention ponds.*
Class 5:	*Specially engineered landfill, including placement into lined discrete cells which are capped and isolated from one another and the environment: This activity is limited to the disposal of non-hazardous waste into lined cells.*

Class 6:	*Biological treatment not referred to elsewhere in this Schedule which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: This activity is limited to the biological treatment of wastewater generated on site.*
Class 7	*Physico-chemical treatments not referred to elsewhere in this Schedule (including evaporation, drying and calcination) which results in final compounds or mixtures which are disposed of by means of any activity referred to in paragraphs 1 to 10 of this Schedule: The activity is limited to the removal of grit from leachate in the leachate lagoon(s).*
Class 13:	*Storage prior to submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where the waste concerned is produced: This activity is limited to the storage of waste in receptacles and designated areas prior to disposal on or off site.*

Recovery Activities

Class 2:	*Recycling or reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes): This activity is limited to the composting of green waste from households and the collection of wastes at the civic waste facility.*
Class 3	*Recycling or reclamation of metals and metal compounds: This activity is limited to the collection of wastes at the civic waste facility.*
Class 4:	*Recycling or reclamation of other inorganic materials: This activity is limited to the collection of waste at the civic waste facility and re-use of construction and demolition waste at the facility as capping or on site road material.*
Class 9:	*Use of any waste principally as a fuel or other means to generate energy: This activity is limited to the use of landfill gas for the generation of electricity/ energy.*
Class 11:	*Use of waste obtained from any activity referred to in a preceding paragraph of this Schedule. This activity is limited to the use of compost generated on site in restoration works.*
Class 13:	*Storage of waste intended for submission to any activity referred to in a preceding paragraph of this Schedule, other than temporary storage, pending collection, on the premises where such waste is produced. This activity is limited to the storage of waste in receptacles and designated areas prior to recovery on or off site.*

4. Licence Requirements

Condition 12 of the Industrial Emissions licence requires the following:

12.3 Environmental Liabilities
12.3.1 The licensee shall as part of the AER, provide an annual statement as to the measures taken or adopted at the site in relation to the prevention of environmental damage, and the financial provisions in place in relation to the underwriting of costs for remedial actions following anticipated events (including closure) or accidents/incidents, as may be associated with the carrying on of the activity.
12.3.2 The licensee shall arrange for the completion, by an independent and appropriately qualified consultant, of a comprehensive and fully costed Environmental Liabilities Risk Assessment (ELRA) to address the liabilities from past and present activities. A report on this assessment shall be submitted to the Agency for agreement within twelve months of date of grant of this licence. The ELRA shall be reviewed as necessary to reflect any significant change on site, and in any case every three years following initial agreement.
The results of the review shall be notified as part of the AER.
12.3.3 As part of the measures identified in Condition 12.3.1, the licensee shall, to the satisfaction of the Agency, make financial provision to cover any liabilities associated with operation (including closure and aftercare) of the facility not already covered by Condition 12.2. The amount of indemnity held shall be reviewed and revised as necessary, but at least annually. Proof of renewal or revision of such financial indemnity shall be included in the annual 'Statement of Measures' report identified in Condition 12.3.1.

This report has been prepared to satisfy this condition of the waste licence. The methodology for the development of the ELRA follows EPA guidance and has been prepared to accurately reflect the risks of unplanned but plausible incidents occurring.

C. SCOPING

The licence condition for the activity states that the ELRA should address the liabilities from past and present activities. In this regard, all aspects of the historic operation and current site operations that pose a plausible risk to the environment are covered in this ELRA.
Planned liabilities associated with closure are not considered in this ELRA and have been addressed in the Closure Plan prepared in accordance with Condition 4 of the licence.

D. RISK IDENTIFICATION

The following section outlines the site characteristics which allow the plausible environmental risks for the activity to be identified.

1. Activity Processes and Activities

The site consists of an engineered landfill facility which accepts non-hazardous waste. Waste from the public is directed to a skip area, which is then transported to the active cells by tractor. Waste from contractors is delivered directly to the active cell. Waste is placed in the cell using a compactor and excavator.

As stated previously, the landfill consists of three phases:

- Phase 1 is an unlined landfill area which closed in 1992. This area is provided with an engineered cap.
- Phase 2 is a lined landfill area which closed in 2006. This area is provided with an engineered cap.
- Phase 3 is a lined landfill area which is now in operation.

All phases of the landfill contain a gas collection infrastructure which connects to a closed flare.

Phases 2 and 3 contain a leachate collection infrastructure which connects to leachate storage tanks.

A civic amenity facility is also contained within the landfill for domestic waste which can be recycled.

2. Inventory of Buildings, Equipment and Plant

- Phase 1, unlined landfill
- Phase 2, lined landfill
- Phase 3, lined landfill
- Leachate lagoon
- Leachate tank
- Surface water lagoon

- Leachate pumps
- Gas collection infrastructure
- Gas flare
- Public skip area
- Waste quarantine area
- Metal recycling area
- Timber/Green waste recycling area
- Civic Amenity area
- Administration building
- Weighbridge
- Wheelwash
- Compactor, excavator, tractor/trailers

3. Inventory of Raw Materials, Products and Waste

- Waste for disposal (2013)

Table 2

Type	Total tonnes
Municipal Waste	18182.20
Unauthorised Site Clean Up	205.88
Clean Up Areas)	498.06
Clean Out (Housing)	86.60
Fly Tipping	467.20
Garden Park	571.54
Litterbins	310.48
Street Cleaning Residues	790.20
Filter Sand	5.56
Screenings	342.14
Treated Sludge	279.46
Drain Cleaning	70.90
Alum Sludge (KKCC)	503.64
Total Disposed	**22314**

- Waste for recovery (2013)

Table 3

Batteries (Car)	8.26
Batteries (Household)	0.00
Bottle banks	73.14
Cardboard	74.18
Flat Glass	34.98
Flourescent Lights	0.60
Food Waste	29.86
Green Waste	269.02
Gypsum	7.74
Light Bulbs (Filament)	0.26
Oil Filters	0.82
Paint Cans	13.32
Paper / Mags	122.58
Plastic Bottles	51.48
Plastic Wrapping	11.00
Scrapmetal	112.54
Tetrapac	0.00
Textiles	6.90
Timber	125.16
Tyres	1.14
Waste Cooking Oil	2.46
Waste Engine Oil	5.04
WEEE	195.98
Total Recovered	**1146**

- Leachate: 10,600 (2013)
- Landfill Gas: 1,406,000 m^3 (2013)

Storage capacities on site are as follows:

- Total landfill waste capacity: 685,000 m^3 (100,000 m^3 remaining July 2014)
- Leachate Lagoon: 350 m^3
- Leachate Tank: 400 m^3
- Surface Water Lagoon: 1,000 m^3

4. Operator Performance

Carlow County Council maintains an Environmental Management System (EMS) which complies with Condition 2.3 of the waste licence which requires that:

'The licensee shall maintain an Environmental Management System. The EMS shall be updated on an annual basis with amendments being submitted to the Agency for its agreement.'

The EMS contains the following components and was last updated in August 2014.

- Schedule of Environmental Objectives and Targets
- Landfill Environmental Management Plan
- Corrective Action Procedures
- Awareness Training Programme

There following environmental complaints were received in relation to the facility in 2013:

- Flies (8)

The following notifiable incidents occurred in 2013:

- Groundwater trigger level exceeded (4)
- Flare shutdown (1)
- Perimeter gas well trigger level exceeded (10)
- VOC diffuse surface emission trigger level exceeded (1)
- Surface water lagoon outlet ELV exceeded (1)

Following EPA audit inspections the following non-compliances were noted:

- None

Monitoring takes place at the following locations in accordance with licence conditions.

- Landfill gas perimeter boreholes
- Upstream and downstream groundwater boreholes
- Perimeter dust locations
- Perimeter noise locations
- Upstream and downstream surface water locations
- Leachate storage tanks and lagoon
- VOC on waste surfaces
- Flare inlet and outlet

5. Environmental Pathways and Sensitivity

Groundwater:
The quaternary geology of the landfill area comprises unconsolidated deposits, most of which were laid down during and immediately following the last glaciation. During the various investigations carried out over the years at the Powerstown Facility, 5 m to 15 m of sands and gravel overlie the thin layer of lodgement till over the area of the landfill. The GSI database for the area shows that the site is underlain by the Milford and Ballysteen Formations. These are Dinantian dolomitised limestones. Both formations dip to the east at approximately 10%, the Milford Formation resting on top of the Ballysteen Formation. The lower part of the Ballysteen Formation consists of well-bedded, relatively clean calcarenitic limestones, which pass gradationally up into finer-grained and more muddy limestones.

The major aquifer in the Lower Carboniferous strata of the Barrow Lowlands is dolomitised limestone and it is classified as a Regionally Important Aquifer by the GSI. Groundwater enters Powerstown landfill via fissure flow in the bedrock and through the permeable fluvio-glacial gravel overburden. Aquifer flow direction is generally to the west towards the River Barrow, but with a northern component discharging to the Powerstown Stream.

Surface water

There is one surface water emission point to the Powerstown Stream, which in turn enters the River Barrow. The River Barrow is currently classed as having Good Status in accordance with Water Framework Directive classifications.

Natura 2000 Sites

The River Barrow is part of the River Barrow and River Nore SAC. Monitoring of the Powerstown Stream does not indicate any significant decrease in water quality downstream of the landfill.

A Natura Impact Statement was carried out in October 2011 which concluded that:

As no negative impacts on the Qualifying Interests of SAC 002162 were detected, it can be stated with full confidence that the Powerstown Landfill is not contributing to any significant cumulative impacts on Conservation Status of the Qualifying Interests of the SAC and is not affecting the sites Conservation Objectives and that no mitigation measures, additional to those already in place, are necessary. The engineering controls at the site, outlined in section 2, will operate to prevent accidental spillages. These are summarised as follows:

- *Direction of all surface water run-off to the surface water attenuation pond*
- *Continuous monitoring of the surface water pond and automatic cut-off controls when exceedances are detected*
- *Oil interceptor facilities at the surface water attenuation pond*
- *Collection of leachate in cells 1-18 and transfer to storage facilities.*

Groundwater

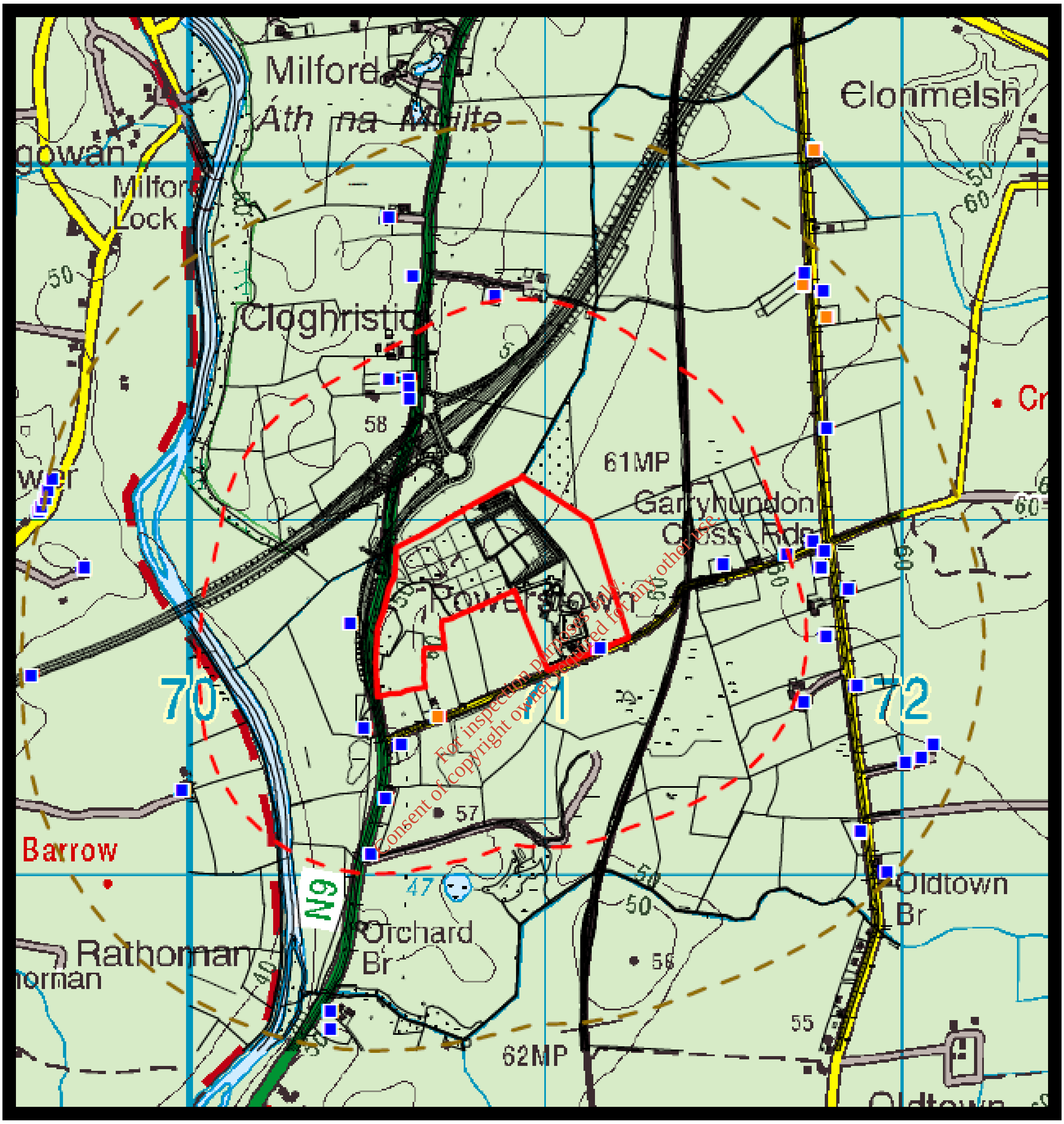
Groundwater monitoring results indicate that there may be diffuse leachate contamination from the unlined landfill, in the area to the west of the site. A Tier 3 Groundwater Risk Assessment, in order to ascertain the effect of the unlined landfill area on groundwater to the west of the facility, was completed in 2014. A copy has been sent to the Agency for comment.

The Risk Assessment concluded that there was no risk to the groundwater within the underlying gravel aquifer at a distance of 200m downgradient of the site associated with current site condition and offsite migration of impacted groundwater. It also concluded that further monitoring of the Powerstown stream be carried out over a 12 month period. This has now commenced.

Human Receptors

The following map shows the location of dwellings which are located within 1000m of the landfill (black dotted line) and within 500m of the landfill (red dotted line).

Figure 1: Location of Dwellings



Risk Identification

During the risk identification, all the processes on-site were identified and the risks associated with each process were listed. All potential causes of failure of the processes and the effect/impact on the environment were identified. All plausible environmental risks identified are listed in Table 4.

Table 4

Risk ID	Process	Potential Risk
1	Landfill fire in waste cells	Release of fugitive air emissions
2	Landfill fire in waste cells	Damage to basal liner, contamination of groundwater and/or soil
3	Active cell filling operations	Damage to basal liner, contamination of groundwater and/or soil
4	Failure of flare	Escape of landfill gas, explosion
5	Failure of gas collection system	Escape of landfill gas
6	Migration of landfill gas	Accumulation of landfill gas in structures
7	Leachate escape from unlined cells	Contamination of groundwater and/or soil
8	Failure of leachate tanks	Contamination of groundwater, soil or surface water
9	Overflow of leachate from cells	Contamination of groundwater, soil or surface water
10	Leachate breakout due to liner failure	Contamination of groundwater and/or soil
11	Leak during leachate tankering onsite	Contamination of groundwater, soil or surface water
12	Leak during leachate tankering offsite	Contamination of groundwater, soil or surface water
13	Failure of leachate collection infrastructure	Contamination of groundwater, soil or surface water
14	No capping in place	Increase in leachate generation, fugitive emissions
15	Degradation of capping	Increase in leachate generation, fugitive emissions
16	Breach of capping system	Increase in leachate generation, fugitive emissions
17	Fuel spillage during machinery fuelling operations from tanker	Contamination of groundwater, soil or surface water
18	Fuel spillage from Administration Building tank	Contamination of groundwater, soil or surface water
19	Weather conditions	Flooding causing uncontrolled surface water discharge

E. RISK ANALYSIS

The risks above were assessed against likelihood and consequence as per Tables 5 and 6 and the results are presented in Table 7.

Table 5: Risk Classification Likelihood

Rating	Likelihood	
	Category	**Description**
1	Very Low	Very low chance of hazard occurring
2	Low	Low chance of hazard occuring
3	Medium	Medium chance of hazard occuring
4	High	High chance of hazard occuring
5	Very high	Very high chance of hazard occuring

Table 6: Risk Classification Consequence

Rating	Consequence	
	Category	**Description**
1	Trivial	No impact or negligible change to the environment
2	Minor	Minor impact/localised or nuisance
3	Moderate	Moderate impact to the environment
4	Major	Severe impact to the environment
5	Massive	Massive impact to a large area, irreversible in medium term

Table 7: Risk Analysis

Risk ID	Process	Potential Risks	Environmental Effect	Likelihood rating	Basis of Likelihood	Consequence Rating	Basis of Consequence	Risk Score
1	Landfill fire	Release of fugitive air emissions	Release of hazardous compounds	2	Site supervision Training of operators Waste Acceptance Procedures	4	Air contamination	8
2	Landfill fire	Damage to basal liner, leakage of leachate to groundwater and/or soil	Groundwater contamination	2	Site supervision Training of operators Provision of composite liner Waste Acceptance Procedures	4	Leachate contamination would result in major effects on groundwater and regional aquifer	8
3	Active cell filling	Damage to basal liner, leakage of leachate to groundwater and/or soil	Contamination of groundwater	1	Site supervision Training of operators Provision of composite liner Provision of drainage layer and geotextile	3	Leachate contamination would result in major effects on groundwater and regional aquifer	3
4	Failure of flare	Escape of landfill gas Risk of explosion	Landfill gas air contamination Risk to operators	2	Regular service checks and construction CQA. ATEX Directive compliance	3	Effects of odours Risk of explosion	6
5	Failure of gas collection system	Escape of landfill gas Risk of explosion	Landfill gas air contamination	2	Regular maintenance checks and	3	Effects of odours	6

			Risk to operators		construction CQA. ATEX Directive compliance			
6	Migration of landfill gas	Accumulation of landfill gas in structures	Risk of explosion	1	Provision of lined cells to prevent migration	3	Risk to occupiers	3
7	Leachate escape from unlined cells	Contamination of groundwater and/or soil	Contamination of groundwater	4	This area has been capped, therefore minimised water infiltration.	3	Groundwater risk assessment indicates moderate impact from leachate	12
8	Failure of leachate tanks	Contamination of groundwater, soil or surface water	Groundwater contamination	2	Regular maintenance checks and construction CQA. Provision of retaining bund Provision of composite liner	3	Leachate contamination would result in major effects on groundwater	6
9	Overflow of leachate from cells	Contamination of groundwater, soil or surface water	Contamination of groundwater	2	CQA control of cell construction. Control of levels by SCADA system	3	Leachate contamination would result in major effects on groundwater	6
10	Leachate breakout due to liner failure	Contamination of groundwater and/or soil	Contamination of groundwater	2	CQA control of cell construction.	3	Leachate contamination would result in major effects on groundwater	6
11	Leak during leachate tankering onsite	Contamination of groundwater, soil or surface water	Groundwater or surface water pollution	2	Leachate transfer is in an area drained to the leachate collection system	3	Groundwater or surface water pollution	6
12	Leak during leachate tankering offsite	Contamination of groundwater, soil or	Groundwater or surface water pollution	2	Leachate transfer is in an area drained to	3	Groundwater or surface water	6

		surface water			the leachate collection system		pollution	
13	Failure of leachate collection infrastructure	Contamination of groundwater, soil or surface water	Groundwater contamination	2	Regular maintenance checks and construction CQA	3	Leachate contamination would result in major effects on groundwater	6
14	No capping in place	Increase in leachate generation Landfill gas escape	Additional leachate removal and treatment Additional landfill gas fugitive emissions	4	No capping in active cells	2	Minor effect due to gas extraction and leachate collection	8
15	Degradation of capping	Increase in leachate generation Landfill gas escape	Additional leachate removal and treatment Additional landfill gas fugitive emissions	2	Regular inspections of system VOC testing	2	Minor effect due to gas extraction and leachate collection	4
16	Breach of capping system	Increase in leachate generation Landfill gas escape	Additional leachate removal and treatment Additional landfill gas fugitive emissions	2	Regular inspections of system VOC testing	2	Minor effect due to gas extraction and leachate collection	4
17	Fuel spillage during machinery fuelling operations from tanker	Contamination of groundwater, soil or surface water	Contamination of surface water, groundwater and soil	2	Delivery only to contained areas allowed	2	Tanker volume is limited, hazardous and persistent hydrocarbons	4
18	Fuel spillage from Administration Building tank	Contamination of groundwater, soil or surface water	Contamination of surface water, groundwater and soil	2	Tank is provided with a bund.	3	Tanker volume is limited, hazardous and persistemt hydrocarbons	6
19	Weather	Flooding causing uncontrolled surface water discharge	Contamination of surface water,	3	Provision of storage lagoon with required capacity	3	Expected high flows in receiving waters.	9

F. RISK EVALUATION

The risks presented in the risk analysis are ranked in Table 8 to assist in identifying the risks for prioritisation in the risk treatment process.

Table 8: Risk Evaluation Table

Risk ID	**Process**	**Potential Risks**	**Likelihood rating**	**Consequence Rating**	**Risk Score**
7	Leachate escape from unlined cells	Contamination of groundwater and/or soil	4	3	12
19	Weather	Flooding causing uncontrolled surface water discharge	3	3	9
1	Landfill fire	Release of fugitive air emissions	2	4	8
2	Landfill fire	Damage to basal liner, contamination of groundwater and/or soil	2	4	8
14	No capping in place	Increase in leachate generation Landfill gas escape	4	2	8
18	Fuel spillage from Administration Building tank	Contamination of groundwater, soil or surface water	2	3	6
8	Failure of leachate tanks	Contamination of groundwater, soil or surface water	2	3	6
9	Overflow of leachate from cells	Contamination of groundwater, soil or surface water	2	3	6
10	Leachate breakout due to liner failure	Contamination of groundwater and/or soil	2	3	6
11	Leak during leachate tankering onsite	Contamination of groundwater, soil or surface water	2	3	6
12	Leak during leachate tankering offsite	Contamination of groundwater, soil or surface water	2	3	6
13	Failure of leachate collection infrastructure	Contamination of groundwater, soil or surface water	2	3	6
4	Failure of flare	Escape of landfill gas Risk of explosion	2	3	6
5	Failure of gas	Escape of	2	3	6

	collection system	landfill gas Risk of explosion			
15	Degradation of capping	Increase in leachate generation Landfill gas escape	2	2	4
16	Breach of capping system	Increase in leachate generation Landfill gas escape	2	2	4
17	Fuel spillage during machinery fuelling operations from tanker	Contamination of groundwater, soil or surface water	2	2	4
3	Active cell filling	Damage to basal liner, contamination of groundwater and/or soil	1	3	3
6	Migration of landfill gas	Accumulation of landfill gas in structures	1	3	3

The risk matrix is displayed in Table 9. The risks have been colour coded in the matrix to provide a broad indication of the critical nature of each risk to facilitate prioritisation of risks for treatment. The risk matrix indicates that there are 5 risks in the amber zone requiring priority treatment. All other risks are located in the green zone indicating the need for continuing awareness and monitoring on a regular basis. However, assessment of the green zone risks has indicated that a number of these risks can be reduced through the implementation of mitigation measures. These risk treatment measures will be adopted where considered cost-effective to further reduce the risks.

Table 9: Risk Matrix

5	**Very High Likelihood**	🟩	🟧	🟥	🟥	🟥
4	**High**	🟩	🟧 **14,**	🟧 **7,**	🟥	🟥
3	**Medium**	🟩	🟩	🟧 **19**	🟧	🟥
2	**Low**	🟩	🟩 **15,16,17**	🟩 **4,5,18,8,9,10,11, 12,13**	🟧 **1,2**	🟧
1	**Very Low**	🟩	🟩	🟩 **3,6**	🟩	🟩
		Trivial	**Minor**	**Moderate**	**Major**	**Massive Consequence**
		1	**2**	**3**	**4**	**5**

G. RISK TREATMENT

The output of the risk treatment process is the development of a statement of measures to be taken to minimise the environmental risk of the activity. The statement of measures is presented in the following table where a set of appropriate and achievable mitigation measures are assigned to each risk, with a risk owner responsibility for the on-going management of the risk and a timeframe for implementation of the risk mitigation measure.

Monitoring and review of the risk assessment process will be carried out to verify continuous improvement in the risk profile of an operation. This on-going review will also facilitate the inclusion of new risks and the updating of existing risks based on implemented risk treatment. The ELRA process will be conducted every three years in line with the licence/permit requirements but reviews should be carried out on a more regular basis in the event of major infrastructural changes on-site or in light of incident investigation.

Table 10: Statement of Measures

Risk ID	**Process**	**Potential Risks**	**Risk Score**	**Mitigation Measures**	**Outcome**	**Action**	**Completion Date**	Landfill Manager
7	Leachate escape from unlined cells	Contamination of groundwater and/or soil	12	Carry out Tier 3 Risk Assessment	Low risk to downstream receptor	On-going stream monitoring	2015	Landfill Manager
19	Weather	Flooding causing uncontrolled surface water discharge	9	Surface water lagoon is designed to control peak flows	On-going maintenance works	Continue surface water system maintenance and controls	On-going	Landfill Manager
1	Landfill fire	Release of fugitive air emissions	8	Waste Acceptance procedures in place	Loads are inspected in order to ensure compliance with procedures	Continue implementation of Waste Acceptance procedures	On-going	Landfill Manager
2	Landfill fire	Damage to basal liner, contamination of groundwater and/or soil	8	Waste Acceptance procedures in place	Loads are inspected in order to ensure compliance with procedures	Continue implementation of Waste Acceptance procedures	On-going	Landfill Manager
14	No capping in place	Increase in leachate generation Landfill gas escape	8	Gas extraction in active cells Temporary capping in other cells	Minimisation of gas escape and leachate generation	Continue provision of temporary gas collection infrastructure	On-going	Landfill Manager
18	Fuel spillage from Administration Building tank	Contamination of groundwater, soil or surface water	6	Carry out bund integrity checks	Confirm bund integrity	Testing required every 3 years	On-going	Landfill Manager
8	Failure of leachate tanks	Contamination of groundwater, soil or surface water	6	Carry out bund integrity checks on storage tank CQA completed on leachate lagoon	Confirm storage integrity	Testing required every 3 years	On-going	Landfill Manager
9	Overflow of leachate from cells	Contamination of groundwater, soil or surface water	6	Provision of SCADA system to control levels	Ensure levels are < 1 metre	Daily checks are carried out	On-going	Landfill Manager
10	Leachate breakout due to liner failure	Contamination of groundwater and/or soil	6	Carry out surface water and groundwater monitoring. CQA completed on liner installation	Ensure no impact is apparent	Carry out required licence monitoring programme	Quarterly	Landfill Manager

11	Leak during leachate tankering onsite	Contamination of groundwater, soil or surface water	6	Provision of method statement to ensure correct operation	Ensure no leaks occur	Weekly supervision of operations	Weekly	Landfill Manager
12	Leak during leachate tankering offsite	Contamination of groundwater, soil or surface water	6	Provision of method statement to ensure correct operation	Ensure no leaks occur	Weekly supervision of operations	Weekly	Landfill Manager
13	Failure of leachate collection infrastructure	Contamination of groundwater, soil or surface water	6	Carry out routine leak testing	Ensure no leaks occur	Carry out required testing	Annually	Landfill Manager
4	Failure of flare	Escape of landfill gas Explosion	6	Appoint specialist contractor to carry out maintenance and calibration	Ensure flare is operating in accordance with manufacturers specification	Carry out required works and testing	Quarterly	Landfill Manager
5	Failure of gas collection system	Escape of landfill gas	6	Inspection of infrastructure Routine VOC testing	Ensure no leaks occur	Provision of required testing	Weekly by site staff Bi-annually by specialist contractor	Landfill Manager
15	Degradation of capping	Increase in leachate generation Landfill gas escape	4	Inspection of infrastructure Routine VOC testing	Ensure no leaks occur	Provision of required testing	Weekly by site staff Bi-annually by specialist contractor	Landfill Manager
16	Breach of capping system	Increase in leachate generation Landfill gas escape	4	Inspection of infrastructure Routine VOC testing	Ensure no leaks occur	Provision of required testing	Weekly by site staff Bi-annually by specialist contractor	Landfill Manager
17	Fuel spillage during machinery fuelling operations from tanker	Contamination of groundwater, soil or surface water	4	Provision of method statement to ensure correct operation	Ensure no leaks occur	Weekly supervision of operations	Weekly	Landfill Manager
3	Active cell filling	Damage to basal liner, contamination of groundwater and/or soil	3	Carry out supervision of waste placement	Confirm that operation comply with Waste Acceptance procedures.	Landfill staff carry out required checks	Daily	Landfill Manager

6	Migration of landfill gas	Accumulation of landfill gas in structures	3	Provision of gas alarms in buildings for methane and carbon dioxide	Ensure trigger levels are not exceeded.	Carry out required calibration checks..	On-going	Landfill Manager

H. WORST CASE SCENARIO

The worst case scenario refers to the event that poses the maximum environmental liability, i.e. consequence, during the period to be covered by the financial provision. The worst case scenario may be represented by the risk with the highest consequence rating. In that case, this risk should be the basis for financial provision and should be quantified and costed. Where two or more risks are identified as having the maximum consequence, then further analysis should be undertaken to identify the most significant of these for quantification and costing. There may be links/domino-effects between individual risks, in which case a number of risks may need to be grouped to represent a worst case scenario. The likelihood is not taken into account in this analysis. Once a risk is considered plausible, it must be included in the assessment.

The worst case scenario is represented by a combination of Risk ID 1 and 2 which represents the risk posed by a fire in the landfill cell area.

I. QUANTIFICATION AND COSTING

Table 11: Quantification and Costing of Worst Case Scenario

Task	Description	Quantity	Unit	Rate	Cost	Rate Source
Response to major fire in landfill active cell area	Fire Fighting	10	day	20,000	200,000	EPA Guidance
	Excavation and construction of temporary lined fire water containment	2	unit	10,000	20,000	EPA Guidance
	Disposal of fire water	2000	M^3	25	50,000	EPA Guidance
	Consultancy costs	20	day	600	12,000	EPA Guidance
	Excavation, transport and placement of burning/hot waste	20	day	3000	60,000	Current rates
	Temporary concrete storage area for	5000	M^2	40	200,000	Current rates

	burning/hot wastes					
	Leachate management	8,000	M^3	10	80,000	Estimated
	Construct new lined waste cell to contain treated waste	5,000	M^2	150	750,000	Recent rates
	Supervision of works	20	day	100	2,000	Estimated
	Surface water monitoring	40	sample	130	5,200	EPA Guidance
	Groundwater monitoring	200	sample	150	30,000	EPA Guidance
	Waste monitoring	40	sample	200	8,000	EPA Guidance
	Air monitoring	40	sample	200	8,000	EPA Guidance
	Ecological monitoring	12	sample	1,200	12,000	EPA Guidance
	Security	20	day	400	8,000	Estimated
	Contingency (10%)				150,000	
				Total	**1,595,200**	

J. CONCLUSION

During the risk identification, all the processes on-site were identified and the risks associated with each process were listed. All potential causes of failure of the processes and the effect/impact on the environment were identified.

The worst case scenario is represented by a combination of Risk ID 1 and 2 which represents the risk posed by a fire in the landfill cell area.

The costs identified with thus scenario have been calculated at €1,595, 200

MAPS

NOTES

1. This drawing is the property of Carlow County Council. It is a confidential document and must not be copied, used, or its content divulged without prior written consent.
2. DO NOT SCALE, use figured dimensions only, if in doubt ask.

LEGEND

● PERIMETER GAS

No	Date		Amendment / Issue	
A	xx/xx/xx		xxxxxxxxxxxxxxxx	

CARLOW COUNTY COUNCIL

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Phone: [illegible] Fax: [illegible]
Email: [illegible]
Carlow Local Authorities, A [illegible] Accredited Company

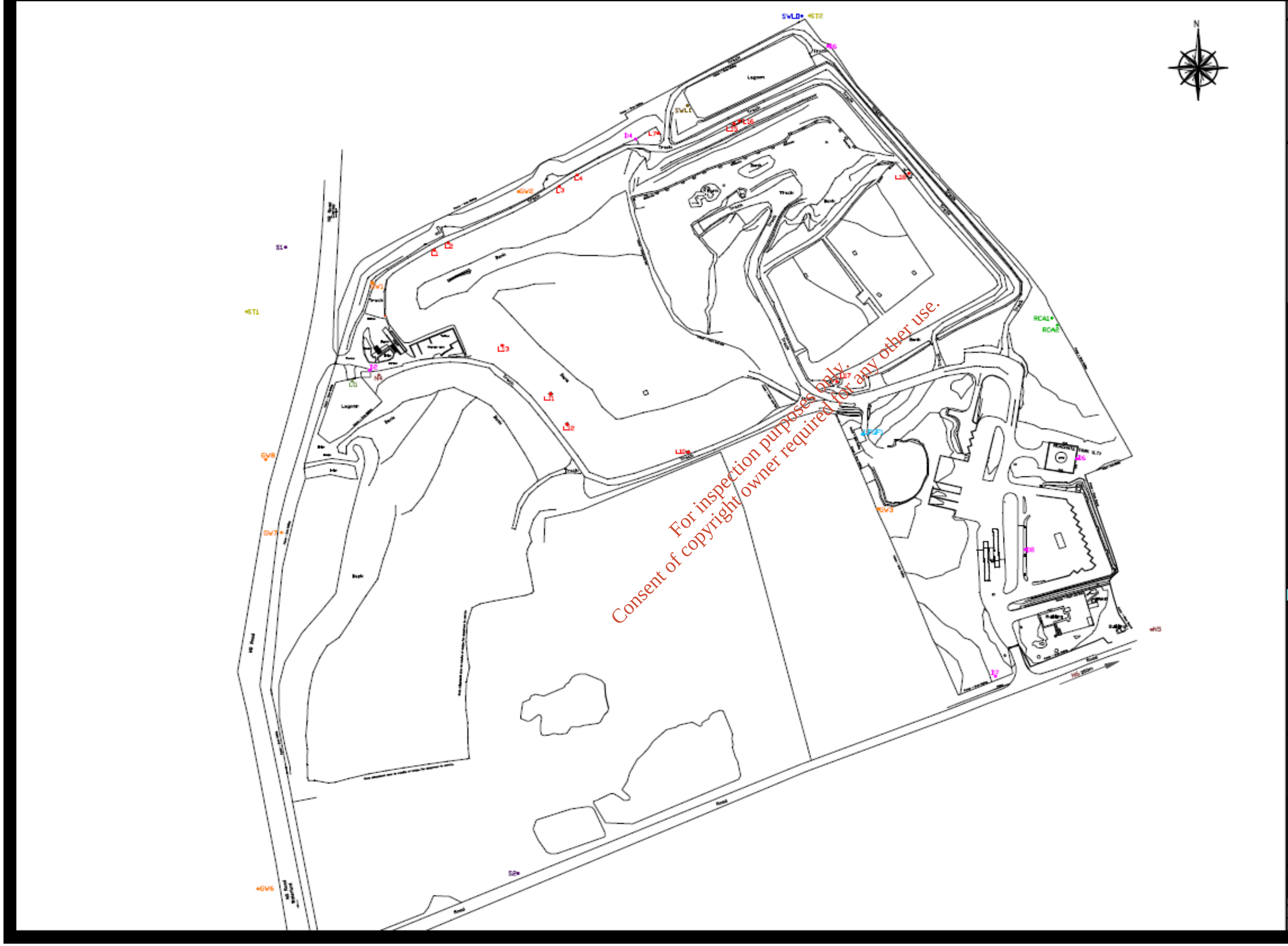
Project:

POWERSTOWN LANDFILL

Title:

PERIMETER GAS MONITORING

Drawn by:	S.K.	Job No:	XXXXXXXXXXXXXX
Checked by:	P.C.	Dwg Loc:	XXXXXXXXXXXXXX
Approved by:	P.C.	Dwg. No: XXXX	Rev: A
Scale:	1/1,250		
Date:	[illegible]		



NOTES

1. This drawing is the property of Carlow County Council. It is a confidential document and must not be copied, used, or its content divulged without prior written consent.
2. DO NOT SCALE, use figured dimensions only, if in doubt ask.

LEGEND

●	GROUND WATER (GW)
●	GROUND WATER (RCA)
●	NEW LOCATION OF FLARE (LFGF1)
●	NOISE (N)
●	NOISE (S)
●	SURFACE WATER POINT (ST)
●	OUTLET FROM SURFACE WATER LAGOON (SWLO)
●	DUST (D)
●	LEACHATE (L)
●	LEACHATE LAGOON (LS)
●	INLET TO SURFACE WATER LAGOON (SWLI)

No	Date		Amendment / Issue	App.
A	xx/xx/xx		xxxxxxxxxxxxxxxx	J.C.

CARLOW COUNTY COUNCIL

Director Of Services: John Carley
The Assembly Rooms, [illegible] Dublin Street, Carlow
Phone: [illegible] Fax: [illegible]
Email: [illegible]

Carlow Local Authorities, A EPD Accredited Company

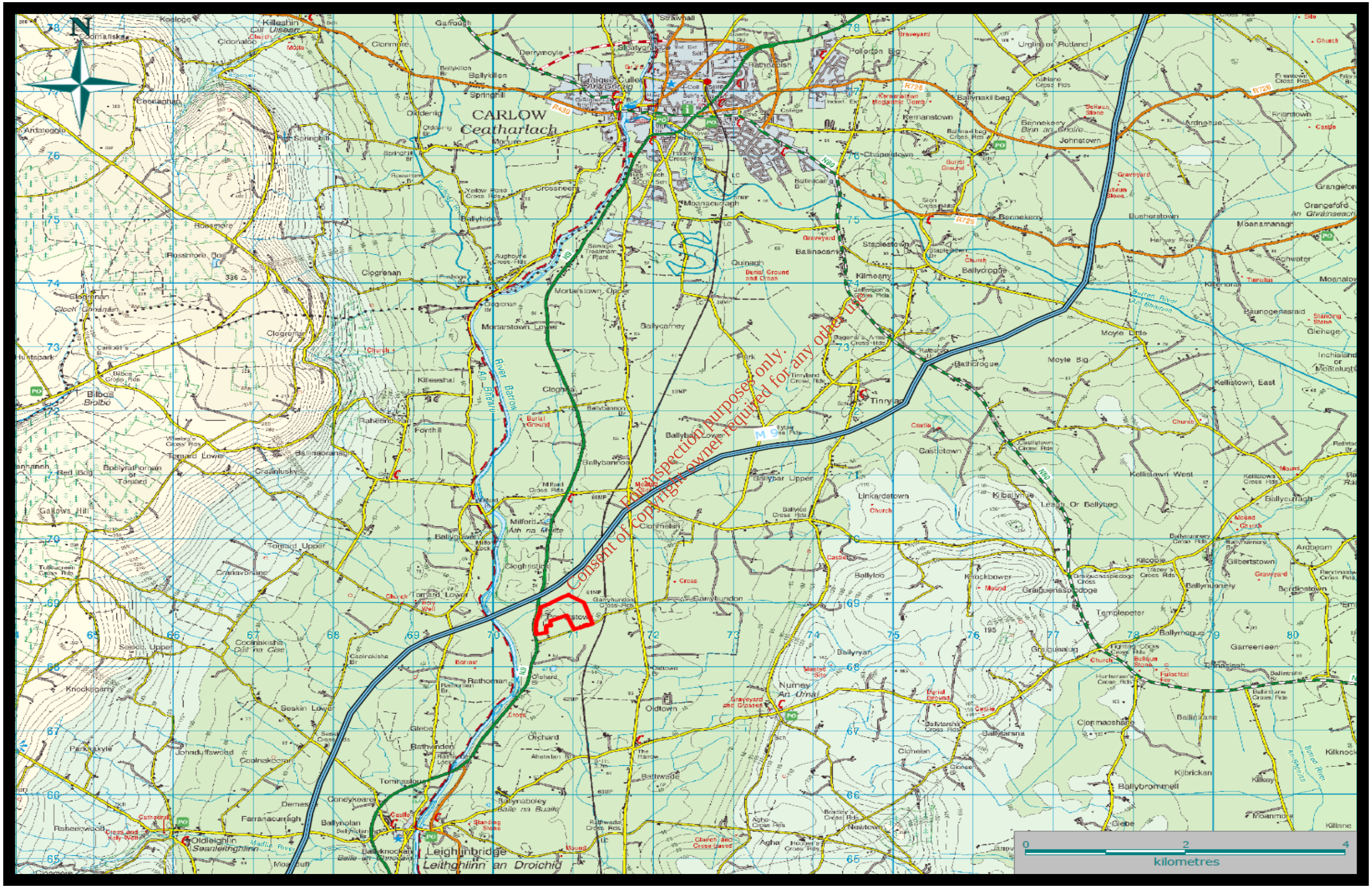
Project:

POWERSTOWN
LANDFILL

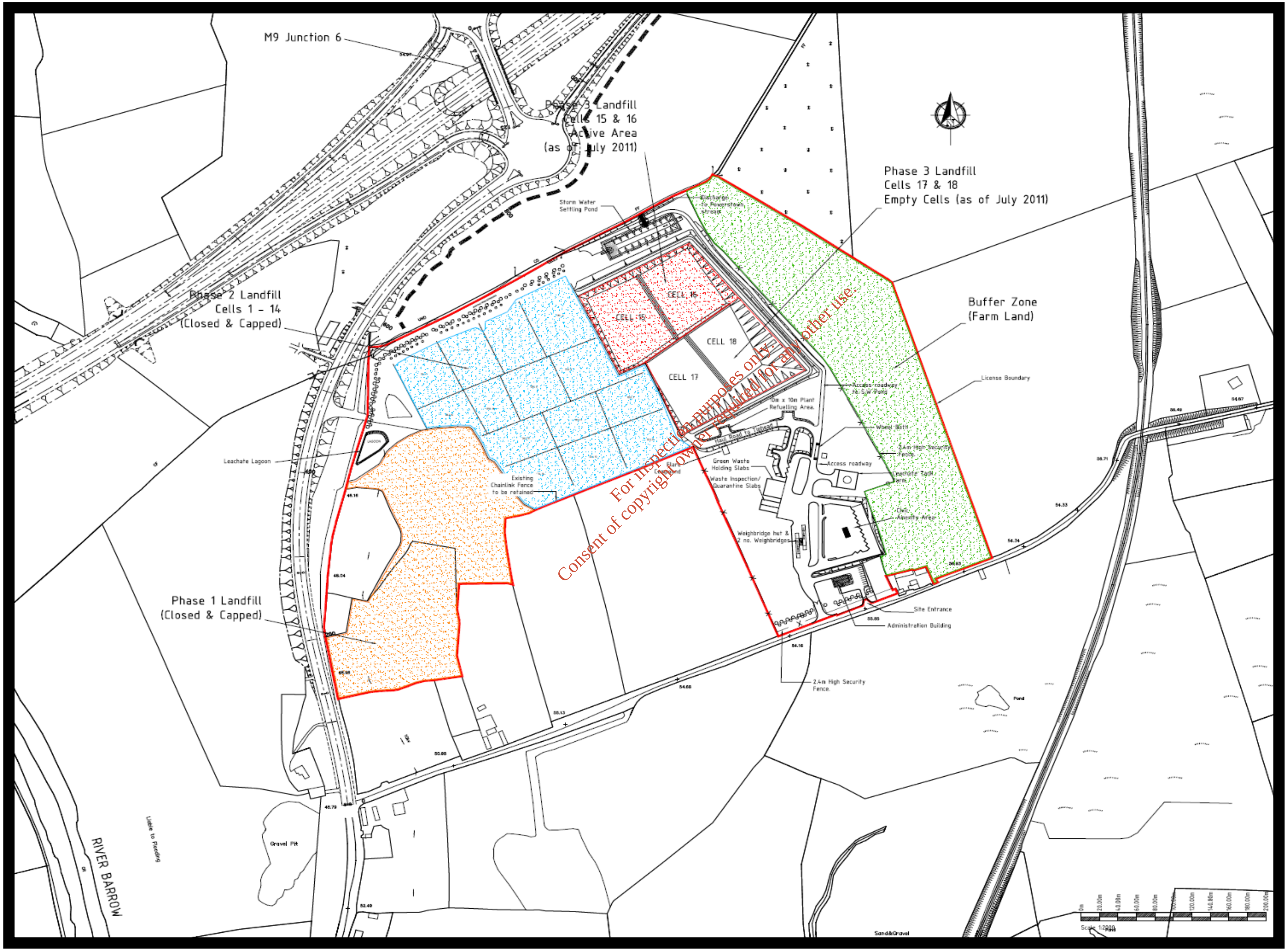
Title:

LANDFILL
MONITORING NON-GAS

Drawn by:	S.K.	Job No:	XXXXXXXXXXXXXX
Checked by:	P.C.	Drw Loc:	XXXXXXXXXXXXXX
Approved by:	P.C.	Dwg. No: XXXX	Rev: A
Scale:	1/1,250		
Date:	[illegible]		



N
CARLOW
Ceatharlach
Leighlinbridge
Leithghlinn an Droichid
River Barrow
M 9
N9
R726
0
2
4
kilometres


M9 Junction 6
Phase 3 Landfill
Cells 15 & 16
Active Area
(as of July 2011)
Phase 3 Landfill
Cells 17 & 18
Empty Cells (as of July 2011)
Storm Water
Settling Pond
Discharge
to Powerstown
stream
CELL 16
CELL 15
CELL 18
CELL 17
Buffer Zone
(Farm Land)
License Boundary
Access roadway
to S.W Pond
10m x 10m Plant
Refuelling Area.
Haul Road to Tiphead
Wheel Bath
2.4m High Security
Fence
Access roadway
Leachate Tank
Farm
Civic
Amenity Area
Green Waste
Holding Slabs
Waste Inspection/
Quarantine Slabs
Flare
Compound
Weighbridge hut &
2 no. Weighbridges
Site Entrance
Administration Building
2.4m High Security
Fence.
Phase 2 Landfill
Cells 1 - 14
(Closed & Capped)
Leachate Lagoon
LAGOON
Existing
Chainlink Fence
to be retained
Phase 1 Landfill
(Closed & Capped)
Pond
Gravel Pit
Liable to Flooding
RIVER BARROW
Sand&Gravel
Scale 1:2000
0m
20.00m
40.00m
60.00m
80.00m
100.00m
120.00m
140.00m
160.00m
180.00m
200.00m