INTEGRATED MATERIALS SOLUTIONS

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Mr David Flynn
Programme Manager, Licencing
Environmental Protection Agency
McCumiskey House
Clonskeagh
Dublin 14

Via Eden

6 December 2018

Dear Mr Flynn,

RE: Technical Amendment Request W0129-02
Change to Waste Acceptance Limits

Integrated Materials Solutions Limited Partnership (IMS) which to apply for a Technical Amendment to Waste Licence W0129-02 in relation to the waste acceptance limits which apply at the landfill facility.

Background

A scoping document was submitted to the Agency's Licence Enforcement Team on 8 March 2018 setting out IMS's intention to request the Agency's approval to change the waste acceptance criteria limits for a number of parameters for specific wastes (Attachment 1).

Following initial feedback IMS commissioned a Hydrogeological Risk Assessment (HRA) and a request for approval was submitted to the Agency's Licence Enforcement Team on 8 June 2018 (LR035174). The submission included the detailed HRA report and a cover letter.

A meeting was held with the site's Inspector team, other Agency staff and Cian O'Hora IMS on 21 August and the Agency requested some additional information and a narrowing of the scope of the request (Attachment 2).

On the back of the meeting further information was submitted on 6 September including a revised report and cover letter (Attachment 3). Additional unrequested further information was submitted on 12 November 2018 (Attachment 4).

On 27 November the site's Inspector informed us that while the Agency were satisfied with the technical elements of the submission, they were of the opinion that the request necessitated a Technical Amendment (Attachment 5).

Specific Wastes & National Waste Capacity

The specific type of waste which this submission relates to is Soil & Stone (17 05 04) and Dredging Material (17 05 06) which currently fall outside of the limits specified in the Licence (Schedule A4). These waste types can display a range of chemical profiles. Dredging spoil regularly contain elevated levels of sulphate and chloride due to the coastal environmental and saline influence. Soil and Stone can also contain elevated concentrations of a number of parameters which may be naturally occurring or due to site history.

The Waste Licence and underlying Landfill Directive allow for the Regulator to increase the limits on a site-specific bases if it is demonstrated that the predicted emissions from the Site will present no additional risk to the environment.

Since 2016 the increase in construction activity and economic activity in general along with additional factors has led to a shortage in capacity in non-hazardous landfills and other waste outlets. The volume of construction and demolition waste in 2016 has been estimated by the Regional Waste Coordinators at 5.4 million tonnes of which c. 12% fall outside the inert WAC limits. The portion of C&D waste which falls outside the inert WAC limits has to either dispose to non-hazardous landfill or export to another country. Both options have significant cost and sustainability implications.

The current projections for C&D wastes are set to increase in the coming years to c. 8 million tonnes in 2020. There is little to no corresponding increase in available void space currently. The Hollywood landfill could present a solutions to divert some of the construction waste material currently taking up valuable space in the non-hazardous landfills which are better suited to MSW or other non-hazardous wastes with a much higher pollution potential.

The specified waste types and parameters have been shown to present no additional risk to groundwater if deposited at the Hollywood landfill. It is hoped that additional specified wastes can be added to risk assessment following further research and testing.

We trust that the enclosed information is satisfactory and if you require any further information please do not hesitate to contact the undersigned.

Yours sincerely,

Cian O'Hora MSc CSci PGeo EurGeol MCIWM MCIWEM
On behalf of IMS

ATTACHMENT 1: SCOPING DOCUMENT

GOLDER

TECHNICAL MEMORANDUM

DATE 08 March 2018 1775927.TM01.B0

TO Mr. Cian O'Hora
Integrated Materials Solutions Limited Partnership

CC Ruth Treacy, Anna Goodwin

FROM Peter Corrigan **EMAIL** pcorrigan@golder.com

SUBMISSION TO EPA REQUESTING CHANGE TO WASTE ACCEPTANCE CRITERIA AS STIPULATED UNDER WASTE LICENCE REGISTER NO. W0129-02

Golder Associates Ireland Ltd (Golder) has been retained by Integrated Materials Solutions Limited Partnership (IMS) to investigate if a proposal for increases to the WAC stipulated under the waste licence for the Hollywood Landfill (W0129-02) could be supported through the preparation of a hydrogeological model and hydrogeological risk assessment (HRA). This proposed change is driven by industry requirements and void capacities at existing landfills to accept these wastes which are currently marginally above the WAC for Hollywood Landfill. The document outlines the background to this proposal, the concept behind the proposal as well as the methodology that would be proposed.

1.0 BACKGROUND

COUNCIL DECISION (2003/33/EC) of 19 December 2002 established criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC. This Decision took effect on 16 July 2004 and Member States were required to apply the criteria set out in section 2 of the Annex to this Decision by 16 July 2005. Section 2 of this Annex lays down the acceptance criteria for each landfill class. Waste may be accepted at a landfill only if it fulfils the acceptance criteria of the relevant landfill class as laid down in section 2 of this Annex.

The first paragraph of section 2 of the Annex states the following:

2. WASTE ACCEPTANCE CRITERIA

This section sets out the criteria for the acceptance of waste at each landfill class, including criteria for underground storage.

In certain circumstances, up to three times higher limit values for specific parameters listed in this section (other than dissolved organic carbon (DOC) in sections 2.1.2.1, 2.2.2, 2.3.1 and 2.4.1, BTEX, PCBs and mineral oil in section 2.1.2.2, total organic carbon (TOC) and pH in section 2.3.2 and loss on ignition (LOI) and/or TOC in section 2.4.2, and restricting the possible increase of the limit value for TOC in section 2.1.2.2 to only two times the limit value) are acceptable, if

- *The competent authority gives a permit for specified wastes on a case-by-case basis for the recipient landfill, taking into account the characteristics of the landfill and its surroundings, and*
- *Emissions (including leachate) from the landfill, taking into account the limits for those specific parameters in this section, will present no additional risk to the environment according to a risk assessment.*

Member States shall report to the Commission on the annual number of permits issued under this provision. The reports shall be sent to the Commission at intervals of three years as part of the reporting on the implementation of the Landfill Directive in accordance with the specifications laid down in Article 15 thereof.

Member States shall define criteria for compliance with the limit values set out in this section.

Section 2 of the Annex continues to provide waste acceptance criteria for various waste acceptance scenarios at different landfills; these are summarised as follows:

- *2.1. Criteria for landfills for inert waste;*
- *2.2. Criteria for landfills for non-hazardous waste;*
- *2.3. Criteria for hazardous waste acceptable at landfills for non-hazardous waste pursuant to Article 6(c)(iii);*
- *2.4. Criteria for waste acceptable at landfills for hazardous waste; and*
- *2.5. Criteria for underground storage*.

As Hollywood Landfill is an inert landfill, only sub section 2.1 of section 2 of the Annex applies and as such, the above paragraph relating to allowing three times higher limit values can be simplified (in terms of W0129-02) to read as follows:

"In certain circumstances, up to three times higher limit values for specific parameters listed in this section (other than dissolved organic carbon (DOC) in sections 2.1.2.1, BTEX, PCBs and mineral oil in section 2.1.2.2, and restricting the possible increase of the limit value for TOC in section 2.1.2.2 to only two times the limit value) are acceptable, if

- *The competent authority gives a permit for specified wastes on a case-by-case basis for the recipient landfill, taking into account the characteristics of the landfill and its surroundings, and*
- *Emissions (including leachate) from the landfill, taking into account the limits for those specific parameters in this section, will present no additional risk to the environment according to a risk assessment."*

2.0 OUTLINE OF CONCEPT FOR ASSESSING EMISSIONS TO GROUNDWATER OF PROPOSED UPDATE TO WAC FOR W0129-02

2.1 Assessment objective

The fundamental objective behind this WAC revision proposal is to present a hydrogeological model developed using LandSim that demonstrates the predicted concentrations in groundwater, which do not exceed selected water quality standards when concentrations in the waste input are increased. This increase in waste input concentrations could be up to three times existing limits in the case of some parameters as outlined above; however, the extent of any proposed increase would be determined through the development of the model. At this point in time, it is possible that the model results may not support increases of up to three times WAC limits, or any increases in WAC limits at all. If the model predictions indicate that a commercially viable increase in WAC limits are favourable, such a proposal would then be put to the EPA who would then be in a position to decide if such a proposal could be approved.

2.2 Methodology

The selection of LandSim as the appropriate modelling tool will be determined by reviewing the extensive available information regarding the geological and hydrogeological setting for the site, including groundwater levels and basal cell elevations. If LandSim modelling remains appropriate, this same site-specific information will also be used to update existing LandSim models to predict the concentration of selected parameters in groundwater at a downgradient compliance point.

LandSim allows for a probabilistic assessment of risk and takes into account uncertainty or natural variation in input parameters, such as leachate composition and the properties of the surrounding environment. A LandSim datasheet is attached to the document. Exact values of input parameters are rarely known. However, each parameter can be described by a range of possible/probable values incorporating the available information. During each simulation the parameters are assigned a value from within the defined ranges. After the model iterations have been completed, a range of possible predicted leakage or outcome values are obtained and it becomes possible to quantify the likelihood of a certain outcome.

This approach uses statistical distributions or probability density functions (PDFs) to characterise some of the input parameters. Each time a calculation is carried out, one value from the defined input distributions is chosen by the computer code and, for example, a concentration at the receptor is calculated. Each result is stored such that after repeating the same calculation many times, an output distribution for the concentration at the receptor is obtained. The distribution output is given in terms of percentiles (%iles). These percentiles specify the probability with which a certain value (e.g. leakage rate) will not be exceeded. For instance, if the 95%ile of a leakage rate distribution is given as 0.1 m^3/day, there is a 95% chance that the actual leakage rate will be below or equal to 0.1 m^3/day. It follows that there is also a 5% chance that the actual leakage rate will be greater than 0.1 m^3/day. The 50%ile output is viewed as the most likely result from the model. The 95%ile output is typically used as a sufficient level of probability to represent the reasonable worst-case output.

In terms of the hydrogeological model that would be developed, the following should be noted:

- It is not intended that every parameter in the full WAC testing suite is modelled in LandSim;
- Model parameters will be selected based on those parameters known to be higher than the standard WAC limits but within the increases that may be permitted under COUNCIL DECISION (2003/33/EC); and
- There are some parameters in the WAC list that we cannot model (e.g. DOC, TDS, TOC, PCBs and Mineral oil).

Although the final list of parameters that would be modelled needs to be confirmed after a comprehensive assessment of available leachate data as well as specific data for the proposed waste streams (C&D fines and currently permitted dredging spoil EWC 170506), the following is suggested as a provisional list of what the modelling may include based on current knowledge of the waste streams:

- Sulphate (common in waste stream and an example of an inorganic cation);
- Chloride (common in waste stream and an example of an unretarded inorganic anion);
- Antimony (common in waste stream);
- Selenium (common in waste stream); and
- Molybdenum (common in waste stream).

We are seeking feedback from the EPA in relation to whether the proposed methodology outlined above is acceptable and will allow the proposal to be adequately assessed. We trust that this memorandum clearly sets out the objectives and methodology that will be adopted in trying to achieve these objectives. Golder uses the LandSim software to support numerous projects each year, including 6-yearly reviews of hydrogeological risk assessments and to supporting proposed permit variations. Recent projects have included a series of hydrogeological risk assessment reviews for Viridor at its sites in England where modelling was required to determine the risk presented to the water environment by a change in the leachate source terms.

3.0 INDUSTRY ASSESSMENT

As construction activity increases throughout Ireland the volume of construction and demolition wastes from basement excavations, port developments and civils projects has increased significantly in recent years. Other related wastes have also increased such as the fines materials generated by the processing of construction and demolitions skips (C&D fines) which have been estimated at c. 200,000 tonnes/annum. These materials generally fall outside the inert landfill limits and have previously been used as engineering materials at a limited number of sites including non-hazardous landfills and mines. The volume of non-inert non-hazardous soil and stones has been estimated at 325,000 tonnes but which could be higher with the current proposals for Dublin Port estimated at generating 150,000 to 200,000 tonnes alone. The volumes of these materials is projected to increase and changes in the allocation of engineering materials and operational practices at licenced sites has resulted in significant shortfalls in void capacity for these types of materials anticipated for mid-2018 and for the coming years. This shortfall of 250,000 tonnes/annum (minimum) has been projected by the Irish Waste Management Association and has been flagged in the National Capacity Reports and Construction Infrastructure Federation Publications. A significant volume of this material is marginally into the non-hazardous landfill categories due to elevated concentrations of sulphates, chloride or heavy metals some of which may be naturally occurring due to the materials environmental setting (e.g. sulphates and chlorides in dredging material).

4.0 CLOSING

We trust that the concept and methodology set out in this document is clear, should you or any other stakeholders require any further clarification, please do not hesitate to contact either of the undersigned and we will provide further clarification as necessary.

Peter Corrigan
Principal

Ruth Treacy
Senior Environmental Scientist

PC/RT/ar

LANDSIM 2.5
GROUNDWATER RISK ASSESSMENT TOOL FOR LANDFILL DESIGN

LandSim was developed by Golder Associates for the Environment Agency of England and Wales and launched in 1996 as a tool to assess the leakage of leachate from landfill sites and its impact on groundwater, to satisfy the requirements of the EU Groundwater Directive (80/68/EEC). It is a well structured and user friendly tool that assesses leakage from a landfill, attenuation in the subsurface environment, and dilution and contaminant transport in the saturated zone.

LandSim uses the Monte Carlo simulation technique to create values for parameters for use in the model calculations by random selection from a pre-defined range (probability density functions). This process is repeated many times to give a range of output values.

LandSim allows landfill operators and regulators to consider the environmental performance of different liners and leachate collection systems, and to take account of the large variety of geological and hydrogeological regimes.

The EU Landfill Directive (99/31/EC) requires pollution to be prevented during the entire life cycle of the landfill.

LandSim 2.5 was launched in 2003 to take account of the inevitable future failure and degradation of active engineering and management control systems.

The model considers changes in the integrity of engineering and other active management control measures throughout the period (centuries) that landfills have the potential to pollute.

The sophisticated approach to simulating changes in leachate quality over time, which was introduced for the EU Landfill Directive's waste acceptance criteria negotiations, has been included in LandSim 2.5.

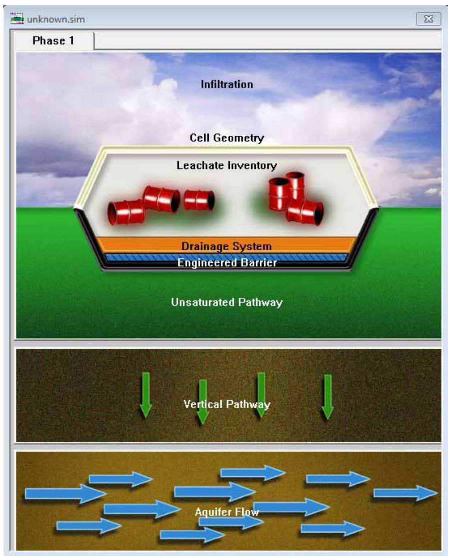
LANDSIM 2.5 OUTPUTS

- Hydraulics: Leachate head, leakage, flow to leachate treatment plant, surface breakout, dilution, leakage, and aquifer flow;
- Concentrations: Source, underside of liner, base of the unsaturated zone, base of the vertical pathway, within the aquifer (monitoring well & compliance point);
- Travel times: Time to peak concentration at base of unsaturated zone and saturated zone (monitoring well & compliance point), breakthrough time.

LandSim 2.5 is also available in a variety of language interfaces.

L A N D · S I M

Visit the LandSim website:
http://www.landsim.co.uk



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For further information please contact:

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LandSim@golder.com

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ATTACHEMENT 2: MEETING MINUTES

Meeting Minutes

MTG000091 - W0129-02, 21/08/2018, WAC Proposal

Organisation:	Integrated Materials Solutions Limited Partnership
Date:	21/08/2018
Regarding:	Other
Location:	Meeting Room 2, McCumiskey House

Attendees

Representing EPA

Cathal Gahan
Carol O'Sullivan
Kevin Motherway

Representing Organisation and/or Other

Cian O'Hora

Licences

Reg No	Licence	County
W0129-02	Integrated Materials Solutions Limited Partnership	Dublin

Issues and Action Items

The EPA and the licensee met to discuss the submission LR035174 "Increase to WAC limits - Hydrogeological Risk Assessment" in relation to the increase of the Waste Acceptance Criteria (WAC) limits for the Hollywood Landfill.

The Agency outlined that the licensee shall narrow the scope of the request, detailing the specific parameters for which they are seeking an increase of WAC for each specific waste stream, providing a justification for same.

Attachments

Documents

ATTACHEMENT 3: RFI RESPONSE COVER LETTER
REVISED HYDORGEOLOGICAL RISK ASSESSMENT REPORT

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Mr Cathal Gahan
Waste Enforcement Section
Environmental Protection Agency
McCumiskey House
Clonskeagh
Dublin 14

Via Eden Only

6 September 2018

RE: Response to Request for Information in relation to Licence Return LR035174

Date: 23 August 2018

This letter and the accompanying revised report set out a response to the Request for Further information issued by the Agency on 22 August in relation to LR035174. The report has been prepared by Golder Associates on behalf of Integrated Materials Solutions.

1. ***Details as to the waste types (including List of Waste code) and parameters for each waste type to which you wish to apply for an increase in WAC.***

The primary waste types which this application relates to is **Soil & Stone, 17 05 04.** Based on current construction activity and enquiries received over the past 12 months we anticipate that this will account for the bulk of material accepted under this request if approved.

Secondary waste types which we also wish to apply for the increased limits include:

LoW Code	Description	Comment
17 05 06	Dredging spoil	Elevated Sulphate and Chloride concentrations are commonly found in coastal environments.
17 09 04	Mixed construction & demolition wastes	Relevant for made ground where there is an element of demolition type materials mixed with soil (e.g. concrete, brick, tile)
19 09 02	Sludges from water clarification	Seasonal variation can result in TOC levels marginally in access of 3% during the winter months
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	Rubble from MRF sites Fines from the recovery of C&D wastes

All the specified wastes must also be classified as non-hazardous and will be subject to waste specific Level 1 Characterisation as required under the Landfill Directive and Waste Licence W0129-02.

Where there is a potential for variability in the specific waste stream a higher frequency of characterisation testing will be required to ensure materials confirm to the specified parameter limits.

The parameters which are proposed to be increased are relevant to the specified wastes are; sulphate, chloride, antimony, selenium, molybdenum, arsenic and Total Dissolved Solids (TDS); and a two times increase for total organic carbon (TOC). All of these parameters have been modelled in the current Hydrogeological Risk Assessment (HRA). It is not proposed that any of the other waste limit values will be increased currently.

2. ***Details as to the possible quantities of these waste streams to be accepted at your facility.***

Based on current enquiries it is estimated that up to 100,000 tonnes of the specified wastes could be accepted at the facility per annum. The HRA has been carried out assuming that 100% of future cells will be filled with higher limit materials so as to provide the most conservative assessment. In practice there will be a mixture of materials in each cell with varying parametric levels (i.e. materials with the higher WAC limits will only represent part of the total materials in a cell).

3. ***A detailed hydrogeological assessment of the site having regard for the complexity of the local bedrock geology and the proximity of the Bog of the Ring water body taking into account previous studies and reports undertaken as well as assessments by the Agency.***

The sites hydrogeology has been well studied and groundwater data from the various geological units has been used in the current HRA. Boreholes in both the Loughshinny and Namurian formations have been included in the assessment as detailed in Section 2.3.1. The hydrogeological properties of each of these units have been considered in the HRA.

The Bog of the Ring (BOTR) groundwater supply (Loughshinny formation and overlying gravels at the wellfield) is detailed in the revised Section 2.3.4 and Section 6. Additional hydrogeological assessments including compressive monitoring of water levels on site and comparisons with data from the BOTR wellfield monitoring data has been ongoing throughout 2018. This is part of EIAR assessments currently being undertaken as part of a planning application for continuation of use and an amendment to the granted SID permission which will also require a Licence Review application. To date no evidence of connection between the site and the BOTR supply has been observed.

The HRA and detailed quantitative risk assessment indicates that based on the site specific parameters there will be no impact on groundwater in either geology beneath the site from the source material with an increased WAC limit. Therefore there is no risk to the BOTR supply.

4. ***A summary and commentary on groundwater and leachate monitoring data for all parameters required under Schedule C2.2 of the Licence.***

Section 2.3.2 has been updated to provide a commentary on the groundwater quality in both the Namurian (Section 2.3.2.1) and Loughshinny (Section 2.3.2.2) formations. A summary of all groundwater data from 2010 to 2017 is included. Leachate monitoring results are detailed in Section 3.2.

5. ***Details of the retardation mechanisms (assumed in the model) perceived to be operating in the aquifer.***

Section 5.1.2 has been updated to provide details of the retardation mechanisms perceived to be operating in the aquifer. All model input parameters are listed with PDFs (where applied) and justifications in Appendix F of the report.

We trust that the enclosed information is satisfactory and if you require any further information please do not hesitate to contact the undersigned.

Yours sincerely,

Cian O'Hora MSc CSci PGeo EurGeol MCIWM MCIWEM
On behalf of IMS

REPORT

HYDROGEOLOGICAL RISK ASSESSMENT FOR INERT WASTE ACCEPTANCE CRITERIA INCREASE

Hollywood Landfill

Submitted to:

Integrated Materials Solutions GP Ltd

College House,
Townsend Street,
Dublin 2

Submitted by:

Golder Associates (UK) Ltd

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1775927.R01.A2 HRA 3 x WAC

06 September 2018

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Table of Contents

TABLES

FIGURES

APPENDICES

DRAWINGS
Drawing 1

APPENDIX A
ARUP 2010: Figure 6 - Site Geological Map

APPENDIX B
Groundwater Elevation Graphs

APPENDIX C
Groundwater Quality Graphs

APPENDIX D
Surface Water Quality Graphs

APPENDIX E
Leachate Elevation Graphs

APPENDIX F
LandSim Model Inputs and Justification

APPENDIX G
LandSim Model Inputs, Results and Graphs

1.0 INTRODUCTION

1.1 Background

Integrated Materials Solutions Limited Partnership (IMS) has commissioned Golder Associates (Golder) to undertake a hydrogeological risk assessment (HRA) of Hollywood Great Landfill facility ('the Site'). The most recent HRA was carried out in December 2010 by ARUP (ARUP, 2010). An earlier HRA was carried out by Golder in 2006 (Golder, 2006).

The Site is an operational landfill located in Hollywood, Naul, Co. Dublin. It is situated approximately 3 km to the southeast of the town of Naul and approximately 23 km north of Dublin city centre. Access to the Site is off Sallowood View road. The Site is located at national grid reference 315558, 257798. The Site layout is shown on Drawing 1.

Historically the Site was a limestone and shale quarry that operated between the late 1940s and 2007. Planning permission for restoration of the quarry was first granted in July 1988 and the first permit for landfilling was issued in 1993 under the European Communities (Waste) Regulations. Since then, Waste Licence W0129 (issued by the Environment Protection Agency (EPA)) has been held by Murphy Concrete Manufacturing Ltd, and subsequently by Murphy Environmental Hollywood Ltd. IMS purchased the Site from Murphy Environmental Hollywood Ltd in June 2017 and currently operates the Site under Waste Licence Register No. W0129-02.

IMS wishes to develop the remainder of the void space at the Site in a phased manner with category B Inert Waste as permitted under the current Waste Licence W0129-02. IMS would like to apply for a derogation of the 3 x Waste Acceptance Criteria (WAC) limits under EC Council Decision 2003/33/EC for sulphate, chloride, antimony, selenium, molybdenum, arsenic and Total Dissolved Solids (TDS); and a two times increase for total organic carbon (TOC). In order to do this, it needs to be demonstrated to the competent authority (the EPA) that the predicted emissions from the Site will present no additional risk to the environment, to allow the EPA to determine if a derogation can be applied to these parameters for the specified waste stream.

1.2 Objective

The objective of this report is to present a HRA for the Site that supports IMS in its intended technical amendment to Waste Licence W0129-02 (i.e. the increase in WAC limits for selected parameters). On this basis, Golder has assessed in this report whether the proposed changes at the Site will adversely affect the hydrogeological regime at, and adjacent to, the Site. The HRA also incorporates any changes to the hydrogeological setting that have taken place at the Site since the 2010 HRA.

This report includes the following:

- A review of the hydrogeological setting to assess whether there are changes to the pathways or receptors;
- Development of a risk assessment model source term to reflect the changes needed in model parameterisation to support the proposed WAC limit amendments;
- An update to the HRA and associated modelling;
- Presentation of the model findings; and
- Discussion of the assessment results.

On 08 March 2018, a technical memorandum from Golder was submitted to the EPA. This document was titled "Submission to EPA requesting change to Waste Acceptance Criteria as stipulated under Waste Licence register no. W0129-02 and scoped out the objectives and methodology that would be followed within this HRA.

1.3 Licence Details

The Site is currently operated under an EPA Waste Licence (no. W0129-02) to accept 500,000 tonnes per annum of inert waste to landfill (excluding those required for engineering or landscaping). Condition 1.8 of the Licence states the following:

Only inert waste may be recovered and disposed of at the facility subject to the maximum quantities and other constraints listed in Schedule A.1: Waste Acceptance of this licence. No liquid wastes or sludges shall be accepted at the facility. No shredded mixed construction and demolition waste may be accepted at the facility.

Further, Condition 8.9 relates to Waste Acceptance & Characterisation Procedures; sections of this condition which are deemed relevant to the content of this report are as follows:

Waste shall only be accepted at the facility from Local Authority waste collection or transport vehicles or holders of waste permits, unless exempted or excluded, issued under the Waste Management (Collection Permit) Regulations, 2001, or as may be amended.

8.9.2 No hazardous or liquid wastes shall be disposed of at the facility.

8.9.3 The licensee shall maintain written procedures for the acceptance and handling of all wastes. These procedures shall include –

(i) details of the pre-treatment of all waste to be carried out in advance of acceptance at the facility and shall also include methods for the characterisation of waste in order to distinguish between inert, non-hazardous wastes.

(ii) the requirements of Schedule A.1: Waste Acceptance, Schedule A.2: Acceptable Waste, Schedule A.3: Acceptance Criteria and Schedule A.4: Limit Values for Pollutant Content for Inert Waste Landfills of this licence.

The procedures shall have regard to the EU Decision (2003/33/EC) on establishing the criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 and Annex II of Directive (199/31/EC) on the landfill of waste.

The licence also allows unlimited disposal of inert mineral excavation wastes arising from quarrying activities at the Site, and permits waste recovery activities, including recycling or reclamation of metals and metal compounds (Class 3), recycling or reclamation of other in organic materials (Class 4) and storage pending collection of these types of material (Class 13).

IMS wishes to increase the WAC limits in the licence for sulphate, chloride, antimony, selenium, molybdenum and arsenic to three times the leaching limit typically applicable for an inert landfill.

1.4 Guidance/Directive Details

COUNCIL DECISION (2003/33/EC) of 19 December 2002 established criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC. This Decision took effect on 16 July 2004 and Member States were required to apply the criteria set out in section 2 of the Annex to this Decision by 16 July 2005. Section 2 of this Annex lays down the acceptance criteria for each landfill class. Waste may be accepted at a landfill only if it fulfils the acceptance criteria of the relevant landfill class as laid down in section 2 of this Annex.

The first paragraph of section 2 of the Annex states the following:

2. WASTE ACCEPTANCE CRITERIA

This section sets out the criteria for the acceptance of waste at each landfill class, including criteria for underground storage.

In certain circumstances, up to three times higher limit values for specific parameters listed in this section (other than dissolved organic carbon (DOC) in sections 2.1.2.1, 2.2.2, 2.3.1 and 2.4.1, BTEX, PCBs and mineral oil in section 2.1.2.2, total organic carbon (TOC) and pH in section 2.3.2 and loss on ignition (LOI) and/or TOC in section 2.4.2, and restricting the possible increase of the limit value for TOC in section 2.1.2.2 to only two times the limit value) are acceptable, if

- *the competent authority gives a permit for specified wastes on a case-by-case basis for the recipient landfill, taking into account the characteristics of the landfill and its surroundings, and*
- *emissions (including leachate) from the landfill, taking into account the limits for those specific parameters in this section, will present no additional risk to the environment according to a risk assessment.*

Member States shall report to the Commission on the annual number of permits issued under this provision. The reports shall be sent to the Commission at intervals of three years as part of the reporting on the implementation of the Landfill Directive in accordance with the specifications laid down in Article 15 thereof.

Member States shall define criteria for compliance with the limit values set out in this section.

Section 2 of the Annex continues to provide waste acceptance criteria for various waste acceptance scenarios at different landfills; these are summarised as follows:

- *2.1. Criteria for landfills for inert waste;*
- *2.2. Criteria for landfills for non-hazardous waste;*
- *2.3. Criteria for hazardous waste acceptable at landfills for non-hazardous waste pursuant to Article 6(c)(iii);*
- *2.4. Criteria for waste acceptable at landfills for hazardous waste; and*
- *2.5. Criteria for underground storage.*

As Hollywood Landfill is an inert landfill, only sub section 2.1 of section 2 of the Annex applies and as such, the above paragraph can be simplified (in terms of W0129-02) to read as follows:

In certain circumstances, up to three times higher limit values for specific parameters listed in this section (other than dissolved organic carbon (DOC) in sections 2.1.2.1, BTEX, PCBs and mineral oil in section 2.1.2.2, and restricting the possible increase of the limit value for TOC in section 2.1.2.2 to only two times the limit value) are acceptable, if

- *the competent authority gives a permit for specified wastes on a case-by-case basis for the recipient landfill, taking into account the characteristics of the landfill and its surroundings, and*
- *emissions (including leachate) from the landfill, taking into account the limits for those specific parameters in this section, will present no additional risk to the environment according to a risk assessment.*

1.5 Sources of Information

The following sources of information have been used to compile this report:

- ARUP, 2010: Hydrogeological quantitative risk assessment and the associated LandSim models;

- ARUP, 2013: Assessment of Hydrogeological Isolation (Bog of the Ring and the MEHL Site);
- EPA Waste Licence number W0129-02;
- EPA, 2011: Water Framework Directive Groundwater Monitoring Programme – Bog of the Ring, PW3;
- European Communities Council Decision 2003/33/EC: Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC; and
- Golder, 2007: Hydrogeological Risk Assessment at Murphy Environmental – Nags head.
- Patel Tonra Ltd: Quarterly Monitoring Reports 2010 to 2017.

The following monitoring data provided by IMS and has, where applicable, been included in this HRA:

- Leachate level data for the period February 2010 to September 2017;
- Leachate quality data for the period February 2010 to September 2017;
- Groundwater level data for the period February 2010 to November 2017;
- Groundwater quality data for the period February 2010 to November 2017; and
- Surface water quality data for the period June 2010 to November 2017.

The previous eight years (2010 to 2017) of background monitoring data has been used to water quality. The assistance of IMS in the provision of data for this is gratefully acknowledged. Golder has not independently verified any of the information supplied.

1.6 Report Structure

Section 1 of this report contains the Introduction and objectives of this report; along with licence details and the sources of information used to prepare this HRA.

Section 2 of this report presents information about the environmental setting of the Site, including a summary of Site-specific groundwater and surface water quality data included in the selected data period.

Section 3 details the current and proposed installation and engineering information for the Site and presents a summary of the leachate level and quality data included in the selected data period.

Section 4 presents the conceptual understanding of the Site that is based on the information in Sections 2 and 3, and has been used to develop the risk assessment model.

Section 5 details the risk assessment process and results.

Section 6 presents the conclusions of the assessment.

Section 7 presents the references used in this report.

2.0 ENVIRONMENTAL SETTING

2.1 Topography and Land Use

The Site is located on a hill with elevations on the western boundary of around 150 m AOD and falling to around 90 m AOD on the eastern boundary. The land use in the surrounding area is predominantly agricultural with some small clusters of domestic dwellings. The Site layout drawing is contained in Appendix A.

2.2 Geology

The geology at the Site is detailed in the 2010 HRA (ARUP, 2010). No new information about the geology is available from more recent site investigations; therefore, a summary of the geology present in the previous HRA is presented below.

2.2.1 Regional Geology

The regional bedrock geology of Meath is divided into Ordovician and Silurian metasediments and volcanics, granites and other igneous rocks, Carboniferous sedimentary rocks, and Permian and Triassic sedimentary rocks. The rocks that underlay the Site are from the Carboniferous period and include (from youngest to oldest):

- **Walshestown Formation** – black shales with ironstone and subordinate siltstone with rippled fine sandstone bands, calcareous mudstone and biosparite.
- **Balrickard Formation** - feldspathic micaceous sandstone with shale and argillaceous fossiliferous micrite.
- **Donore Formation** – an erosional boundary that resembles the Balrickard Formation in some places and the Loughshinny Formation in others.
- **Loughshinny Formation** - limestone breccias and turbidites.
- **Naul Formation** – limestones with shales.
- **Lucan Formation** - dark grey well bedded cherty, graded limestones and calcareous shales.

These Carboniferous rock units are folded into a gentle syncline with an axis that runs roughly WNW-ESE. A number of faults are also present in the area, which generally trend N-S or NE-SW.

In some areas of the region, bedrock is exposed at the surface (i.e. there are no soils or superficial deposits mapped). Where there is superficial geology cover, this typically comprises Quaternary Glacial Tills that are limestone dominated. Associated soils classified as Gleys cover most of the area, expect around the Site where the soils are classified as part of the Brown Earth Group.

The Walshestown Formation, Balrickard Formation and Donore Formation are identified as being from the Namiruan Age in the ARUP 2010 report and are collectively referred to as the Namurian Formations in this report.

2.2.2 Local Site Geology

Investigation works have been undertaken at the Site in the past and are detailed in the 2010 ARUP report. Geophysical work indicated a major bedrock fault running roughly N-S across the Site and another that trends E-W with a down-throw on the northern side of approximately 60 m. These faults result in different geological formations being present beneath the northern and southern parts of the Site.

Using a combination of the mapped geology, Site borehole logs and geophysics survey findings, the local geology beneath the Site identified by ARUP (ARUP, 2010) comprises the Loughshinny Formation to Walshestown Formation segment of the regional geological stratigraphy. A copy of the ARUP geological map of the Site is included in Appendix B. The strata dip towards the north, with the older Loughshinny Formation typically present in the base of the southern part of the Site and the younger Walshestown Formation is present in the base of the northern part of the Site. The central section of the Site is the most affected by faulting and it mainly underlain by the Balrickard Formation, but the faulting can result in either the Balrickard or Donore Formation also being encountered directly under the Site.

The southern part of the Site is bisected by the N-S tending fault, which results in the eastern half being underlain by the Balrickard Formation and the western half being underlain by the Loughshinny Formation. In-situ soils are typically not present at the Site due to stripping and stockpiling during quarry operations. Where they remain, the Quaternary superficial deposits comprise Glacial Till that has a clayey / silty matrix with pebble sized clasts. The superficial deposits are typically less than 5 m thick.

It is stated in the Golder HRA (Golder, 2007) that samples of clay have previously been taken and tested and found to have hydraulic conductivities as low as 8.6 x 10^{-11} m/s. This material has been used as a source for the liner material that forms the base of the engineered landfill cells.

2.3 Hydrogeology

2.3.1 Site Groundwater Levels and Flow Directions

A summary of the available groundwater level monitoring data (as elevations) for the period January 2010 to November 2017 is presented in Table 1. The location of the monitoring wells is shown on Drawing 1. A graph of groundwater elevations is presented in Appendix B. For the purposes of this summary, the data from any borehole screened within the Walshestown Formation, Balrickard Formation or Donore Formation is identified as being from the Namiruan Foramtions.

Table 1: Summary of Groundwater Level Monitoring Data (January 2010 to November 2017)

Location ID	Screened Formation	Number of Measurements	Groundwater Elevation (m AOD)			
			Minimum	Mean	95th percentile	Maximum
BH-4A	Loughshinny	29	92.0	94.8	96.9	97.0
BH-5	Namurian	46	100.8	102.8	103.9	112.9
BH-6	Namurian	26	117.3	118.8	120.4	120.4
BH-8A	Namurian	16	103.9	106.4	108.7	109.2
BH-9	Namurian	53	103.8	106.4	108.3	109.2
BH-10A	Loughshinny	45	98.9	100.5	101.9	103.4
BH-11A	Namurian	50	98.4	98.5	98.5	98.7
BH-12	Loughshinny	51	97.7	101.1	102.5	102.9
BH-13	Namurian	50	108.4	112.8	116.8	121.5
BH-14	Loughshinny	47	97.7	99.4	100.4	100.6

Groundwater elevations range between approximately 99 m AOD and 120 m AOD. It should be noted that the higher end of this range represents a maximum recorded groundwater elevation at selected boreholes (BH6 and BH 13). The highest elevations are recorded in those locations screened within the Namurian Formations. The elevations recorded at BH-6 (located away from the Site boundary to the northwest) are reportedly reflecting the level of the casing because groundwater at this location is artesian. The groundwater elevations recorded in the other Namurian locations indicate that the highest elevations are recorded in borehole BH-13 (typically 112 m AOD to 115 m AOD). The lowest elevations are recorded in boreholes BH-11A (typically around 98. 5 m AOD). Although there is limited groundwater elevation data available, the groundwater contours for the Namurian that area presented on Drawing 1 indicate groundwater flow is towards the east. If the artesian groundwater elevation in BH-6 is included, the groundwater flow direction is in the Namurian is towards the southeast.

The groundwater elevations recorded in boreholes screened within the Loughshinny Formation indicate that the highest elevations are recorded in borehole BH-12 (100 m AOD to 103 m AOD) and the lowest elevations are recorded in borehole BH-4A (typically around 97 m AOD), which suggests groundwater flow in the Loughshinny Formation is towards the east. Groundwater contours are presented in Drawing 1 contained in Appendix A. At the time of the 2010 ARUP HRA, the groundwater flow was towards the southeast, but this was determined using data from additional boreholes located in the centre of the Site that are no longer monitored.

The groundwater elevations in the Loughshinny Formation are all below the basal formation elevation of the Site (minimum 104.5 m AOD). Groundwater elevations in the Namurian are below this elevation in the northeast of the Site. Along the western boundary of the Site, groundwater elevations in the Namurian are around or just above the basal formation elevation, which indicates the west-central part of the Site that is underlain by the Namurian Formations has little or no unsaturated zone present beneath the landfill cells.

In the western part of the Site, the Loughshinny Formation aquifer is overlain by a partially saturated Namurian poor/non-aquifer. Groundwater elevations in the Namurian Formations are higher than in the underlying Loughshinny Formation and groundwater flow form the Namurian downwards into the Loughshinny Formation aquifer is likely to occur. The groundwater elevations in the Loughshinny Formation on the eastern side of the Site are recorded as being higher than the top of the formation, which indicates that, in the eastern part of the Site at least, the groundwater in the Loughshinny Formation is confined and under pressure. There is no Namurian groundwater monitoring along the eastern side of the Site, so it is not possible to discuss relative groundwater levels in each formation or the vertical hydraulic gradients.

Using the data included in this HRA, the gradient of groundwater flow in the locally important Loughshinny Formation aquifer has been determined from recent data (June 2017 and September 2017) as ranging between 0.0028 and 0.0045 towards the east. The groundwater gradient in the Namurian is more variable and ranges from 0.0046 to 0.03 towards the east.

2.3.2 Site Groundwater Quality

This section focusses on the existing groundwater quality in relation to the parameters of interest that are monitored at the Site (i.e. chloride, sulphate, arsenic and TOC). Based on the groundwater flow direction in each of the strata, the data has been divided into up-, cross- and down-gradient results. Graphs are presented in Appendix C.

Other parameters listed in the Table C2.2 of the Licence that are required to be monitored in groundwater at the Site are also discussed with respect to the Site Quarterly Monitoring Reports and Annual Environmental Reports (Patel Tonra Ltd, all dates).

2.3.2.1 Namurian Groundwater Quality

A summary of the groundwater quality monitoring that has been undertaken between February 2010 and November 2017 in boreholes screened within the Namurian Formations (i.e. boreholes BH-5, BH-6, BH-8A, BH-9, BH-11A and BH-12) is presented in Table 2. Where concentrations were below the limit of detection (LOD), half the detection limit has been used to determine the mean and 95th percentile values.

Background groundwater quality in the Namurian Formations is considered to be represented by the values from BH-8A, BH-9 and BH-13. There is no notable difference between the groundwater quality up- and down-gradient of the Site. Sulphate concentrations in BH-9 have been increasing during the data period included in this HRA. This location is considered to be up-gradient of the Site, so the change in concentrations is likely to be originating from off-Site and may be related to the geology in the area because Namurian shales can contain pyrite (an iron sulphide).

Table 2: Summary of Groundwater Quality Data for the Namurian Formations

	BH ID	Parameter	Number of samples	Number of samples >LOD	Concentration (mg/l)			
					Min.	Mean	95th percentile	Max.
Up-gradient	BH-8A	Arsenic	16	4	<0.0025	0.00184	0.0041	0.0045
		Chloride	16	16	25.5	34.4	37.2	37.5
		Sulphate	16	16	10.6	17.35	26.36	36.36
		TOC	16	2	<2	1	3	6
	BH-9	Arsenic	29	17	<0.0025	0.00551	0.0127	0.0401
		Chloride	32	32	19.6	25.8	28.9	30.1
		Sulphate	32	32	32	56.57	85.30	182.37
		TOC	32	18	<2	5	14	18
	BH-13	Arsenic	29	9	<0.0025	0.00223	0.0050	0.008
		Chloride	32	32	20.3	37.0	44.1	47.1
		Sulphate	32	32	9.14	18.04	51.39	62.99
		TOC	32	14	<2	4	10	18
Cross-gradient	BH-5	Arsenic	23	15	<0.0025	0.00782	0.0270	0.046
		Chloride	26	26	15.4	21.3	24.3	26.0
		Sulphate	26	26	46.1	65.81	82.37	84.34
		TOC	26	12	0.45	4	13	17
	BH-6	Arsenic	31	3	<0.001	0.0013	0.0028	0.0048
		Chloride	35	35	19.2	21.3	26.4	29.6
		Sulphate	35	35	1.82	31.59	47.25	64.65
		TOC	29	15	<1	4	14	18
Down-gradient	BH-11A	Arsenic	36	35	<0.0025	0.023	0.063	0.068
		Chloride	40	40	21.7	23.3	24.8	25.0
		Sulphate	40	40	5.41	11.79	15.38	31.30
		TOC	34	15	<2	4	14	19

The most recent Site Quarterly Monitoring Reports for the data review period compare groundwater quality to the EPA trigger levels set out in the Licence, and also to rounded-up Groundwater Regulations (2016) threshold values for groundwater for indicative purposes. This following text presents a brief summary of the above data in relation to these values.

The arsenic concentrations are variable across the Site and are variable over time with no clear trends. The highest concentrations are recorded at down gradient location BH-11A. There is no Licence trigger level for arsenic. Concentrations at BH-5 (cross-gradient), BH-9 (up-gradient), BH-11A (down-gradient) and BH-13 (up-gradient) have equalled or exceeded the Groundwater Regulations value of 0.008 mg/l on one or more occasions during the data period. The EPA does not require the reporting of elevated concentrations of arsenic as incidents as this is naturally-occurring in the soils and geology of the area.

Chloride concentrations are highest in BH-8A and BH-13 (both up-gradient) and the maximum concentration of 47.1 mg/l was recorded in BH-13 in September 2016. No concentrations exceed the Licence trigger level of 75 mg/l or the Groundwater Regulations threshold value of 187.5 mg/l.

Sulphate concentrations are highest at up-gradient location BH-9 and cross gradient location BH-5. Concentrations are typically less than 90 mg/l, with only one concentration recorded at 182.37 mg/l in BH-9 in November 2015. This single concentration exceeds the Licence trigger level of 150 mg/l, but not the Groundwater Regulations threshold value of 187.5 mg/l. All other concentrations are below both the Licence trigger value and the Groundwater Regulations threshold value.

TOC concentrations are highly variable across the Site and over time; however, the Licence trigger level of 50 mg/l has not been exceeded on any occasion during the data period. The maximum concentration of 19 mg/l was recorded from BH-11A in February 2010.

With respect to the other parameters listed in the Table C2.2 of the Licence that are required to be monitored in groundwater at the Site, the Site Quarterly Monitoring Reports also present the results of the groundwater quality monitoring for these and compare them to the Groundwater Regulations (2016) threshold values for groundwater and EPA trigger levels set out in the Licence. Based on these reports, the following comments can be made:

- Visual/odour –samples are typically reported as having no odour, but are commonly red or brown due to sediment.
- Ammoniacal nitrogen concentrations in the Namurian that are above the LOD range from 0.03 mg/l to 1.78 mg/l. The quarterly monitoring reports compare ammoniacal nitrogen concentrations to a value of 0.18 mg/l. Exceedances have occurred up-cross and down-gradient of the Site and are noted as potentially resulting from sewage or agricultural contamination in the area. There is no Licence trigger value for this parameter.
- Dissolved oxygen concentrations in the Namurian range from 0.05 mg/l to 11 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Electrical conductivity values in the Namurian range from 0.053 mS/cm to 0.872 mS/cm and do not exceed the Groundwater Regulations limits of 1.875 mS/cm. There is no Licence trigger value for this parameter.
- pH values in the Namurian range from 6.1 to 10.4. Most values lie within the Licence permitted range between 6 and 9.
- Boron concentrations in the Namurian range from LOD to 0.105 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.

- Calcium concentrations in the Namurian range from 0.6 mg/l to 120 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Cadmium concentrations in the Namurian range from 0.00002 mg/l to 0.0022 mg/l. All values are below the Licence limit of 0.004 mg/l.
- Chromium concentrations in the Namurian range from LOD to 0.0127 mg/l. All values are below the Groundwater Regulations (2016) threshold value of 0.04 mg/l.
- Copper concentrations in the Namurian range from LOD to 0.007 mg/l. All values are below the Licence limit of 0.5 mg/l.
- Cyanide concentrations in the Namurian range from below the LOD to 0.01 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Fluoride concentrations in the Namurian range from below the LOD to 0.4 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Iron concentrations in the Namurian range from below the LOD to 1.56 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter. Concentrations are noted in the monitoring reports as potentially being influenced by the bedrock geology of the area.
- Lead concentrations in the Namurian range from below the LOD to 0.014 mg/l. This maximum exceeds the Groundwater Regulations (2016) threshold value of 0.008 mg/l and occurs in BH-5 (cross-gradient) in Q1 2010. All other results are below the threshold value.
- List I/II organic substances have typically not been detected in groundwater. One above LOD concentration of 0.0001 mg/l was reported in BH-11A (down-gradient) in Q1 2015, but all other results in all other boreholes have been below LOD.
- Magnesium concentrations in the Namurian range from 0.8 mg/l to 22 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Manganese concentrations in the Namurian range from below LOD to 0.456 mg/l. The EPA does not require the reporting of elevated concentrations of manganese as incidents, as this is naturally-occurring in the soils and geology of the area. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Mercury concentrations in the Namurian range from below LOD to 0.001 mg/l. The Groundwater Regulations (2016) threshold value for this parameter is 0.0008 mg/l, which is exceeded at BH-13 in Q1 2016. No other results exceed the threshold value.
- Potassium concentrations in the Namurian range from 0.5 mg/l to 6.8 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Sodium concentrations in the Namurian range from 10.9 mg/l to 675 mg/l. The Licence limit of 80 mg/l has been exceeded at BH-5 (cross-gradient) and BH-6 (cross-gradient).
- Phosphorous concentrations in the Namurian range from 0.013 mg/l to 5.9 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- TON concentrations in the Namurian range from 0.08 mg/l to 7.6 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.

- TOC concentrations in the Namurian range from 0.45 mg/l to 18 mg/l. No results exceed the Licence limit of 50 mg/l.
- Zinc concentrations in the Namurian range from 0.0016 mg/l to 0.257 mg/l. The Groundwater Regulations (2016) threshold value of 0.008 mg/l is exceeded at all up-, cross- and down-gradient locations.
- Phenol concentrations in the Namurian range from below the LOD to 0.003 mg/l. No values exceed the Licence limit of 0.1 mg/l.
- Coliforms are detected in Namurian groundwater. Faecal coliform counts range from 0 to 5, and total coliform counts range from 0 to 58. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter. Values reported are noted as potentially resulting from agricultural contamination in the area.

2.3.2.2 Loughshinny Groundwater Quality

A summary of the groundwater quality monitoring that has been undertaken between February 2010 and November 2017 in boreholes screened within the Loughshinny Formation (i.e. boreholes BH-4A, BH-10A, BH-12 and BH-14) is presented in Table 3. Where concentrations were below the limit of detection (LOD), half the detection limit has been used to determine the mean and 95th percentile values.

Given the groundwater flow direction is towards the east in the Loughshinny Formation, background groundwater quality in the Loughshinny Formation is considered to be represented by the values from BH-12. The cross- and down-gradient analysis results are similar to the up-gradient results, except for sulphate concentrations from samples taken in BH-10A (located cross-gradient of the Site), which are notably higher than at any of the other three locations. Chloride concentrations in BH-10A have also been increasing steadily over the data period included in this HRA. This is not the case in down-gradient borehole BH-4A. The cause of the higher sulphate concentrations may be related to the geology in the area because Namurian shales can contain pyrite. The cause of the increase in chloride concentrations is not known, but is unlikely to be related to Site activities given the location of the boreholes in which the trends have been observed, and that similar trends are not seen in the down-gradient boreholes.

Table 3: Summary of Groundwater Quality Data for the Loughshinny Formation

	BH ID	Parameter	Number of samples	Number of samples >LOD	Concentration (mg/l)			
					Min.	Mean	95th percentile	Max.
Up-gradient	BH-12	Arsenic	29	3	<0.0025	0.00181	0.00494	0.0102
		Chloride	32	32	1.0	8.1	26.6	32.5
		Sulphate	32	32	0.36	8.64	29.43	39.5
		TOC	32	18	<2	3.69	10.00	12.00
Cross-gradient	BH-10A	Arsenic	34	14	0.0011	0.00233	0.0044	0.0125
		Chloride	37	37	23.6	44.5	59.3	59.5
		Sulphate	36	36	221.90	282.35	401.01	548.19
		TOC	31	16	<2	4.90	15.00	27.00

	BH ID	Parameter	Number of samples	Number of samples >LOD	Concentration (mg/l)			
					Min.	Mean	95th percentile	Max.
Down-gradient	BH-4A	Arsenic	28	5	<0.0009	0.0018	0.0047	0.0065
		Chloride	31	31	6.5	21.6	26.7	28.1
		Sulphate	31	31	12.66	38.72	64.32	93.50
		TOC	31	14	<0.2	3.69	12.00	17.00
	BH-14	Arsenic	29	3	<0.0009	0.00225	0.0026	0.028
		Chloride	32	32	10.7	27.1	36.3	45.1
		Sulphate	32	32	7.60	22.83	45.57	59.98
		TOC	31	26	<2	5.45	11.00	11.00

The most recent Site Quarterly Monitoring Reports for the data review period compare groundwater quality to the EPA trigger levels set out in the Licence, and also to rounded-up Groundwater Regulations (2016) threshold values for groundwater for indicative purposes. The following text presents a brief summary of the above data in relation to these values.

The arsenic concentrations are variable across the Site and are variable over time with no clear trends. There is no Licence trigger level for arsenic. Concentrations at BH-10A (cross-gradient), BH-12 (up-gradient) and BH-14 (down-gradient) have exceeded the Groundwater Regulations value of 0.008 mg/l on one or more occasions during the data period. The EPA does not require the reporting of elevated concentrations of arsenic as incidents as this is naturally-occurring in the soils and geology of the area.

Chloride concentrations are highest in BH-10A (cross-gradient). Concentrations have been increasing over the whole data period and peaked in late 2017 at just over 59 mg/l. No concentrations exceed the Licence trigger level of 75 mg/l or the Groundwater Regulations threshold value of 187.5 mg/l.

Sulphate concentrations are highest at cross-gradient location BH-10A. Concentrations at this location are commonly between 225 mg/l and 310 mg/l, but with a maximum 548.19 mg/l in December 2010. Concentrations at all other locations are less than 100 mg/l. Only concentrations in BH-10A exceed the Licence trigger level of 150 mg/l and the Groundwater Regulations threshold value of 187.5 mg/l. The monitoring reports suggest that sulphate could be naturally occurring from metals sulphides in the geology.

TOC concentrations are highly variable across the Site and over time; however, the Licence trigger level of 50 mg/l has not been exceeded on any occasion during the data period. The maximum concentration of 27 mg/l was recorded from BH-10A in March 2012.

With respect to the other parameters listed in the Table C2.2 of the Licence that are required to be monitored in groundwater at the Site, the Site Quarterly Monitoring Reports also present the results of the groundwater quality monitoring for these and compare them to the Groundwater Regulations (2016) threshold values for groundwater and EPA trigger levels set out in the Licence. Based on these reports, the following comments can be made:

- Visual/odour –samples are typically reported as having no odour, but are commonly red or brown due to sediment.
- Ammoniacal nitrogen concentrations in Loughshinny groundwater that are above the LOD range from 0.02 mg/l to 5.29 mg/l. The quarterly monitoring reports compare ammoniacal nitrogen concentrations to a value of 0.18 mg/l. Exceedances have occurred up-cross and down-gradient of the Site and are noted as potentially resulting from sewage or agricultural contamination in the area. There is no Licence trigger value for this parameter.
- Dissolved oxygen concentrations in Loughshinny groundwater range from 0.12 mg/l to 71 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Electrical conductivity values in Loughshinny groundwater range from 0.083 mS/cm to 1.318 mS/cm and do not exceed the Groundwater Regulations limits of 1.875 mS/cm. There is no Licence trigger value for this parameter.
- pH values in Loughshinny groundwater range from 5.5 to 10.65. Most values lie within the Licence permitted range between 6 and 9.
- Boron concentrations in Loughshinny groundwater range from 0.015 mg/l to 0.069 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Calcium concentrations in Loughshinny groundwater range from 7.2 mg/l to 274.4 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Cadmium concentrations in Loughshinny groundwater range from 0.0001 mg/l to 0.005 mg/l. Most values are below the Licence limit of 0.004 mg/l. The only exceedance is from BH-12 (up-gradient) in Q1 2016.
- Chromium concentrations in Loughshinny groundwater range from 0.0001 mg/l to 1.8 mg/l. The only concentrations to exceed the Groundwater Regulations (2016) threshold value of 0.04 mg/l was recorded in a sample taken from BH-10A in Q4 2015 and may represent a unit reporting error.
- Copper concentrations in Loughshinny groundwater range from below the LOD to 0.025 mg/l. All values are below the Licence limit of 0.5 mg/l.
- Cyanide concentrations in Loughshinny groundwater range from below the LOD to 0.02 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Fluoride concentrations in Loughshinny groundwater range from below the LOD to 0.3 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Iron concentrations in Loughshinny groundwater range from 0.007 mg/l to 0.365 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter. Concentrations are noted in the monitoring reports as potentially being influenced by the bedrock geology of the area.
- Lead concentrations in Loughshinny groundwater range from 0.0005 mg/l to 0.005 mg/l. No concentrations exceed the Groundwater Regulations (2016) threshold value of 0.008 mg/l.
- List I/II organic substances have not been detected in Loughshinny groundwater at concentrations above the LOD.
- Magnesium concentrations in Loughshinny groundwater range from 0.01 mg/l to 18.1 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.

- Manganese concentrations in Loughshinny groundwater range from 0.002 mg/l to 0.373 mg/l. The EPA does not require the reporting of elevated concentrations of manganese as incidents as this is naturally-occurring in the soils and geology of the area. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Mercury concentrations in Loughshinny groundwater range from below LOD to 0.001 mg/l. The Groundwater Regulations (2016) threshold value for this parameter is 0.0008 mg/l, which is exceeded at BH-10A in Q1 2016. No other results exceed the threshold value.
- Potassium concentrations in Loughshinny groundwater range from 0.7 mg/l to 5.9 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- Sodium concentrations in Loughshinny groundwater range from 1 mg/l to 657.3 mg/l. The Licence limit of 80 mg/l has been exceeded at BH-4A (down-gradient). The monitoring reports comment that the application of fertilisers or the natural geology could influence sodium concentrations.
- Phosphorous concentrations in Loughshinny groundwater range from 0.049 mg/l to 4.91 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- TON concentrations in Loughshinny groundwater range from 0.2 mg/l to 11.2 mg/l. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter.
- TOC concentrations in Loughshinny groundwater range from 0.43 mg/l to 27 mg/l. No results exceed the Licence limit of 50 mg/l.
- Zinc concentrations in Loughshinny groundwater range from 0.003 mg/l to 0.154 mg/l. The Groundwater Regulations (2016) threshold value of 0.008 mg/l is exceeded at all up-, cross- and down-gradient locations.
- Phenols concentrations in Loughshinny groundwater range from below the LOD to 0.0025 mg/l. No values exceed the Licence limit of 0.1 mg/l.
- Coliforms are detected in Loughshinny groundwater. Faecal coliform counts range from 0 to 2, and total coliform counts range from 0 to 50. There is no Licence limit or Groundwater Regulations (2016) threshold value for this parameter. Values reported are noted as potentially resulting from agricultural contamination in the area.

2.3.3 Water Supplies and Protection Areas

The ARUP HRA (ARUP, 2010) identifies a series of water supply sources located approximately 2.5 km northeast of the Site. These are understood to be part of the Bog of the Ring water supply area, which has a protection area that extends around the supply wells.

The outer protection area extends, at its closest, to within approximately 1 km of the northern Site boundary. This well field abstracts groundwater from the Loughshinny Formation and provides a water supply to Balbriggan and the surrounding area. The work that has been conducted regarding the potential hydraulic connection between the Site and the BOTR is summarised in Section 2.3.4.

The ARUP report also identifies a series of single wells that are known to the Geological Survey of Ireland. These are located to the north and east of the Site and the nearest is located approximately 1 km east of the Site. The presence of mapped supply wells has been reviewed as part of this work and these water supplies and the drinking water protection area remain present (Geological Survey of Ireland, 2018). No new sources or protection areas have been identified. However, it should be noted that it is not a requirement for wells to be registered with the Geological Survey of Ireland, so the dataset may not be complete. The ARUP HRA (ARUP,

2010) reports that the majority of local houses are on mains water supply. ARUP undertook a survey to identify water supplies local to the Site that were not on the Geological Survey of Ireland database. This survey identified three properties that have mains water supply, but also have groundwater abstraction wells. The supply located to the east of the Site was noted as being used for watering gardens.

2.3.4 Bog of the Ring (BOTR)

The Geological Survey of Ireland has identified a 'zone of contribution' (ZOC) around the BOTR supply through a combination of groundwater monitoring data and numerical modelling. The ZOC includes an inner and an outer protection area. These are demarcated in order to provide a screening tool for activities proposed in the area that could present a risk to the supply.

The outer protection area for the BOTR supply wells is intended to include the whole capture zone from which the supply wells draw groundwater. In the case of the BOTR supply wells, their outer capture zone extends, at its closest, to within approximately 1 km of the northern Site boundary, which suggests that groundwater beneath the Site should not be contributing to the supply.

In recent months, IMS has retained CDM Smith to further investigate the possibility of a hydraulic connection between the Site and the BOTR supply. The objective of CDM Smiths' work is to address concerns around water extraction at the BOTR due to a potential hydrogeological connection between the aquifer beneath the Site and the aquifer that supplies the BOTR. The CDM Smith scope of work includes a review of the available data. Further to this, well installations and well pump tests will be carried out with a view to demonstrating whether the aquifer underneath the Site is hydraulically influenced by the BOTR wellfield.

To date, CDM Smith has carried out a comprehensive review of the available information (CDM Smith, 2018). The well installations and pump tests have yet to be completed and are expected to commence in the coming months. CDM Smith considered currently available groundwater elevation data for on-Site (i.e. landfill) monitoring wells and for observation wells in the area, including some located near the BOTR abstraction wells. The groundwater contour plot incorporating this data suggests that groundwater at the Site is flowing east-southeast and then south – i.e. not towards the BOTR. This finding is similar to that presented in the 2010 ARUP HRA which indicated groundwater flow in the Loughshinny Formation was towards the southeast, also not in the direction of the BOTR supply wells.

Although pumping data for the BOTR abstractions (e.g. which wells were abstracted from, pumping times and volumes) was not available for the CDM Smith review in 2018, the times at which pumping was occurring were inferred from marked changes in the groundwater level at the nearest observation well (OW2D). Graphs of the groundwater elevation at OW2D were prepared by CDM Smith to show the periods of time when abstraction was inferred to be occurring. The same time series graph was then shown on a graph of groundwater elevation monitoring data from other Loughshinny observation wells and on-Site groundwater monitoring wells.

Despite being located adjacent to each other, the groundwater elevations in OW2S (shallow), shows a more muted and delayed response to changes in abstraction to OW2D (deep). This is considered likely to be because OW2D is screened in the same strata as the abstractions, but that OW2S is screened in the overlying superficial deposits. Observation locations OW3S and OW3D showed an even more muted and delayed response to abstraction changes. These observation wells are located approximately 1 km east of OW2D.

The Site is located approximately 2.5 km south of OW2D. The groundwater elevation in Loughshinny Formation monitoring wells BH15a, BH17 and BH24 was recorded during CDM Smith's data collection period. Data from these locations indicated an increase in groundwater level during the period of abstraction rather than drawdown effects. This response is considered by CDM Smith to be related to a period of heavy rainfall during Storm Emma.

Time series graphs have been prepared by CDM Smith for groundwater elevation monitoring data from Loughshinny observation wells near the BOTR and from on-Site groundwater monitoring wells. Over the period covered by these graphs, CDM Smith noted no distinct influence on groundwater elevations in the Loughshinny Formation beneath the Site when abstraction at the BOTR was inferred to have been occurring. This finding supports earlier findings by ARUP 2010. It is expected that the well pumps tests which will be completed soon will provide a high level of confidence that there is no hydraulic connection between the aquifer underneath the Site and the aquifer that supplies the BOTR supply.

Further commentary will be provided in Section 6, Discussion and Conclusions in relation to the findings of this HRA and its potential implications on the BOTR.

2.3.5 Groundwater Body Status

The Site is located within the ‘Lusk-Bog of the Ring’ groundwater body. Environmental Protection Agency (EPA) data reported for the 2010-2015 Water Framework Directive period (EPA, 2018) indicates this water body has a ‘good overall status (chemical status good, quantitative status poor).

2.3.6 Groundwater Vulnerability

Groundwater vulnerability describes how vulnerable the groundwater is to pollution from human activities. The criteria for determining groundwater vulnerability were developed by the Geological Survey of Ireland and considers the proximity of the bedrock to the surface and the hydraulic properties of the overlying material.

The Site is located in an area that has been defined as having ‘E’ (extreme) or ‘X’ (rock at or near surface) vulnerability (Geological Survey of Ireland, 2018). This indicates a very high degree of vulnerability to pollution and is likely to be due to only a thin layer of overlying materials being present, or the bedrock being exposed at the surface, which limits the attenuation of pollutants.

2.3.7 Aquifer Classification

The Geological Survey of Ireland classifies the aquifers in Ireland based on the hydrogeological characteristics, size and productivity of the groundwater resource. The three main classifications are Regionally Important Aquifers, Locally Important Aquifers and Poor Aquifers. The aquifer classifications of the geological formations at the Site were presented in the 2010 ARUP report and have been confirmed as part of this work (Geological Survey of Ireland, 2018). The classifications are presented in Table 4.

Table 4: Aquifer Classification (after Geological Survey of Ireland – GSI)

<table>
<tr><th colspan="2">Lithology</th><th>GSI Aquifer Classification</th></tr>
<tr><td rowspan="3">Namurian Formations</td><td>Walshestown Formation</td><td rowspan="2">Poor aquifer (bedrock which is generally unproductive except for local zones)</td></tr>
<tr><td>Balrickard Formation</td></tr>
<tr><td>Donore Formation</td><td>Poor to locally important aquifer (depending on lithological similarity to overlying Balrickard, or underlying Loughshinny, Formation)</td></tr>
<tr><td colspan="2">Loughshinny Formation</td><td rowspan="3">Locally important aquifer (bedrock which is generally moderately productive)</td></tr>
<tr><td colspan="2">Naul Formation</td></tr>
<tr><td colspan="2">Lucan Formation</td></tr>
</table>

2.3.8 Aquifer Characteristics

The geological formations present at the Site are most likely to have a secondary permeability associated with discrete fracture horizons, rather than a matrix permeability. Groundwater flow paths, travel times, and well yields can be very variable in such lithologies depending on the presence or absence of fractures and their connectivity.

There has been no further investigations into the hydraulic properties of the geological formations at the Site since those presented in the ARUP HRA (ARUP, 2010) and in the Golder HRA (Golder, 2007), therefore the data applied to the previous HRA remains applicable. A summary of that data is presented in Table 5.

Table 5: Summary of Aquifer Property Data

Borehole ID(s)	Strata	Test Method	No. of Tests	Hydraulic Conductivity (m/s)		
				Min.	Geometric mean	Max.
BH-5, BH-6, BH-8, BH-11A, BH-16 and BH-19	Namurian (i.e. Walshestown and Balrickard Formations)	Variable Head Test	6	1.1×10^{-6}	3.06×10^{-5}	5.7×10^{-4}
BH-16	Walshestown Formation	Packer Test	2	2.2×10^{-6}	n/a	3.3×10^{-6}
BH-15a	Loughshinny Formation	Variable Head Test	1*	1.0×10^{-6}		
BH-17	Loughshinny Formation	Pumping Test (recovery data)	1	1.7×10^{-4} ^		
BH-18	Loughshinny/ Donore Formation	Packer Test	1	2.2×10^{-6}		
BH-10A	Limestone	Falling and rising head tests	2	2.1×10^{-7}	n/a	3.6×10^{-7}
BH-12A	Limestone	Rising head test	1	1.1×10^{-8}		
BH-12B	Shale	Rising head test	1	2.3×10^{-8}		
BH-13	Shale	Falling and rising head tests	2	1.1×10^{-6}	n/a	1.8×10^{-6}

* most responses too fast to be recorded

^ ARUP reported value based on assumption that aquifer is 50 m thick

The ARUP HRA (ARUP, 2010) also presents interpretation of monitoring data collected during the pumping test. This interpretation states that the N-S trending fault hinders groundwater flow instead of providing a preferential pathway, but it does not provide a complete barrier to groundwater flow. It also states that the E-W trending fault does not present any barrier to groundwater flow and the fault off-set is likely to provide lateral connection between the Loughshinny Formation and the water bearing strata in the Namurian deposits. The ARUP report also concludes that the pumping test data indicates the Loughshinny Formation is likely to be a confined aquifer.

2.4 Hydrology

2.4.1 Rainfall and Recharge

The ARUP 2010 report included rainfall data from Dublin Airport. The annual rainfall for the years 2003 to 2009 ranged between 643.2 mm and 942.3 mm, and the 30 year average was reported as 750 mm/year. The data for these years area reproduced in Table 6.

Historical monthly rainfall data is available online from the Irish Meteorological Service (Irish Meteorological Service Online, 2018). Dublin Airport remains the nearest weather station to the Site with online access to historical data. The data from 2010 to 2017 is now available, and the annual totals range from 660.7 mm in 2017 to 927.2 mm in 2014, with an average annual precipitation over that period of 767 mm. This data is within the range of the earlier data. The data are also presented in Table 6.

Table 6: Meteorological Data 2003 to 2017 (Dublin Airport)

Year	Annual Precipitation (mm)	Annual PE* (mm)	Estimated AE (mm)	Estimated Annual Effective Rainfall (mm)	Estimated Recharge	
					Coefficient 80%	Coefficient 90%
2017	660.7	552.7	525.1	135.6	108.5	122.1
2016	713.6	571.0	542.5	171.2	136.9	154.0
2015	878.4	511.3	485.7	392.7	314.1	353.4
2014	927.2	No data	Not calculated			
2013	763.9	No data	Not calculated			
2012	849.5	No data	Not calculated			
2011	671.8	No data	Not calculated			
2010	671.4	No data	Not calculated			
2009^	920.2	521	495.0	425.3	340.2	382.7
2008^	942.3	531	504.5	437.9	350.3	394.1
2007^	784.4	531	504.5	280.0	224.0	252.0

Year	Annual Precipitation (mm)	Annual PE* (mm)	Estimated AE (mm)	Estimated Annual Effective Rainfall (mm)	Estimated Recharge	
					Coefficient 80%	Coefficient 90%
2006^	740.6	597	567.2	173.5	138.8	156.1
2005^	680.3	526	499.7	180.6	144.5	162.5
2004^	752.4	563	534.9	217.6	174.0	195.8
2003^	643.2	558	530.1	113.1	90.5	101.8

* Penman/Monteith

^ Precipitation and PE data from this year originally presented in ARUP, 2010.

Recharge to an aquifer (i.e. the proportion of precipitation that reaches the water table) depends on precipitation, evapotranspiration and the soil moisture deficit. Recharge can be estimated by applying a recharge coefficient to the effective rainfall. A method of estimating effective rainfall (i.e. the proportion of rainfall that is potentially available for recharge and/or runoff) is recommended by the Working Group on Groundwater (2005). The method multiplies the potential evapotranspiration (PE) by 0.95 to get a value for actual evapotranspiration (AE), which is then subtracted from rainfall to give an estimate of effective rainfall. The recharge coefficient selected depends on the geology and groundwater vulnerability.

The hydrogeological setting of the Site indicates that rock is at/near the surface and the groundwater vulnerability is 'extreme'. In this case the Working Group on Groundwater suggests a recharge coefficient of between 80% and 90%. Using the years between 2003 and 2017 where precipitation and potential evapotranspiration data are available, this would result in a recharge estimate of between 90.5 mm/yr and 394.1 mm/yr. However, this method does not take into account the possibility of the at/near surface bedrock having a low hydraulic conductivity and being a poor or low productivity aquifer. In cases where a location is underlain by a poor aquifer the recharge should be limited to 100 mm/yr, and to between 150-200 mm/yr where the aquifer is low only local importance (i.e. likely to have limited productivity) (Working Group on Groundwater, 2005).

The annual recharge to open waste is estimated as being equivalent to the effective rainfall (i.e. precipitation - actual evapotranspiration), which ranges from 113.1 mm/yr to 437.9 mm/yr over the data period included in Table 6.

2.4.2 Infiltration

The interpretation of infiltration testing at trial pit locations in the north eastern corner of the Site indicate that the material at the base of the excavation has a low infiltration rates that are in the order of 10^{-8} m/s to 10^{-7} m/s (ARUP, 2010). This property represents the vertical permeability of the matrix of the material at the surface of the Site rather than the hydraulic properties of the bedrock below. This relatively low vertical permeability at this surface could restrict recharge rates to the underlying bedrock.

2.4.3 Surface Water Environment

The closest watercourse to the Site is a small stream that runs along the northern boundary of the Site. This stream flows from west to east. The EPA name for this stream is the Toonman Branch of the Ballough Stream. Another watercourse is located approximately 200 m south of the Site, and is the Knightstown Branch of the same Ballough Stream, and it also generally flows towards the east. Approximately 350 m west of the Site is the Woodpark House Branch of the Ballough Stream, which flows first to the west, then south and then east.

Neither the Toonman Branch nor the Knightstown Branch are classified under the Water Framework Directive. The Woodpark House Branch and the Ballough Stream are classified as having a poor status for the 2010-2015 Water Framework Directive period (EPA, 2018).

The ARUP HRA (ARUP, 2010) states that the basal elevation of the stream on the northern boundary of the Site is above the elevation of groundwater in that area, and that there are lower hydraulic conductivity superficial deposits that remain present at the surface. ARUP interprets this to suggest that groundwater flow does not support surface water flow in the watercourse adjacent to the Site.

2.4.4 Site Surface Water Quality

This section presents the existing surface water quality in relation to the parameters of interest that are monitored in surface water (i.e. chloride and sulphate) and other parameters of interest in relation to surface water (namely pH, ammoniacal nitrogen, total suspended solids and chemical oxygen demand). Graphs of surface water quality over time for these parameters are presented in Appendix D.

The pH values are neutral to slightly alkaline. Chloride concentrations are low compared to typical water quality standards (<50 mg/l compared to a standard of 250 mg/l). Sulphate concentrations from SWD-6 (which is water taken from the rock quarry currently located in the southern part of the Site) are higher than at the other surface water monitoring locations. This could be linked to the higher sulphate concentrations in groundwater up-gradient of the Site that have been detected in the west and south of the Site (i.e. BH-9 and BH-10A).

3.0 INSTALLATION AND OPERATIONAL INFORMATION

3.1 Operational and Proposed Activities and Installation Details

A summary of the installation details (existing and proposed) is included in Table 7. Cells 1, 2, 3 and 5 are complete and are partially capped and restored. Cell 4 is currently available for landfilling activities. Cell 6 is intended to be the next cell developed, which will be started once the formation level of at least 104.5 m AOD has been achieved by infilling the water-filled void currently present in its base. It is intended to backfill the water-filled quarry void in Cell 6 with compacted Category A inert material (subject to EPA approval).

Table 7: Summary of Installation Details

Cell	Waste Type	Filling Dates (approximate start and end dates)	Status	Basal Lining System	Sidewall Lining System	Capping System and Restoration
Cell 1	Inert (regular WAC limits)	Jul-03 to Jun-06	Filled and partially capped/ restored (subsoil only).	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Low permeability subsoil layer of 0.85m. Topsoil layer of 0.15m.
Cell 2	Inert (regular WAC limits)	Jun-04 to Sep-06	Filled and partially capped/	1 m clay with a maximum permeability	1 m clay with a maximum permeability	Low permeability subsoil layer

Cell	Waste Type	Filling Dates (approximate start and end dates)	Status	Basal Lining System	Sidewall Lining System	Capping System and Restoration
			restored (subsoil only).	of 1 x 10^{-7} m/s. No basal drainage system.	of 1 x 10^{-7} m/s	of 0.85m. Topsoil layer of 0.15m.
Cell 3	Inert (regular WAC limits)	Jul-06 to Sep-07	Filled and partially capped/ restored (subsoil only).	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Low permeability subsoil layer of 0.85m. Topsoil layer of 0.15m.
Cell 4	Inert (3 x WAC limits)	Constructed Jul-07 to Dec-08. Filled 2013 onwards.	Operational	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 5a	Inert (regular WAC limits)	Sep-08 to 2009	Filled and temporarily capped (subsoil only).	1m clay with apermeability of 1.8 x 10^{-9} m/s.No basal drainage system.	1m clay with a permeability of 1.8 x 10^{-9} m/s.	Low permeability Subsoil layer of 0.85m and Topsoil layer of 0.15m.
Cell 5b	Inert (regular WAC limits)	Sep-08 to 2009	Filled and temporarily capped (subsoil only).	1m clay with a permeability of 1.8 x 10-9 m/s. No basal drainage system.	1m clay with a permeability of 1.8 x 10^{-9} m/s.	Low permeability Subsoil layer of 0.85m and Topsoil layer of 0.15m.
Cell 6	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability	1 m clay with a maximum permeability	Subsoil layer and topsoil layer. Top

Cell	Waste Type	Filling Dates (approximate start and end dates)	Status	Basal Lining System	Sidewall Lining System	Capping System and Restoration
				of 1 x 10^{-7} m/s. No basal drainage system.	of 1 x 10^{-7} m/s	soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 7a	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 7b	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 8	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 9	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and

Cell	Waste Type	Filling Dates (approximate start and end dates)	Status	Basal Lining System	Sidewall Lining System	Capping System and Restoration
				drainage system.		subsoils at least 1 m.
Cell 10a	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 10b	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.
Cell 11	Inert (3 x WAC limits)	Proposed	Undeveloped	1 m clay with a maximum permeability of 1 x 10^{-7} m/s. No basal drainage system.	1 m clay with a maximum permeability of 1 x 10^{-7} m/s	Subsoil layer and topsoil layer. Top soils – 0.15 m to 0.3 m. Total of top soils and subsoils at least 1 m.

CQA results from the basal lining of the completed cells indicates that the actual hydraulic conductivity of the basal liner ranges from 1.4 x 10^{-11} m/s and 9.7 x 10^{-9} m/s, which is two to four orders of magnitude less permeable than the licence requires.

At the northern end of the Site, the surrounding land surface is at an elevation of approximately 125 m AOD. The land surface is slightly higher at the southern end of the Site where it is approximately 136 m AOD. The maximum height of the restoration contours is 148 m AOD, rising from 109 m AOD at the northern end of the Site to 148 m AOD around the Site entrance area, and then dropping again to 137 m AOD at the southern end. The restoration elevations are intended to be in line with the natural topography of the area.

3.2 Leachate

3.2.1 Leachate Management

There are no leachate drainage systems or management at the Site. There are leachate monitoring wells in each of the completed cells and leachate management may be introduced in the future should the very low basal liner hydraulic conductivity result in basal leakage being lower than the rate of infiltration through the cap and the waste becoming saturated. Any leachate management that is required in the future will be agreed with the regulatory authority. For the purposes of this assessment, it is assumed that, if required, leachate levels will be managed so that cells do not overtop and result in surface water breakout.

3.2.2 Leachate Levels

Leachate level monitoring is taking place in the Site, which indicates there are perched levels of liquid within the landfill cells, which will have originated from direct precipitation and run-off ending up in the base of the clay lined cells.

A summary of the leachate level monitoring data for the period February 2010 to September 2017 is presented in Table 8. A chart showing leachate levels over time is presented in Appendix E. The location of the monitoring wells is shown on Drawing 1.

Table 8: Summary of Leachate Level Monitoring Data (February 2010 to September 2017)

Location ID	Number of Measurements	Leachate Elevation (m AOD)			
		Minimum	Mean	95th percentile	Maximum
LC-1	16	108.2	118.3	122.6	123.4
LC-2	2	109.5	109.6	109.7	109.8
LC-3	19	114.7	117.7	119.2	123.9
LC-4	18	103.5	108.5	113.1	116.5

The basal elevation of these monitoring locations is reported by IMS to be 105.5 m AOD. Excluding the single value recorded at LC-4 that is below this, the height of leachate on the base ranges from 1.8 m to 10.7 m. There is no basal drainage blanket in any of the cells and no leachate management, and the basal liners has a very low hydraulic conductivity, so it is possible that these leachate levels may represent the saturated waste mass.

At present, there is an increasing trend in leachate levels within the existing cells, but leachate breakout has not occurred. The Licensee is currently investigating leachate management options and is expected to make a submission relating to this once the process of selecting the most appropriate option is complete. Options for leachate management and discharge could include abstraction followed by tankering to a waste water treatment plant, or discharge to a sewer connection, or discharge via a reed bed, or reverse osmosis. Leachate build-up rates could also be reduced by installing lower permeability capping.

3.2.3 Leachate Quality

Leachate quality sampling and analysis is also taking place. This section presents the leachate quality in relation to the parameters of interest in leachate that are monitored at the Site (i.e. chloride, sulphate and TOC) and key landfill leachate indicator parameters (i.e. pH and ammoniacal nitrogen).

A summary of the composition of the liquid with respect to these parameters is presented in Table 9. Where concentrations were below the limit of detection (LOD), half the detection limit has been used to determine the mean and 95th percentile values.

Other parameters listed in the Table C2.2 of the Licence that are required to be monitored in leachate at the Site are also discussed with respect to the findings of the Site Quarterly Monitoring Reports (Patel Tonra Ltd, all dates).Table 9: Summary of Leachate Quality Monitoring Data (February 2010 to September 2017)

Parameter	Well ID	Number of Samples	Number of samples >LOD	Concentration			
				Minimum	Mean	95th percentile	Maximum
pH	LC-1	8	8	6.8	7.20	7.73	7.9
	LC-2*	0	n/a	n/a	n/a	n/a	n/a
	LC-3	10	10	6.7	7.5	8.07	8.2
	LC-4	10	10	7.0	7.7	7.96	8.0
Ammoniacal Nitrogen NH4 as N (mg/l)	LC-1	14	14	0.93	16.54	35.14	64.53
	LC-2*	1	1	2.53	n/a	n/a	n/a
	LC-3	15	14	<0.03	3.80	10.68	11.27
	LC-4	17	17	0.09	0.73	1.34	1.34
Chloride (mg/l)	LC-1	15	15	29.4	566.8	927.32	950.0
	LC-2*	1	1	138.8	n/a	n/a	n/a
	LC-3	16	16	109.3	293.9	556.28	646.5
	LC-4	17	17	174.9	321.0	402.90	417.3
Sulphate (mg/l)	LC-1	14	14	496.9	1224.3	1903.93	2484.8
	LC-2*	1	1	944.0	n/a	n/a	n/a
	LC-3	15	15	619.1	1260.7	1751.89	1754.7
	LC-4	16	16	493.6	827.5	1252.77	1625.1
TOC (mg/l)	LC-1	12	12	6	28	62.35	97
	LC-2*	0	n/a	n/a	n/a	n/a	n/a
	LC-3	13	13	8	24	64.20	87
	LC-4	12	12	13	89	122.75	131

* No access to this location for much of the HRA data period

The Site Quarterly Monitoring Reports for the data review period compare the leachate monitoring data to the Class A3 surface waters values in the Surface Water Regulations, SI No. 294 of 1989 – The European

Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations and/or the L/S=10l/kg WAC values listed in Table A.4.1 of Waste Licence W0129-02. The Class A3 surface waters value for pH is between 5.5 and 9 and the leachate pH measurements are within this range. The ammoniacal nitrogen concentrations in leachate are consistently higher than the Class A3 surface waters value of 0.7 mg/l. Chloride concentrations in leachate are consistently higher than the Class A3 surface waters value of 250 mg/l, but have been below the L/S=10l/kg WAC value of 800 mg/l in all locations since April 2013. The sulphate concentrations measured in leachate are all higher than the Class A3 surface waters value of 200 mg/l and are commonly around or above the L/S=10l/kg WAC value of 1000 mg/l.

With respect to the other parameters listed in the Table C2.2 of the Licence that are required to be monitored in leachate at the Site, the Site Quarterly Monitoring Reports also present the results of the leachate quality monitoring for these and compare them to the Class A3 surface waters values in the Surface Water Regulations, SI No. 294 of 1989 – The European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations and/or the L/S=10l/kg WAC values listed in Table A.4.1 of Waste Licence W0129-02. Based on these reports, the following comments can be made:

- Visual/odour – the leachate samples from all locations were commonly noted as having black or brown sediment present and having occasional eggy odours. There is no Class A3 surface waters value or WAC value for this parameter.
- Chemical oxygen demand values measured in leachate between Q1 2010 and Q4 2017 range between 15 mg/l and 446 mg/l. The Class A3 surface waters value for this parameter is 40 mg/l, which has been exceeded at all leachate monitoring locations. There is no WAC value for this parameter.
- Electrical conductivity values measured in leachate between Q1 2010 and Q4 2017 range between 0.51 mS/cm and 310 mS/cm. The Class A3 surface waters value for this parameter is 1 mS/cm, which has been exceeded at all leachate monitoring locations. There is no WAC value for this parameter.
- List I/II organic substances have not typically been detected in leachate at concentrations above the laboratory limit of detection. One above limit of detection result of 0.0001 mg/l was returned for the sample taken from LC-1 in Q1 2015. There is no Class A3 surface waters value or WAC value for this parameter.
- Potassium values measured in leachate between Q1 2010 and Q4 2017 range between 2.7 mg/l and 119.2 mg/l. There is no Class A3 surface waters value or WAC value for this monitoring parameter.
- Sodium values measured in leachate between Q1 2010 and Q4 2017 range between 34.2 mg/l and 598.1 mg/l. There is no Class A3 surface waters value or WAC value for this monitoring parameter.
- Total oxidised nitrogen values measured in leachate between Q1 2010 and Q4 2017 range between 0.06 mg/l and 9.2 mg/l. There is no Class A3 surface waters value or WAC value for this monitoring parameter.

Phenols have not typically been detected in leachate at concentrations above the laboratory limit of detection. One above limit of detection result of 0.2 mg/l was returned for the sample taken from LC-1 in Q3 2014, which is above the Class A3 surface waters value of 0.1 mg/l. There is no WAC value for this parameter.

3.3 Groundwater Management

There has been active dewatering in the past at the Site; however, this was ceased in 2007 when quarrying activities also ceased. There is currently no active groundwater management or dewatering taking place. It is considered that the past dewatering does not have any effect on the current groundwater profile which is reflective of the hydrogeological conditions at the time of monitoring.

Groundwater elevations are below the base of most of the Site, except the southwestern corner where Cell 6 is intended to be constructed, which will be infilled to achieve a basal elevation about groundwater elevations prior to being engineered as a cell. There is no intention within the design to include groundwater underdrainage in any future cells.

Monitoring at the Site is used to maintain compliance with the waste licence (in terms of waste acceptance and water quality) and to monitor any changes in groundwater quality.

4.0 CONCEPTUAL SITE MODEL

This section present the conceptual understanding of the potential route by which hazardous substances and non-hazardous pollutants in the landfill could be transported to the key receptor of interest. This conceptual site model (CSM) is based on the conceptual cross section shown in Figure1, which has been developed based on the available geological, installation and groundwater monitoring information. The groundwater elevations indicated on the conceptual cross section are the mean groundwater levels recorded during the data period covered in this HRA.

4.1.1 Source

The source of risk presented to groundwater that is being considered by this assessment is any leachate that is generated by the inert fill material.

At present, the composition of the material coming into the Site is required to comply with the standard WAC limits set out in EC Council Decision 2003/33/EC. IMS wishes to increase the limit of the composition of the source material to three times the WAC limits with respect to sulphate, chloride, antimony, selenium, molybdenum and arsenic. Therefore, the source term modelled in this risk assessment includes these parameters at the maximum three times WAC concentration. The current and proposed WAC limits are presented in Table 10.

Table 10: Source Term Values

Parameter	WAC Limit (mg/l)	3 x WAC Limit (mg/l)
Sulphate	1500	4500
Chloride	460	1380
Antimony	0.1	0.3
Selenium	0.04	0.12
Molybdenum	0.2	0.6
Arsenic	0.06	0.18

The source term for all existing cells that are capped (i.e. 1, 2, 3, 5a and 5b) will use the normal WAC limit concentration. The source term for all cells that will accept waste in the future (i.e. 4, 6, 7a, 7b, 8, 9, 10a, 10b and 11) will use the proposed three times WAC limit. Single concentrations have been applied in the model to represent a conservative case where all waste received is at the maximum concentrations.

The approach to considering TOC and TDS concentrations is discussed further in Section 5.5 and 5.6, respectively.

4.1.2 Pathway

Based on the understanding of the construction of the current cells, the construction of the proposed future cells and the hydrogeology at the Site, the pathway considered in this assessment is primarily as follows:

1) Leakage through the engineered/compacted basal clay liner;

2) Vertical transport through the unsaturated Namurian deposits before entering the saturated zone;

3) Transport through the saturated Namurian deposits (classed as a poor aquifer); and

4) Lateral groundwater flow towards the east and off-Site within the Loughshinny aquifer.

Groundwater elevation data indicates that the western central section of the Site around BH-8, BH-9 and BH-13 has little or no unsaturated zone, so the pathway in this area would include either a very small or no Namurian unsaturated zone travel.

The geological information indicates that the pathway in the southwestern corner of the Site (which is directly underlain by the Loughshinny Formation) would be as follows:

1) Leakage through the engineered/compacted basal clay liner;

2) Vertical transport through the unsaturated Loughshinny deposits before entering the saturated zone; and

3) Lateral groundwater flow towards the east and off-Site within the Loughshinny aquifer.

4.1.3 Receptors and Compliance Points

The main hydrogeological receptor at the Site is considered to be the Loughshinny Formation, which is classified as being locally important aquifer.

According to the Groundwater Directive, hazardous substances should be prevented from entering groundwater. The hazardous substance included in this assessment is arsenic. For hazardous substances, the receptor point will be the point of entry to groundwater beneath the Site (i.e. the base of the unsaturated zone). However, monitoring compliance at a location beneath the landfill is not possible, so in practice the compliance point would be groundwater in the aquifer immediately downgradient of the landfill cells.

According to the Groundwater Directive, the discharge of non-hazardous pollutants should be limited such as to prevent pollution. The non-hazardous pollutants in this assessment include sulphate, chloride, antimony, selenium and molybdenum. For non-hazardous pollutants, the receptor point will be groundwater at the downgradient Site boundary (i.e. the licence boundary).

By selecting a receptor that is close to the Site, it is protective of the aquifer further away from the Site because additional dilution, dispersion and retardation would occur between the Site and a point further away.

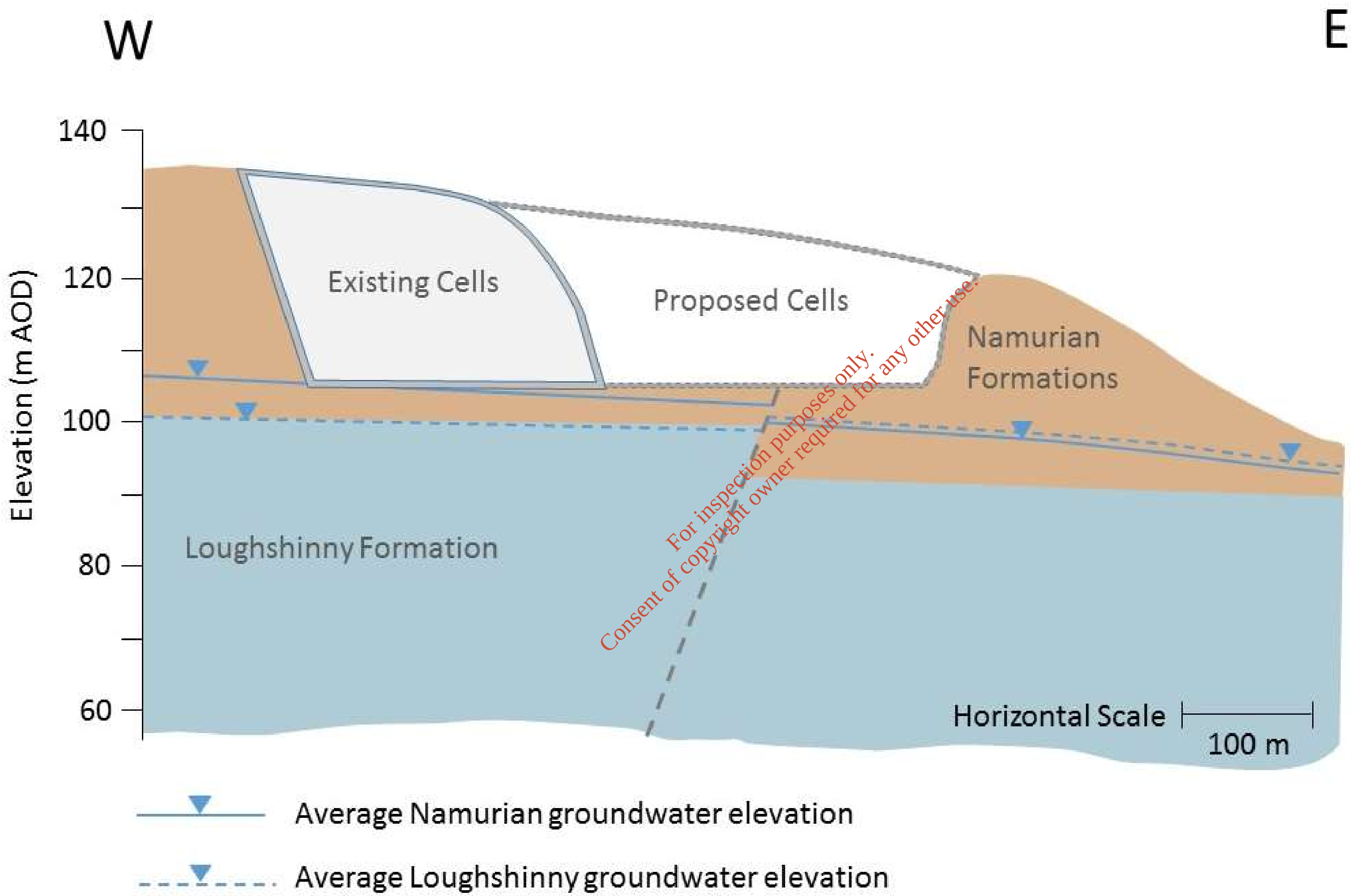

Figure 1: Conceptual Cross Section through the Centre of the Site

5.0 HYDROGEOLOGICAL RISK ASSESSMENT

5.1 Nature of the Hydrogeological Risk Assessment

5.1.1 Modelling Approach

The hydrogeological setting of the Site indicates that groundwater elevations are around or below base of landfill across most of the site; particularly in direction of groundwater flow in the aquifer receptor. On this basis, the LandSim modelling approach used in previous HRAs for this Site remains valid and the probabilistic software LandSim 2.5 has been used for the hydrogeological risk assessment.

Exact values of input parameters are rarely known. However, each parameter can be described by a range of possible/probable values incorporating the available information. During each simulation the parameters are assigned a value from within the defined ranges. After the model iterations have been completed, a range of possible predicted leakage or outcome values are obtained and it becomes possible to quantify the likelihood of a certain outcome.

This approach uses statistical distributions or probability density functions (PDFs) to characterise some of the input parameters. Each time a calculation is carried out, one value from the defined input distributions is chosen by the computer code and, for example, a concentration at the receptor is calculated. Each result is stored such that after repeating the same calculation many times, an output distribution for the concentration at the receptor is obtained. The distribution output is given in terms of percentiles (%iles). These percentiles specify the probability with which a certain value (e.g. leakage rate) will not be exceeded. For instance, if the 95%ile of a leakage rate distribution is given as 0.1 m^3/day, there is a 95% chance that the actual leakage rate will be below or equal to 0.1 m^3/day. It follows that there is also a 5% chance that the actual leakage rate will be greater than 0.1 m^3/day. The 50%ile output is viewed as the most likely result from the model. Golder consider that the 95%ile output is sufficient to represent the reasonable worst case output for the Site HRA.

5.1.2 Model Scenarios and Parameterisation

One model scenario is included in this assessment. The scenario considers that all future landfilling at the Site will have a single source term concentration of three times the standard WAC limit. No failure scenarios have been modelled because there are no leachate or groundwater management systems to fail and there is no HDPE liner to degrade or tear. Waste acceptance will be managed though waste testing and gate acceptance procedures to manage the potential for rogue loads of material entering the Site that do not meet the acceptance criteria.

It should be noted that the inputs to the model are based on a single waste type for each individual cell and as such a conservative “worst case” scenario has to be adopted. Hence, for all future cells, the model is based on the premise that all waste in these cells will be at the increased acceptance limits. In reality, this “worst case” scenario is not representative of the waste that would be placed within these cells if the proposal to increase WAC was approved. The percentage of waste which would require increased WAC would only be a percentage of the overall waste emplaced in the future cells and would be dependent on market conditions.

All model input parameters are listed with PDFs (where applied) and justifications in Appendix F. For the parameters that are currently analysed for from the samples of groundwater collected (i.e. chloride, sulphate and arsenic), background groundwater quality has been accounted for in the models.

With regard to biodegradation, retardation and dispersion and in the LandSim pathways, retardation and dispersion have been included, but biodegradation has not.

Excluding biodegradation as a mechanism within the all pathways (i.e. the mineral liner, the unsaturated pathway, the vertical pathway and the aquifer pathway) means that the model is conservative in its predictions because contaminant mass loss through biodegradation is not simulated.

Dispersion will occur in all pathways because this is a physical mechanism by which water, and the dissolved chemicals within in it, spreads out in the aquifer as it moves with advective flow. Dispersion does not change the total contaminant mass present, but is a mixing process that changes how quickly it travels and how much it spreads out in the pathway before reaching the receptor. This spreading is cause by three main physical mechanisms:

1) molecules having to move around particles or through the fissures that make up the pathway through any material, which results in the water having to take a tortuous and branching path through the channels, and, therefore, varying travel times;

2) molecules travelling at different velocities in the pore spaces due to the drag exerted on the water by the rough pore surfaces; and

3) molecules traveling at different velocities along the total flow path due to differences in the size of the pores or channels they have to travel through.

Modelling convention sets the longitudinal dispersivity value at 10% of the pathway length (i.e. the amount of dispersion that is predicted to occur in the direction of groundwater flow. Transverse dispersivity is conventionally set at 30% of the longitudinal dispersivity (approximately 3% of the pathway length). This smaller dispersion value represents the amount of spread that is predicted perpendicular to the direction of groundwater flow. Dispersion is only simulated in LandSim within the unsaturated and saturated aquifer pathways, and not within the mineral liner.

Retardation is the process by which contaminant transport is delayed by the chemical partitioning onto the particles along the pathway and it is possibe to simulate this in LandSim along all elements of the pathway. As with dispersion, retardation does not change the total contaminant mass present in the model, but can delay its arrival at the receptor. Within the LandSim model, chloride and sulphate are completely unretarded (i.e. their travel is not simulated as being slowed down by retardation). These modelled parameters will travel with the groundwater at its velocity. All other modelled parameters are assumed to be retarded to some degree.

5.2 Priority Contaminants to be Modelled

The parameters that IMS wishes to apply for three times WAC limit derogation are sulphate, chloride, antimony, selenium, molybdenum and arsenic; and a two times increase for TOC. The parameters included in the LandSim model are sulphate, chloride, antimony, selenium, molybdenum and arsenic. TOC and TDS cannot be modelled in LandSim, so are not included in the quantitative assessment and are discussed separately in Section 5.5 and 5.6.

5.3 Environmental Assessment Limits

The receptor sensitivity can be gauged by the specification of Environmental Assessment Limits (EALs). EALs are used to benchmark the results of predictive modelling. The modelling approach taken in this report is not borehole/location specific. EALs, therefore, differ from compliance levels, which are borehole/location specific for a Site.

For the purposes of this HRA, the EALs have been set at applicable groundwater quality standards presented in Table 11 that have been taken from the following sources in order of priority:

1) European Union (Drinking Water) Regulations 2014 drinking water standards; and

2) WHO drinking water standards (4th edition).

Table 11: Environmental Assessment Limits for Groundwater

Parameter	EAL (mg/l)	Source

Sulphate	250	European Union (Drinking Water) Regulations 2014
Chloride	250	European Union (Drinking Water) Regulations 2014
Antimony	0.05 (50 µg/l)	European Union (Drinking Water) Regulations 2014
Selenium	0.01 (10 µg/l)	European Union (Drinking Water) Regulations 2014
Molybdenum	0.07	WHO drinking water standards
Arsenic	0.01 (10 µg/l)	European Union (Drinking Water) Regulations 2014

5.4 Emissions to Groundwater

Model input and results files and graphs of the predicted water concentrations at the 50^{th} and 95^{th} percentiles for the model 'WAC_v1.sim' are presented in Appendix G.

5.4.1 Hazardous Substances

The Environment Agency (England and Wales) risk assessment guidance for landfills[1] states that compliance points for predictive modelling of hazardous substances will normally be set immediately down-gradient of the discharge, at a point just below the water table adjacent to the edge of the discharge area and within the expected vertical mixing depth. Practically, compliance points will usually be a borehole located directly adjacent to the landfill on the down-gradient side as there would be problems associated with pathway creation if a groundwater monitoring well were to be drilled through a landfill into the underlying saturated strata. On this basis, the results presented in this section are those predicted for each cell's specific immediately down-gradient monitoring well. The results of the model 'WAC_v1.sim' at the 50^{th} (most likely) and 95^{th} (worst case) percentiles are presented in Table 12.

Table 12: Hazardous Substances (Arsenic) Concentrations at Cell Monitoring Wells

Compliance Point	50%ile		95%ile		EAL (mg/l)
	Peak Conc. (mg/l)	Approx. Time to Peak (yrs)	Peak Conc. (mg/l)	Approx. Time to Peak (yrs)	
Cells 1,2,3 & 5	No breakthrough*		No breakthrough*		0.01
Cell 4	No breakthrough*		No breakthrough*		0.01
Cell 6	No breakthrough*		0.0083	>10,000^	0.01
Cell 7a	No breakthrough*		0.0082	>10,000^	0.01
Cell 7b	No breakthrough*		0.0082	>10,000^|	0.01
Cell 8	No breakthrough*		No breakthrough*		0.01
Cell 9	No breakthrough*		No breakthrough*		0.01
Cell10a	0.0042	>10,000^	0.0088	>10,000^	0.01

[1] www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate#compliance-point – accessed 30 April 2018

Compliance Point	50%ile		95%ile		EAL (mg/l)
	Peak Conc. (mg/l)	Approx. Time to Peak (yrs)	Peak Conc. (mg/l)	Approx. Time to Peak (yrs)	
Cells 1,2,3 & 5	No breakthrough*		No breakthrough*		0.01
Cell 10b	No breakthrough*		0.0081	>10,000^	0.01
Cell 11	No breakthrough*		No breakthrough*		0.01

* Background concentration in aquifer only^ Peak not reached by end of model period (20,000 years)

None of the peak arsenic concentrations predicted in groundwater at the wells immediately down-gradient of each of the cells exceed the EAL. Concentrations are typically predicted to remain at background levels throughout the whole period of the model (i.e. 20,000 years) and when arsenic is predicted to breakthrough to concentrations above that in the background aquifer, it does not do so until after 10,000 years. It is, therefore, considered that the risk to groundwater from the arsenic under the modelled conditions is acceptable.

5.4.2 Non-Hazardous Pollutants

The model '*WAC_v1.sim'* has also been run to determine the peak concentrations of non-hazardous pollutants modelled at the down-gradient receptor Site boundary compliance point. Concentrations reported by the model for sulphate, chloride, antimony, selenium and molybdenum are presented in Table 13.

The result presented for arsenic, chloride and sulphate include concentrations in background groundwater as well as the predicted input from the landfill.

It should be noted that, due to the probabilistic nature of the model, exact values of outputs are unique to a single run sequence, for this reason results are quoted to a maximum of three significant figures as beyond this their values are likely to be affected by the precision of the random sampling procedure.

Table 13: Non-Hazardous Pollutant Concentrations at the Site Boundary Compliance Point

Parameter	50%ile		95%ile		EAL (mg/l)
	Peak Concentration (mg/l)	Approximate Time to Peak (yrs)	Peak Concentration (mg/l)	Approximate Time to Peak (yrs)	
Sulphate	46.9	464	156	420	250
Chloride	22.5	344	54.5	300	250
Antimony	No breakthrough predicted		1.5×10^{-5}	>10,000^	0.05
Selenium	1.81×10^{-4}	7,428	1.17×10^{-3}	7,428	0.01
Molybdenum	9.13×10^{-7}	>10,000^	1.64×10^{-3}	>10,000^	0.07

^ Peak not reached by end of model period (20,000 years)

The EAL for each of the parameters was not predicted to be exceeded at either the 50th or 95th percentiles. It is, therefore, considered that the risk to groundwater from non-hazardous pollutants under the modelled conditions is acceptable.

5.5 Total Organic Carbon Discussion

It is not possible to model TOC in LandSim, so this section presents a qualitative discussion on the relationship between TOC and dissolved organic carbon (DOC), and the ways that concentrations of these could be managed and monitored.

TOC has a standard WAC limit under the 2003 EC Council Decision of 30,000 mg/kg in the solid (soils) material. The EC Council Decision allows, in the case of soils, a higher limit value of up to two times the standard limit to be admitted if the competent authority gives permission, provided the DOC value of 500 mg/kg is achieved at L/S = 10 l/kg (either at the soil's own pH or at a pH value between 7.5 and 8.0). Based on the maximum increase of TOC that could be permitted by the competent authority, it could be possible to apply for a higher limit value of up to 60,000 mg/kg.

In relation to the assessment of risk to the groundwater environment, DOC is of more relevance than TOC, and an increase in TOC does not necessarily equate to a proportional increase in DOC because it depends on how soluble to organic carbon component is within the waste mass.

The 2003 EC Council Decision does not allow for the possibility of increasing the WAC limit for DOC. Providing the soil material entering a landfill has a DOC of 500 mg/kg or less at L/S = 10 l/kg (or C_0 percolation value for the eluate of 160 mg/l), then a higher TOC could be accepted with agreement of EPA.

The European Union (Drinking Water) Regulations 2014 classes TOC as an indicator parameter and, rather than give a specific value for the maximum concentration in water, it presents a parametric value of 'no abnormal change'.

Based on the above, it is suggested that, if an increase in TOC WAC limits of up to two time the standard limit is applied for, there are control measures that could be put in place to monitor TOC and DOC in the waste material, the leachate and in groundwater to ensure that the requirements of the EC Council Decisions and the European Union (Drinking Water) Regulations are met.

These could include the following:

- Gate acceptance processes and the results of WAC testing used to manage the concertation of TOC in the solids and DOC in the eluate in relation to the waste arriving at the Site;
- Leachate at the Site is already monitored for concentrations of TOC and DOC. This continues for the existing cells and is also a requirement for all future inert cells to allow trends and any abnormal changes outside the normal fluctuations to be identified; and
- For management purposes, a Site-specific control value for DOC concentrations in leachate in each cell could be set at 75% of the DOC eluate limit applied for the incoming solid material (i.e. 120 mg/l). DOC concentrations in leachate could be monitored in each cell and if this value is exceeded, appropriate measures (to be agreed with the competent authority) could be put in place. These could include the retesting of a sample to confirm the result and the cessation of tipping of high organic carbon waste in that cell.

Monitoring of TOC in groundwater is already taking place at the Site and could continue in order to be used to monitor trends and identify any increases that are outside the normal fluctuations.

5.6 Total Dissolved Solids Discussion

Section 2.1.2.1 of Council Decision 2003/33/EC provides leaching limit values for waste acceptable at an inert facility. The table of limit values presented in this section of Council Decision 2003/33/EC provides leaching liquid to solid (L/S) ratio limit values for Total Dissolved Solids (TDS), but also notes that the values for TDS can be used alternatively to the values for sulphate and chloride. As is the case with TOC, TDS cannot be modelled in Landsim and, as such, it is not possible to predict the concentrations of this parameter over time for the given Site conditions.

TDS will be dependent on the concentrations of a number of soluble sources within the waste. Two of these sources will be sulphate and chloride, which have both been modelled within the HRA presented in this report at concentrations three times the standard WAC limits. If sulphate and chloride WAC limits are increased to three times the standard WAC limits, and there is no corresponding increase in TDS WAC limits, the contribution that sulphate and chloride could present to TDS concentrations means that TDS has the potential to be a limiting factor in terms of WAC when an increase to limits for certain parameters are considered. As an example, it is plausible that the Site may not be able to accept a specific waste that is acceptable in terms of the increased limits for sulphate and chloride (as well as all other WAC limits) if that waste is outside the standard WAC limit for TDS. Therefore, it is recommended that IMS also applies for a corresponding increase to three times the WAC for TDS.

Although TDS cannot be modelled, the predicted concentrations of associated parameters, chloride and sulphate, in groundwater are below the assessment EALs. TDS mainly presents a risk to surface water and can largely be mitigated through monitoring and controls on emissions to surface waters.

On the basis of what is presented above, it is considered that increasing the WAC limit for TDS to correspond with the proposed increases in the WAC limits for chloride and sulphate is a way of ensuring that the objective of increasing the WAC for Hollywood Landfill is achieved.

6.0 DISCUSSION AND CONCLUSIONS

In accordance with the Groundwater Directive, hazardous substances should be prevented from forming a discernible discharge in groundwater. Discharge of non-hazardous pollutants also needs to be limited so as to prevent pollution. This assessment considered the potential presence of a range of parameters that included both hazardous substances and non-hazardous pollutants that could be present in the waste and any leachate produced at the Site, and that potential for leachate to migrate to the surrounding water environment.

Based on the assumptions that the increased WAC limits will not be exceeded, and that the landfill will be constructed and operated as planned, the model indicates that the EAL for each of the parameters is not predicted to be exceeded at either the 50th or 95th percentiles. It is, therefore, considered that the risk to groundwater from the selected hazardous substances (i.e. arsenic) and the selected non-hazardous pollutants (i.e. sulphate, chloride, antimony, selenium and molybdenum) under the modelled conditions is acceptable.

An assumption of the model is that leachate levels within the waste mass will be managed so they do not break out at the surface of the cells. The hydraulics of the model predict that (given the properties of the waste, the amount of water that infiltrates from precipitation, and the low hydraulic conductivity of the basal liner,) leachate levels will continue to increase and need to be managed to prevent surface breakout. Provided leachate levels are managed and surface breakout does not occur then the assumptions on which the model is based, remain valid and surface water is not introduced as an additional receptor.

Monitoring at the Site should continue to be used to maintain compliance with the waste licence. The selected model parameters, plus TOC (and DOC in the case of groundwater) should be monitored in leachate, groundwater and surface water. Groundwater levels should continue to be monitored, so that the data can be used in future work to determine that the conceptual site model used in this assessment remains valid.

Given that the model indicates that the EAL for each of the parameters selected is not predicted to be exceeded at either the 50th or 95th percentiles for a scenario where waste with the proposed elevated WAC is placed at the landfill, it is considered the risk to groundwater directly underneath the Site from the selected hazardous substances (i.e. arsenic) and the selected non-hazardous pollutants (i.e. sulphate, chloride, antimony, selenium and molybdenum) under the modelled conditions is acceptable. On this basis, namely that the risk to the underlying aquifer is acceptable and given all indications to date from numerous studies carried out by two different independent consultants indicate the lack of any hydraulic connectivity between the Site and the BOTR, it is predicted that there is no discernible risk to the existing BOTR supply from the proposed WAC increase for inert waste at Hollywood Landfill.

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Patel Tonra Ltd, 2012b: Quarter 1, 2012 Groundwater and Leachate Monitoring Report, Hollywood Inert Landfill. June 2012.

Patel Tonra Ltd, 2012c: Quarter 2, 2012 Groundwater and Surface Water Monitoring Report, Hollywood Inert Landfill. August 2012.

Patel Tonra Ltd, 2012d: Quarter 3, 2012 Groundwater and Leachate Monitoring Report, Hollywood Inert Landfill. October 2012.

Patel Tonra Ltd, 2013a: Quarter 4, 2012 Groundwater Monitoring Report, Hollywood Inert Landfill. February 2013

Patel Tonra Ltd, 2013b: 2012 Annual Environmental Report for Murphy Environmental Hollywood Ltd. March 2013.

Patel Tonra Ltd, 2013c: Quarter 1, 2013 Groundwater Monitoring Report, Hollywood Inert Landfill. June 2013.

Patel Tonra Ltd, 2013d: Quarter 1, 2013 Leachate Monitoring Report, Hollywood Inert Landfill. June 2013.

Patel Tonra Ltd, 2013e: Quarter 2, 2013 Groundwater Monitoring Report, Hollywood Inert Landfill. July 2013.

Patel Tonra Ltd, 2013f: Quarter 3, 2013 Groundwater Monitoring Report, Hollywood Inert Landfill. October 2013.

Patel Tonra Ltd, 2013g: Quarter 3, 2013 Leachate Monitoring Report, Hollywood Inert Landfill. October 2013.

Patel Tonra Ltd, 2013h: Quarter 4, 2013 Groundwater Monitoring Report, Hollywood Inert Landfill. December 2013.

Patel Tonra Ltd, 2014a: 2013 Annual Environmental Report for Murphy Environmental Hollywood Ltd. February 2014.

Patel Tonra Ltd, 2014b: Quarter 1, 2014 Groundwater Monitoring Report, Hollywood Inert Landfill. March 2014.

Patel Tonra Ltd, 2014c: Quarter 1, 2014 Leachate Monitoring Report, Hollywood Inert Landfill. March 2014.

Patel Tonra Ltd, 2014d: Quarter 2, 2014 Groundwater Monitoring Report, Hollywood Inert Landfill. June 2014.

Patel Tonra Ltd, 2014e: Quarter 3, 2014 Groundwater Monitoring Report, Hollywood Inert Landfill. September 2014.

Patel Tonra Ltd, 2014f: Quarter 3, 2014 Leachate Monitoring Report, Hollywood Inert Landfill. September 2014.

Patel Tonra Ltd, 2014g: Quarter 4, 2014 Groundwater Monitoring Report, Hollywood Inert Landfill. December 2014.

Patel Tonra Ltd, 2015a: 2014 Annual Environmental Report for Murphy Environmental Hollywood Ltd. February 2015.

Patel Tonra Ltd, 2015b: Quarter 1, 2015 Groundwater Monitoring Report, Hollywood Inert Landfill. April 2015.

Patel Tonra Ltd, 2015c: Quarter 1, 2015 Leachate Monitoring Report, Hollywood Inert Landfill. April 2015.

Patel Tonra Ltd, 2015d: Quarter 2, 2015 Groundwater Monitoring Report, Hollywood Inert Landfill. June 2015.

Patel Tonra Ltd, 2015e: Quarter 3, 2015 Groundwater Monitoring Report, Hollywood Inert Landfill. September 2015.

Patel Tonra Ltd, 2015f: Quarter 3, 2015 Leachate Monitoring Report, Hollywood Inert Landfill. September 2015.

Patel Tonra Ltd, 2016a: Quarter 4, 2015 Groundwater Monitoring Report, Hollywood Inert Landfill. January 2016.

Patel Tonra Ltd, 2016b: 2015 Annual Environmental Report for Murphy Environmental Hollywood Ltd. March 2016.

Patel Tonra Ltd, 2016c: Quarter 1, 2016 Groundwater Monitoring Report, Hollywood Inert Landfill. April 2016.

Patel Tonra Ltd, 2016d: Quarter 1, 2015 Leachate Monitoring Report, Hollywood Inert Landfill. April 2016.

Patel Tonra Ltd, 2016e: Quarter 2, 2016 Groundwater Monitoring Report, Hollywood Inert Landfill. June 2016.

Patel Tonra Ltd, 2016f: Quarter 3, 2016 Groundwater Monitoring Report, Hollywood Inert Landfill. November 2016.

Patel Tonra Ltd, 2016g: Quarter 3, 2016 Leachate Monitoring Report, Hollywood Inert Landfill. November 2016.

Patel Tonra Ltd, 2017a: Quarter 4, 2016 Groundwater Monitoring Report, Hollywood Inert Landfill. January 2017.

Patel Tonra Ltd, 2017b: 2016 Annual Environmental Report for Murphy Environmental Hollywood Ltd. February 2017.

Patel Tonra Ltd, 2017c: Quarter 1, 2017 Groundwater Monitoring Report, Hollywood Inert Landfill. May 2017.

Patel Tonra Ltd, 2017d: Quarter 1, 2017 Leachate Monitoring Report, Hollywood Inert Landfill. May 2017.

Patel Tonra Ltd, 2017e: Quarter 2, 2017 Groundwater Monitoring Report, Hollywood Inert Landfill. July 2017.

Patel Tonra Ltd, 2017f: Quarter 3, 2017 Groundwater Monitoring Report, Hollywood Inert Landfill. September 2017.

Patel Tonra Ltd, 2017g: Quarter 3, 2017 Leachate Monitoring Report, Hollywood Inert Landfill. September 2017.

Patel Tonra Ltd, 2018a: Quarter 4, 2017 Groundwater Monitoring Report, Hollywood Inert Landfill. January 2018.

Patel Tonra Ltd, 2018b: 2017 Annual Environmental Report for IMSL Hollywood. March 2018.

Working Group on Groundwater, 2005: Guidance on the Assessment of the Impact of Groundwater Abstractions. Guidance Document no. GW5, dated March 2005.

Signature Page

Golder Associates (UK) Ltd

Richard Lansley
Senior Hydrogeologist

Peter Corrigan
Project Manager

AG/RL/PC/ar

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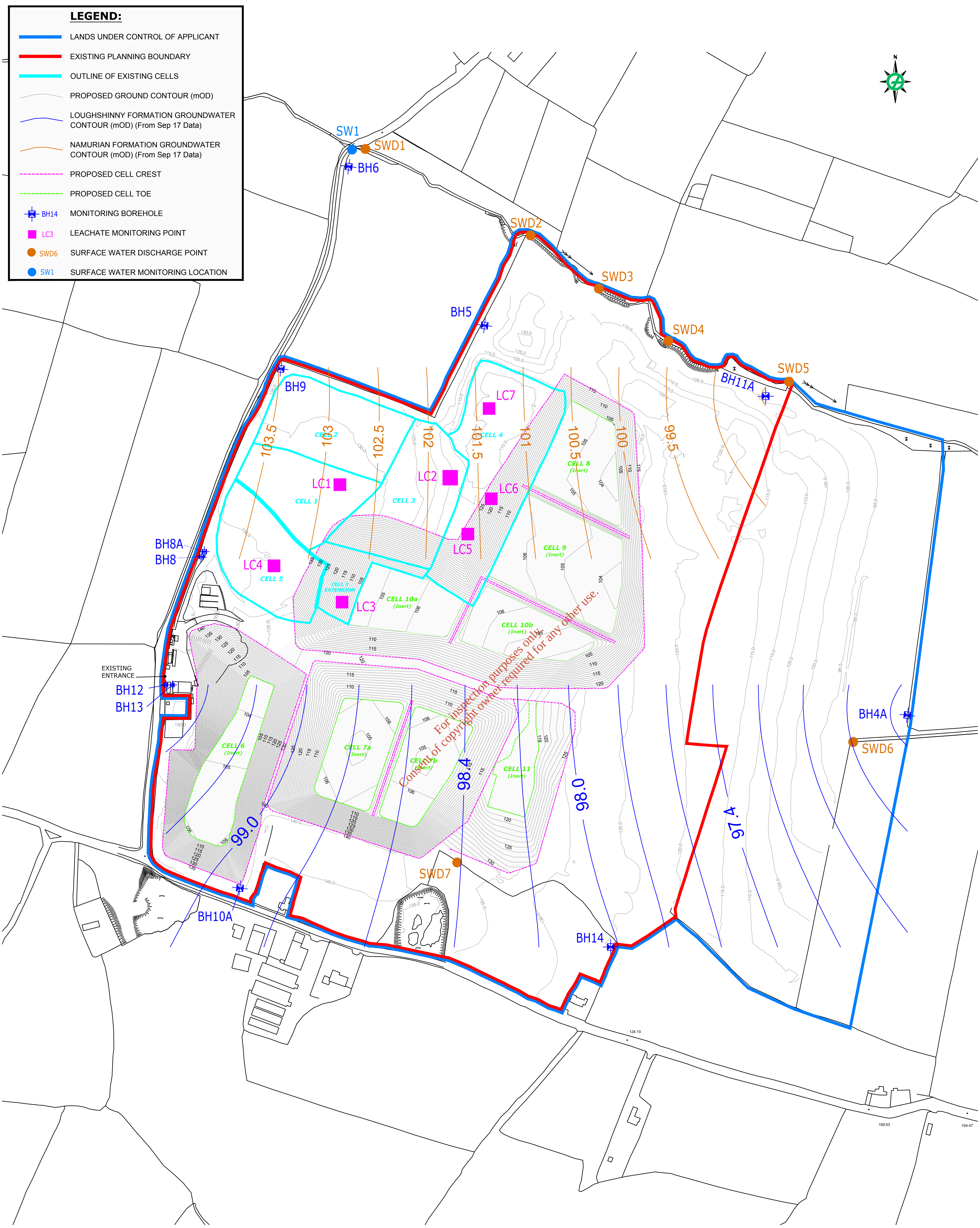
DRAWINGS

Drawing 1

Path: \\naa1-s-main01\Company\PROJECTS\2017\1775927 - Hollywood Landfill Quarry Cell\11. GRAPHICS\13. Phasing Drawings - 24 April 2018\04 - Final drawings\ | File Name: 06 - GW & SW.dwg



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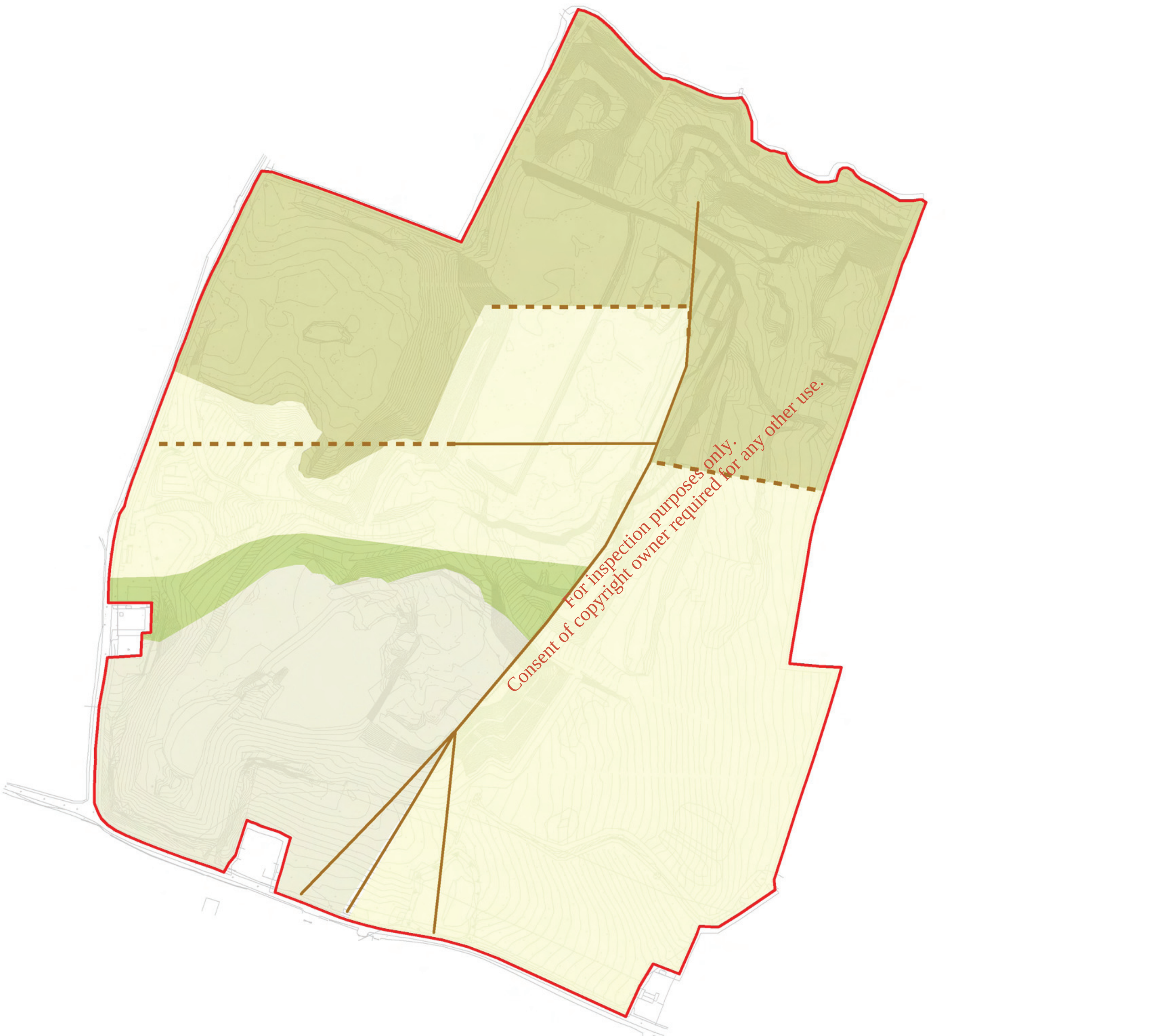
PROJECT	LANDFILL DEVELOPMENT
CONSULTANT	Golder Associates
YYYY-MM-DD	2018-May-17
PREPARED	POB
DESIGN	PC
REVIEW	PC
APPROVED	PC
TITLE	HYDROGEOLOGICAL RISK ASSESSMENT FOR INERT WASTE ACCEPTANCE CRITERIA INCREASE
PROJECT No.	1775927
DRAWING No.	01
Rev.	A
SCALE	1:2,000 A1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A1

25 mm

APPENDIX A

ARUP 2010: Figure 6 - Site Geological Map



ARUP

wyg

patel tonra ltd environmental solutions

MANAHAN PLANNERS Chartered Town Planning Consultants

Murphy Environmental Hollywood Ltd

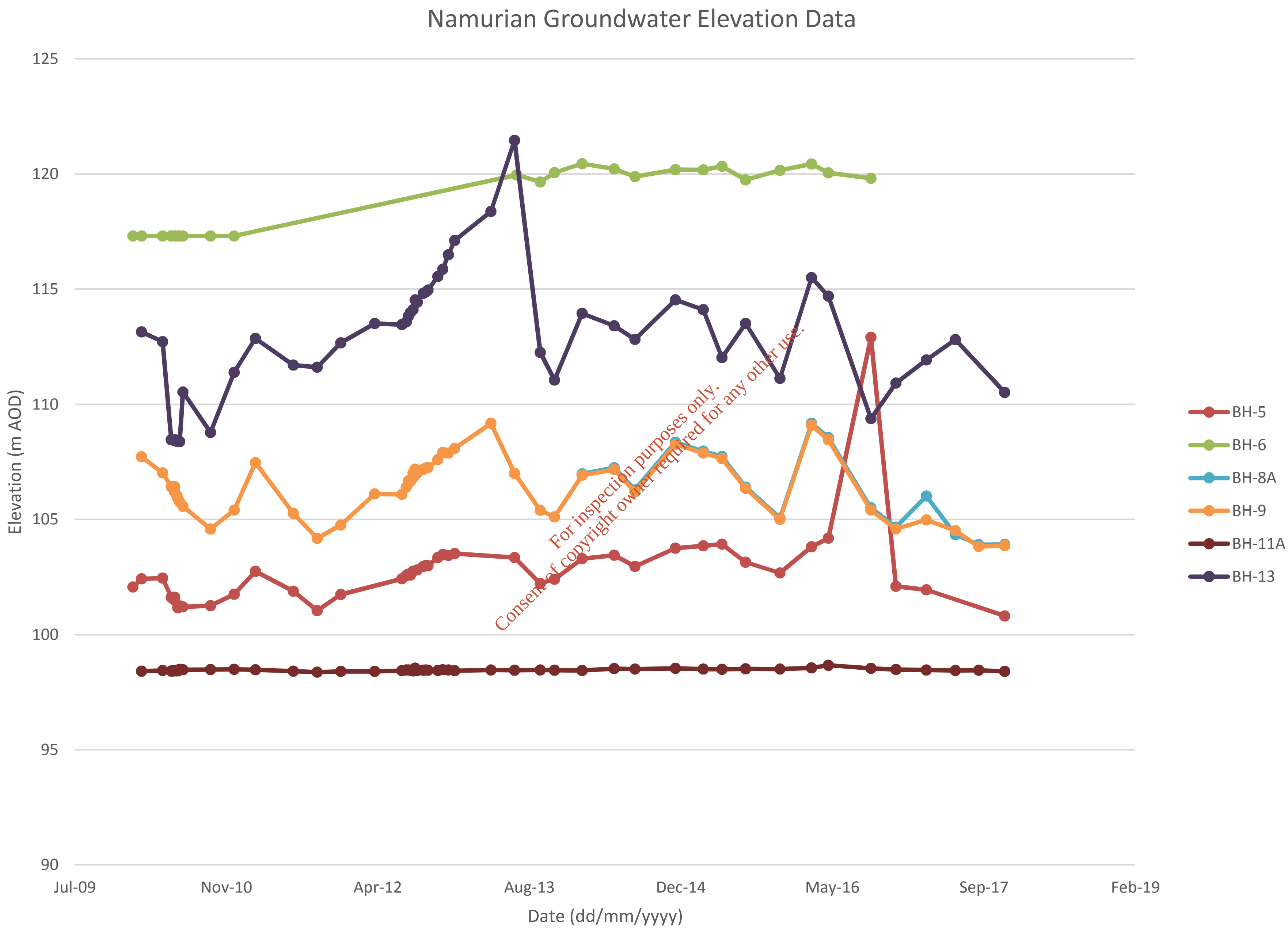
MEHL Integrated
Waste Management Facility
Hollywood Great, Nags Head, Naul, Co Dublin

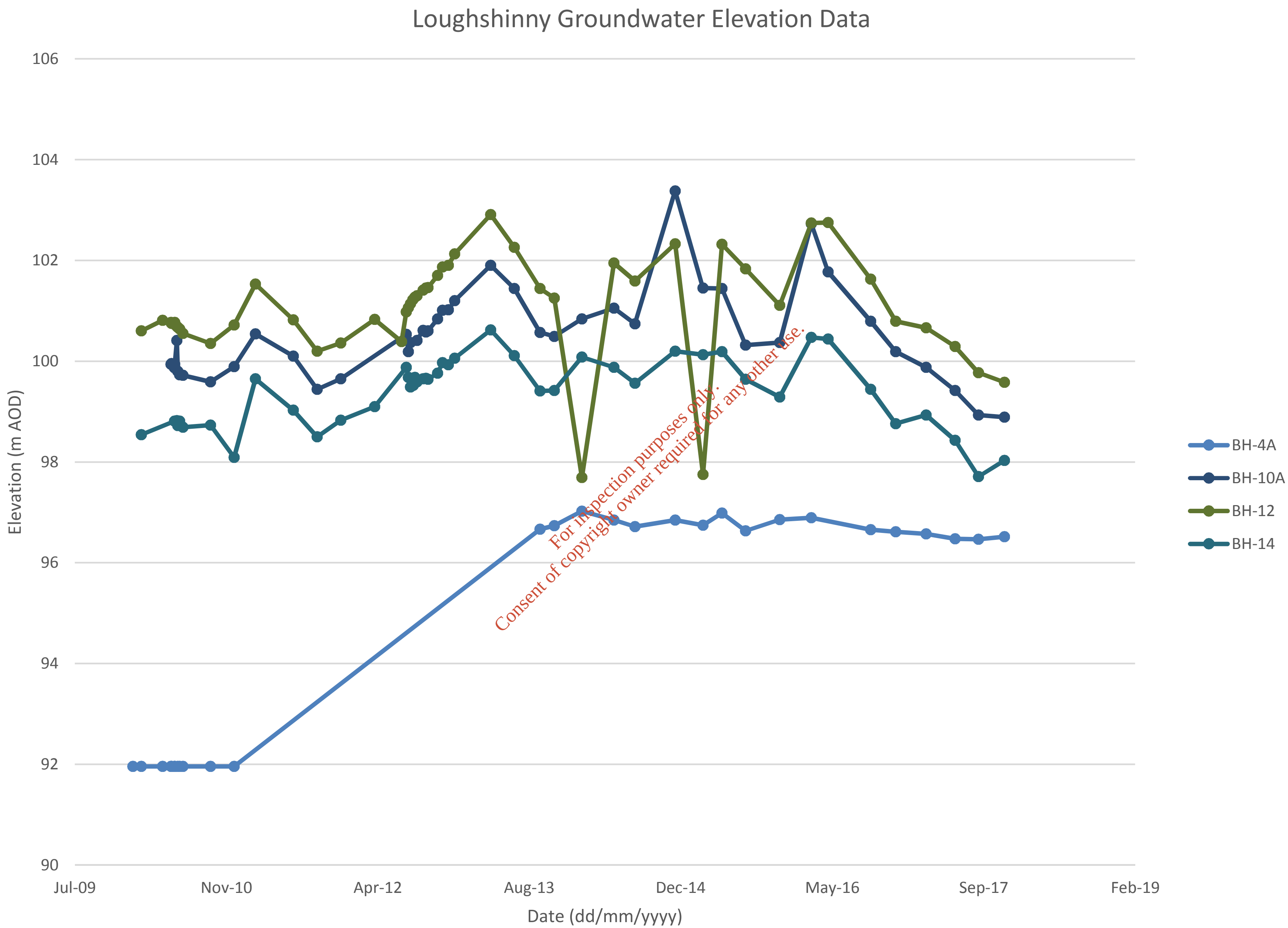
Site Geological map

December 2010 Figure **6**

APPENDIX B

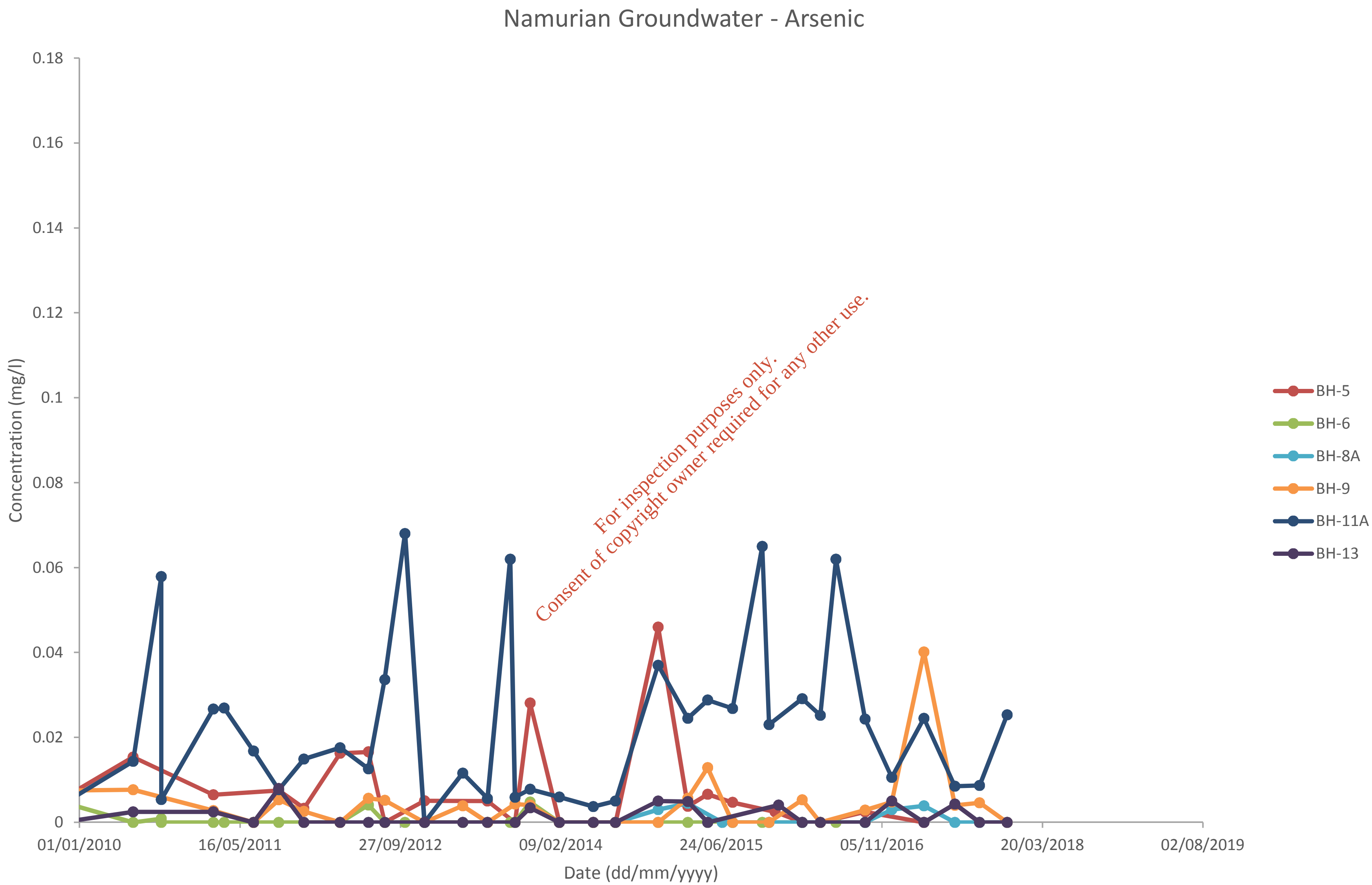
Groundwater Elevation Graphs

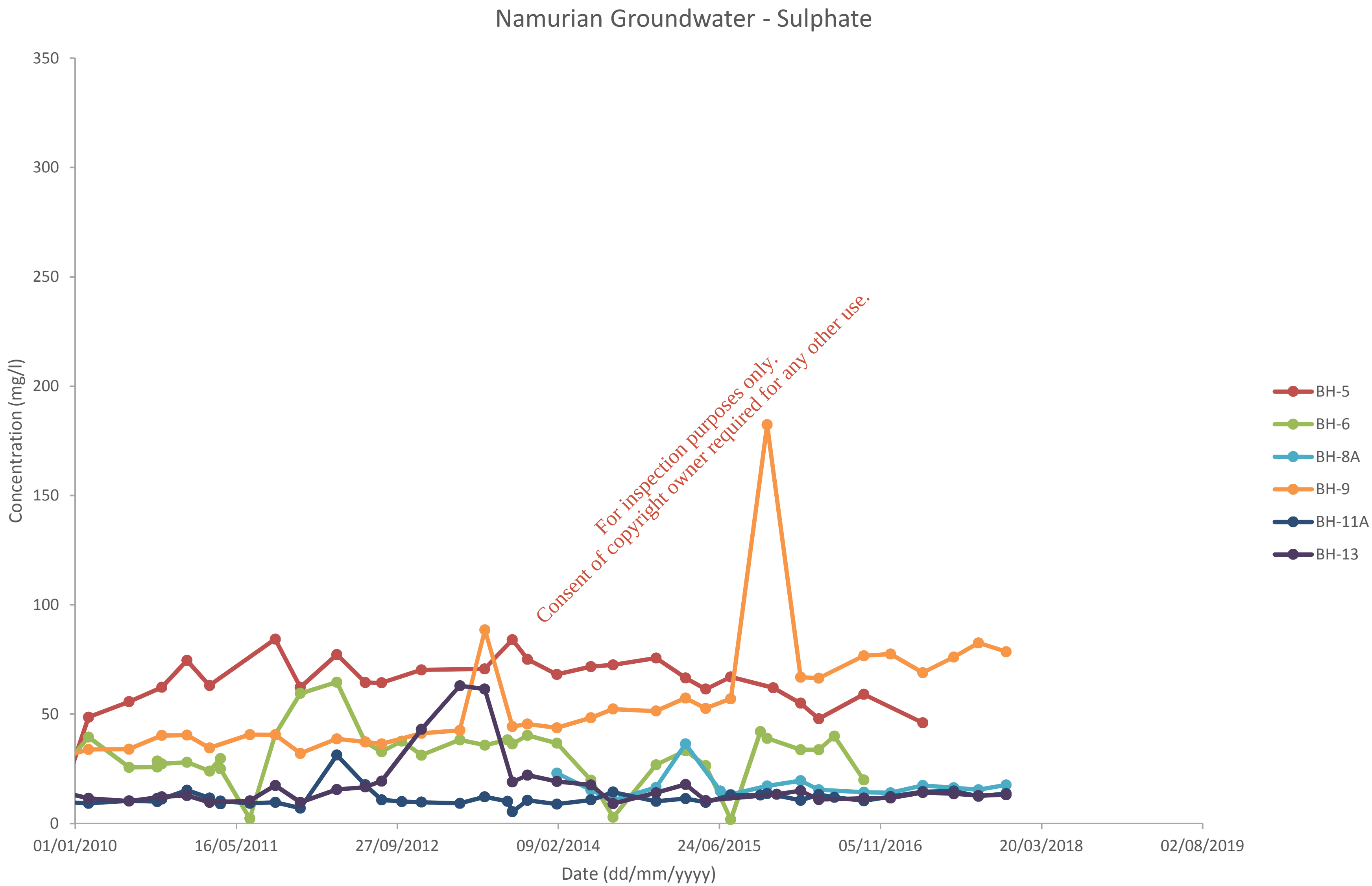

Namurian Groundwater Elevation Data
125
120
115
110
105
100
95
90
Elevation (m AOD)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date (dd/mm/yyyy)
BH-5
BH-6
BH-8A
BH-9
BH-11A
BH-13

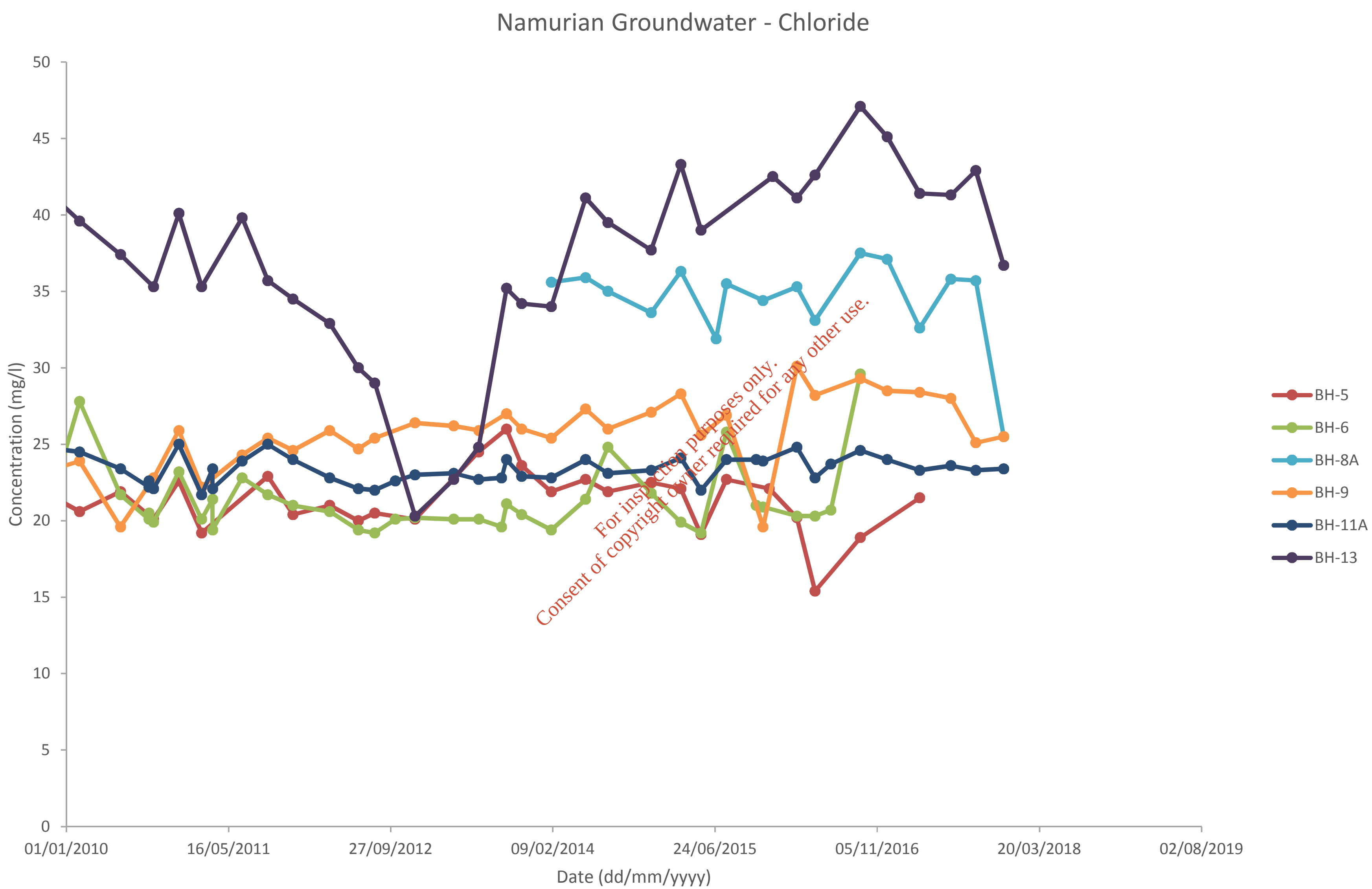

Loughshinny Groundwater Elevation Data
106
104
102
100
98
96
94
92
90
Elevation (m AOD)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date (dd/mm/yyyy)
BH-4A
BH-10A
BH-12
BH-14

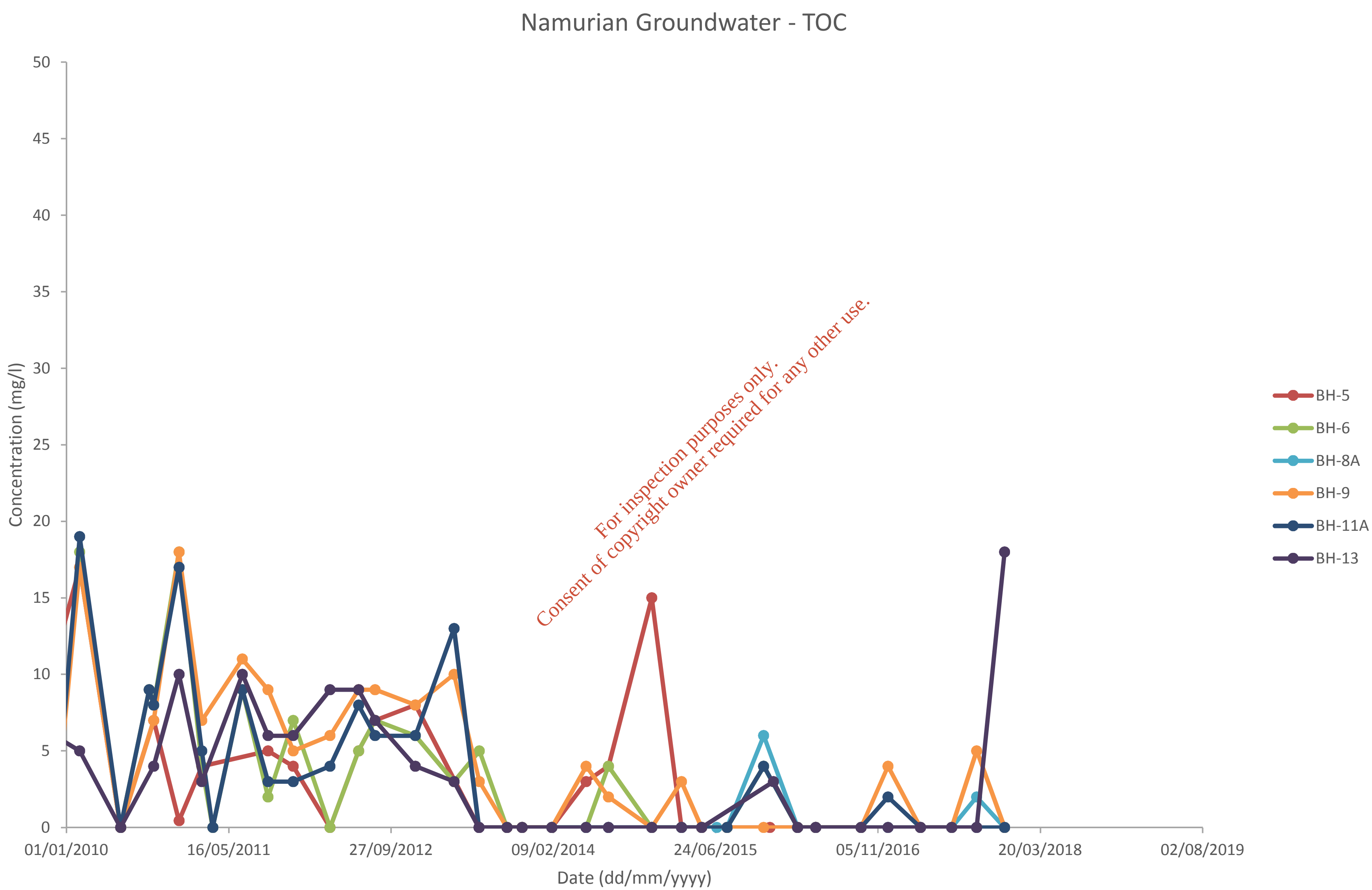
APPENDIX C

Groundwater Quality Graphs


Namurian Groundwater - Arsenic
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Concentration (mg/l)
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-5
BH-6
BH-8A
BH-9
BH-11A
BH-13


Namurian Groundwater - Sulphate
Concentration (mg/l)
350
300
250
200
150
100
50
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-5
BH-6
BH-8A
BH-9
BH-11A
BH-13


Namurian Groundwater - Chloride
Concentration (mg/l)
50
45
40
35
30
25
20
15
10
5
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-5
BH-6
BH-8A
BH-9
BH-11A
BH-13


Namurian Groundwater - TOC
Concentration (mg/l)
50
45
40
35
30
25
20
15
10
5
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-5
BH-6
BH-8A
BH-9
BH-11A
BH-13
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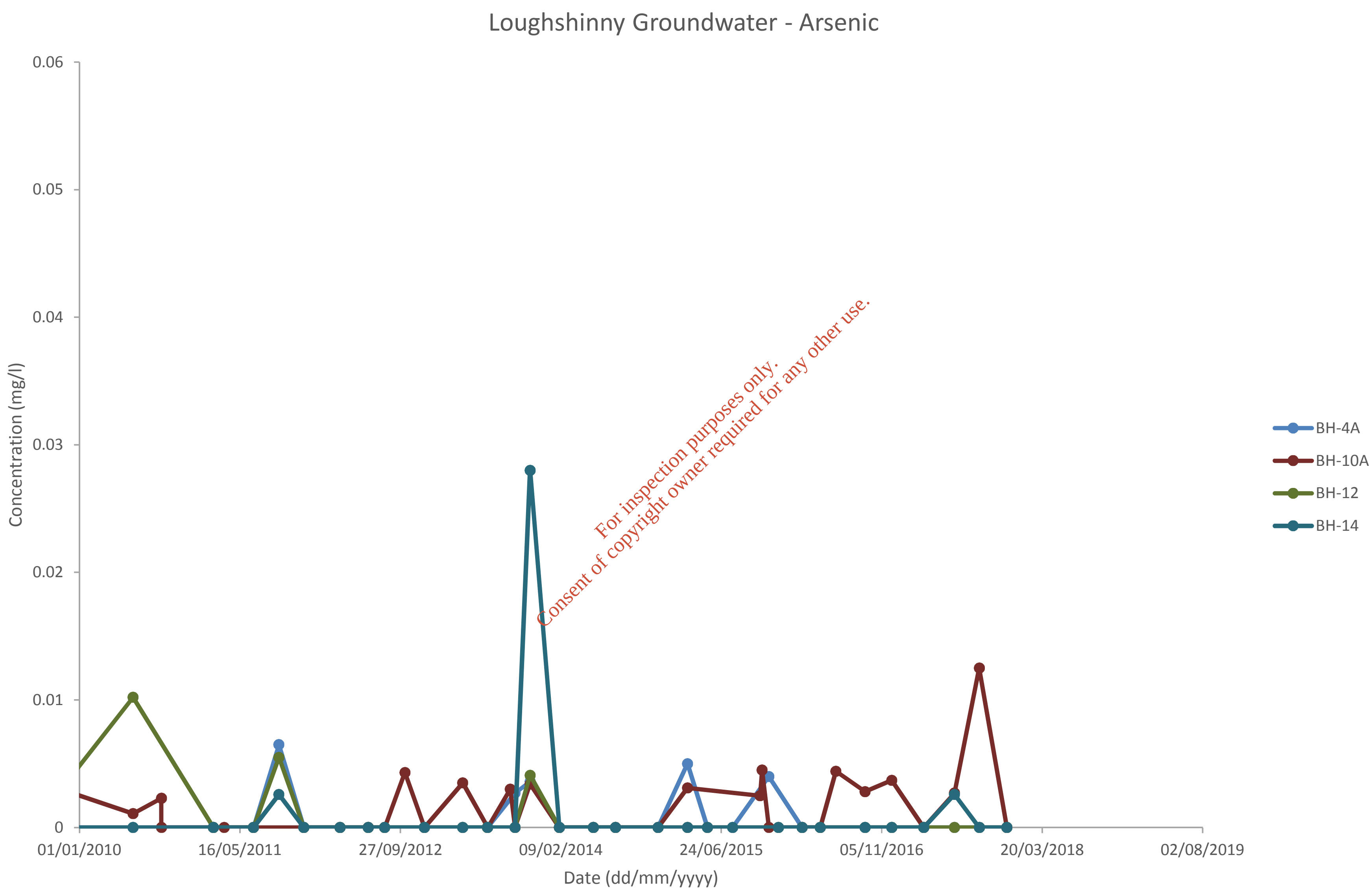
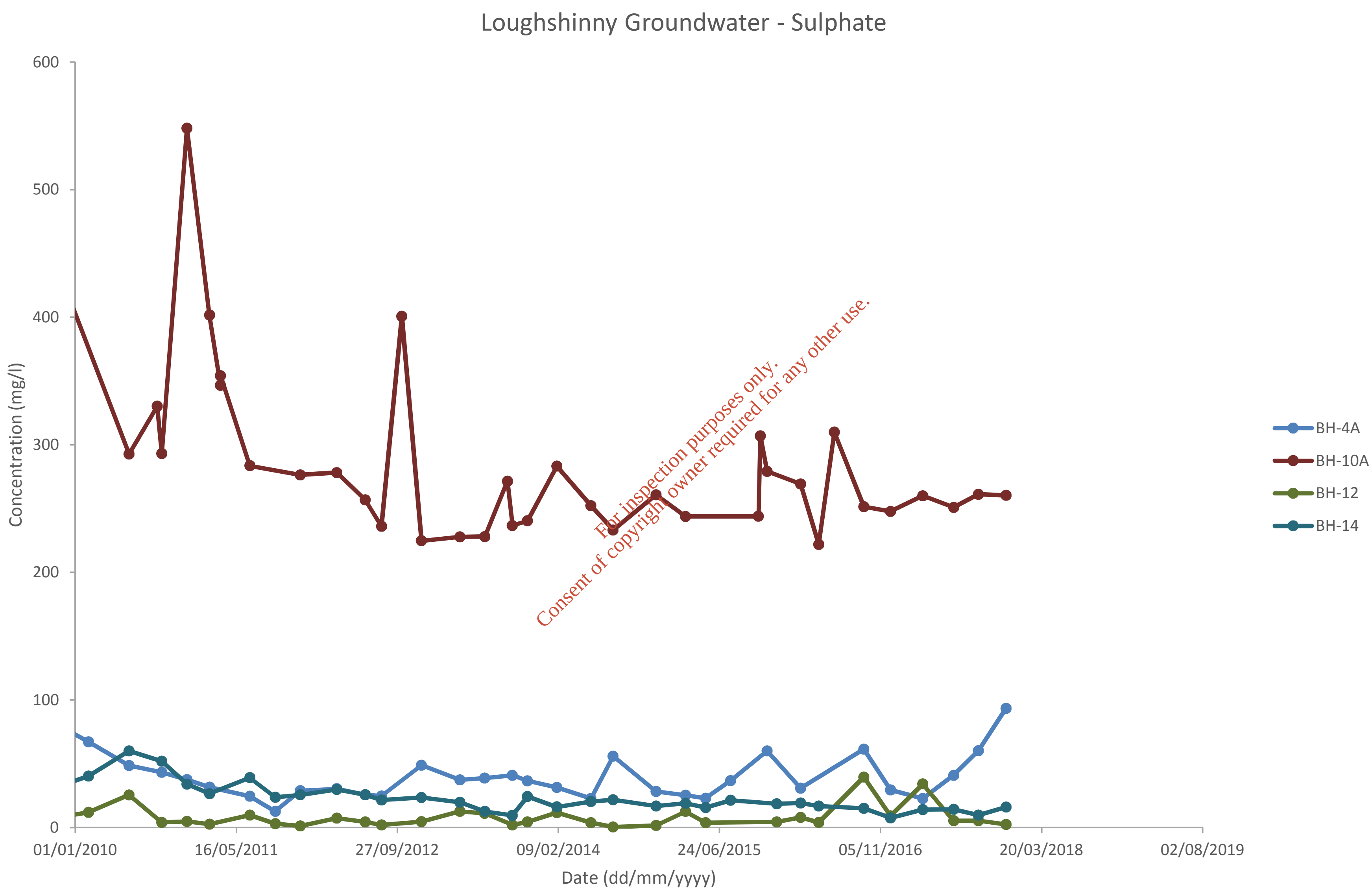
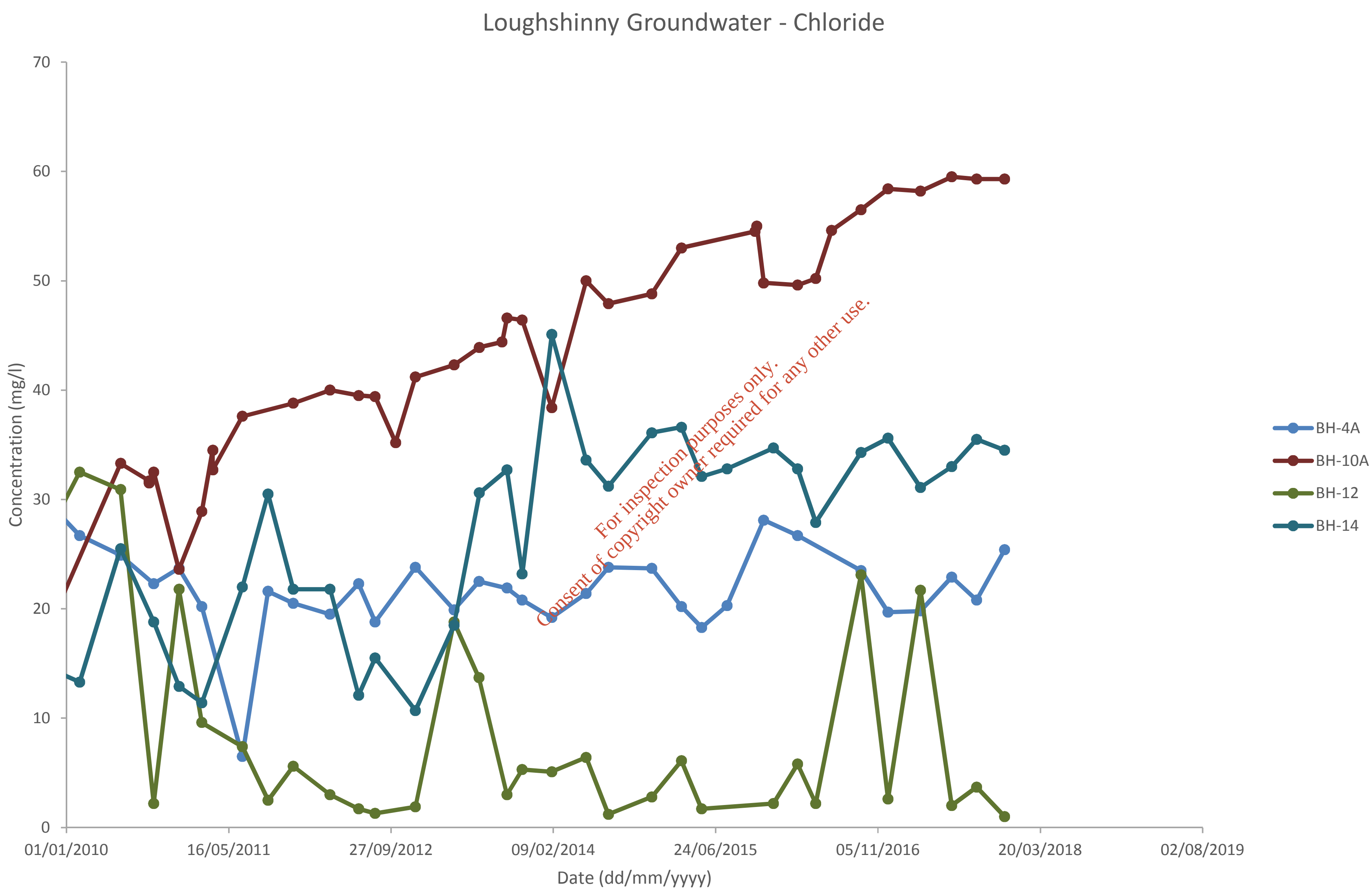
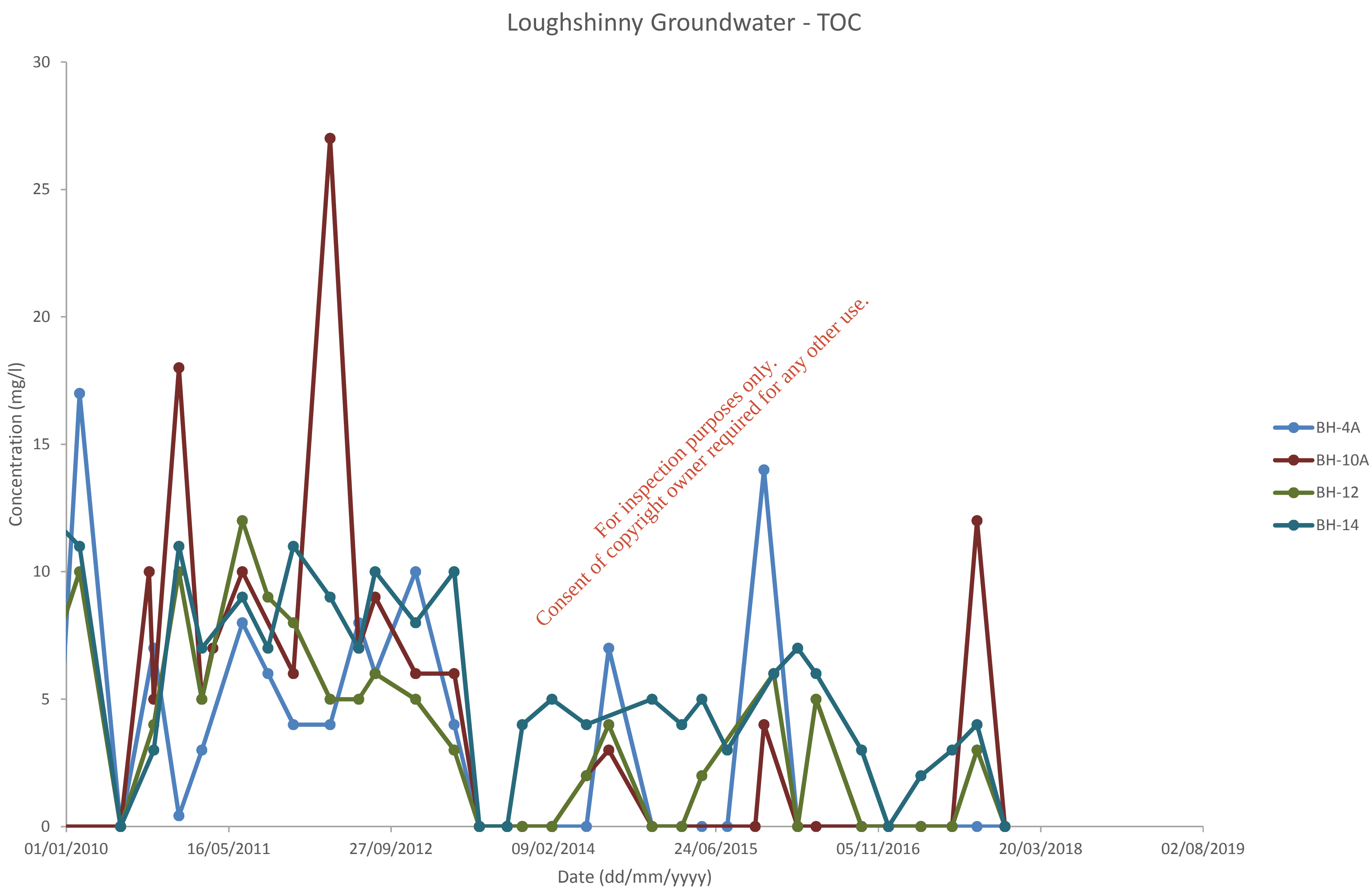
Consent of copyright owner required for any other use.


Loughshinny Groundwater - Arsenic
0.06
0.05
0.04
0.03
0.02
0.01
0
Concentration (mg/l)
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-4A
BH-10A
BH-12
BH-14

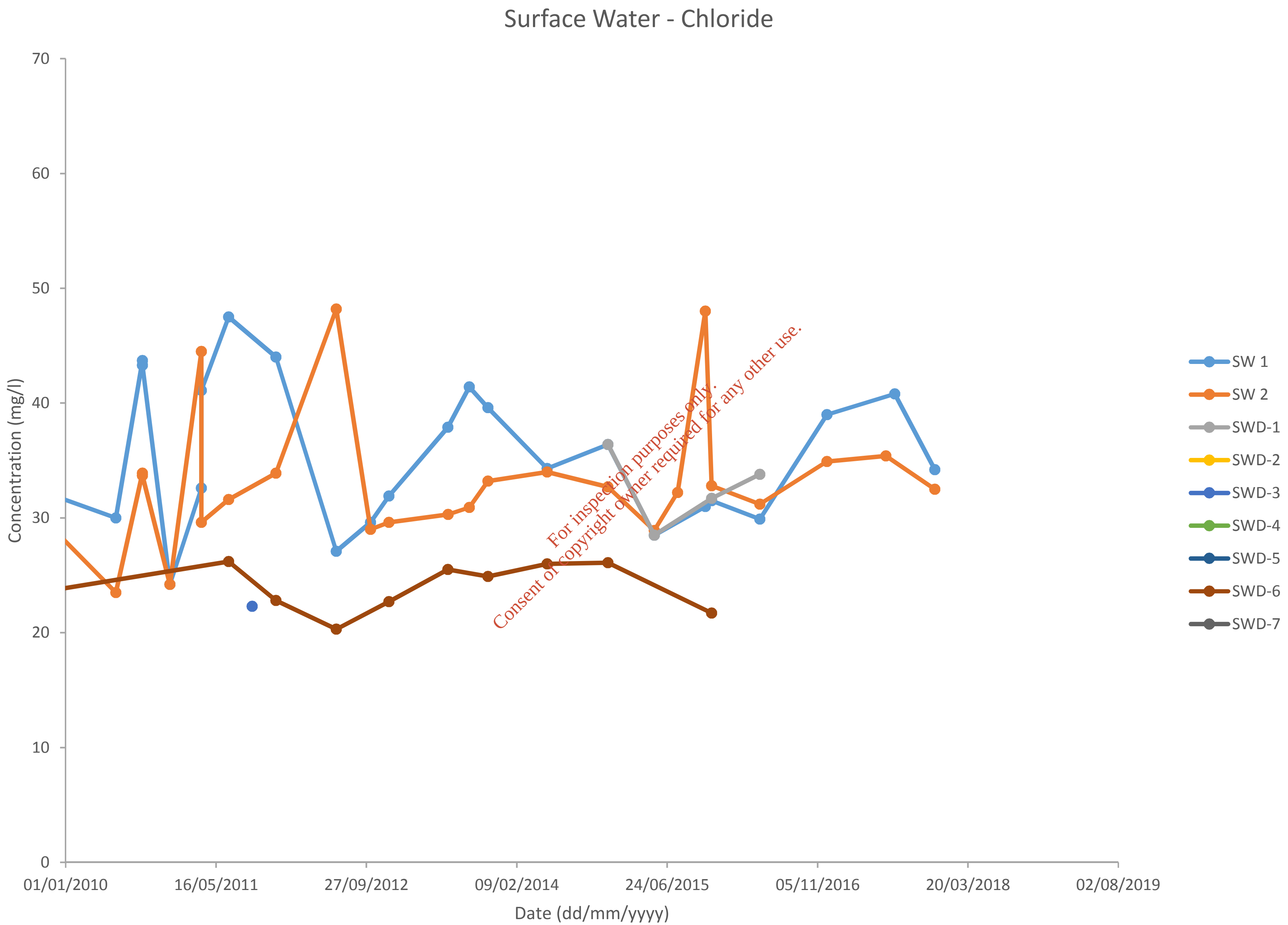

Loughshinny Groundwater - Sulphate
Concentration (mg/l)
600
500
400
300
200
100
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-4A
BH-10A
BH-12
BH-14

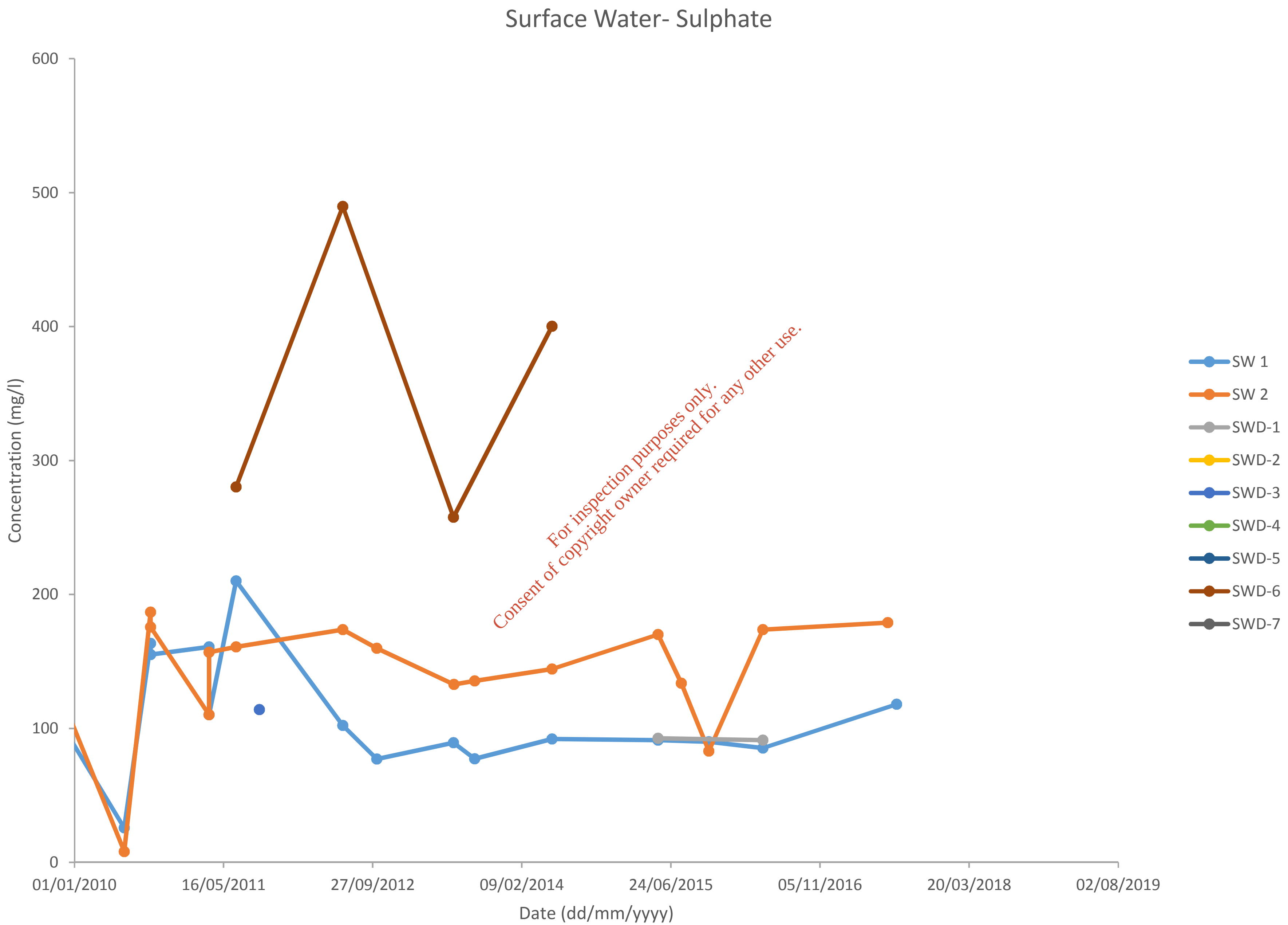

Loughshinny Groundwater - Chloride
Concentration (mg/l)
0
10
20
30
40
50
60
70
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-4A
BH-10A
BH-12
BH-14

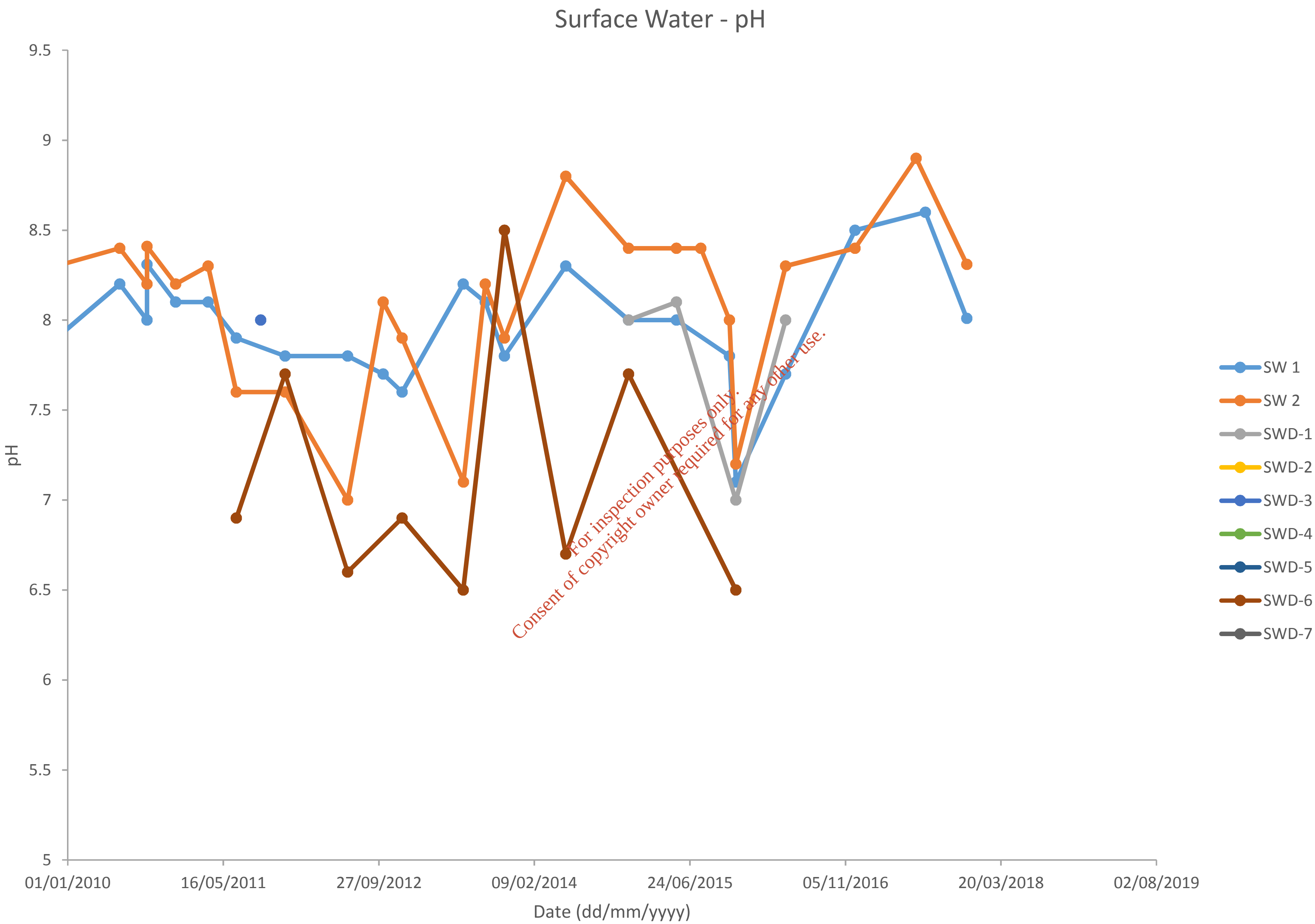

Loughshinny Groundwater - TOC
Concentration (mg/l)
30
25
20
15
10
5
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
BH-4A
BH-10A
BH-12
BH-14

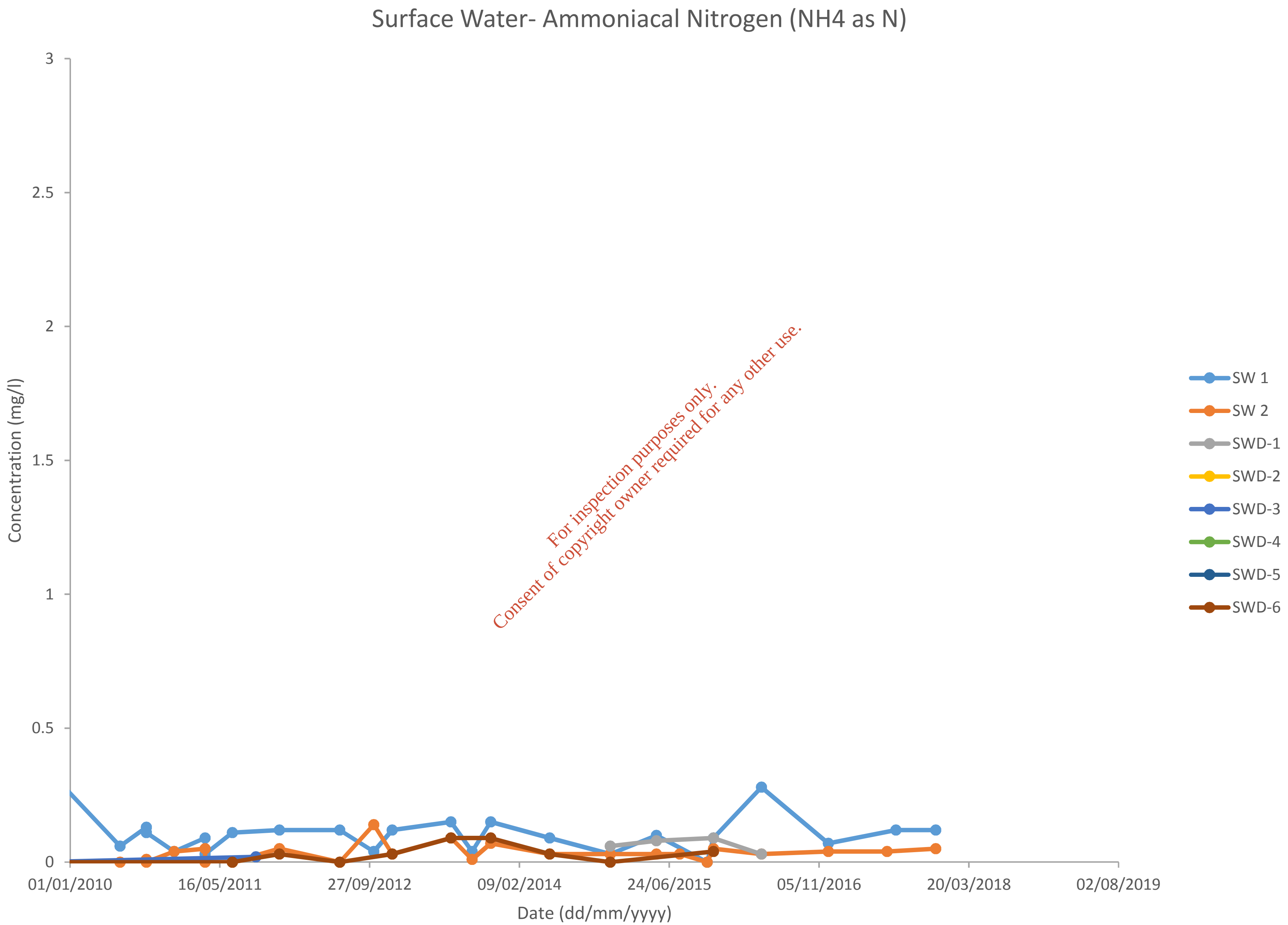
APPENDIX D

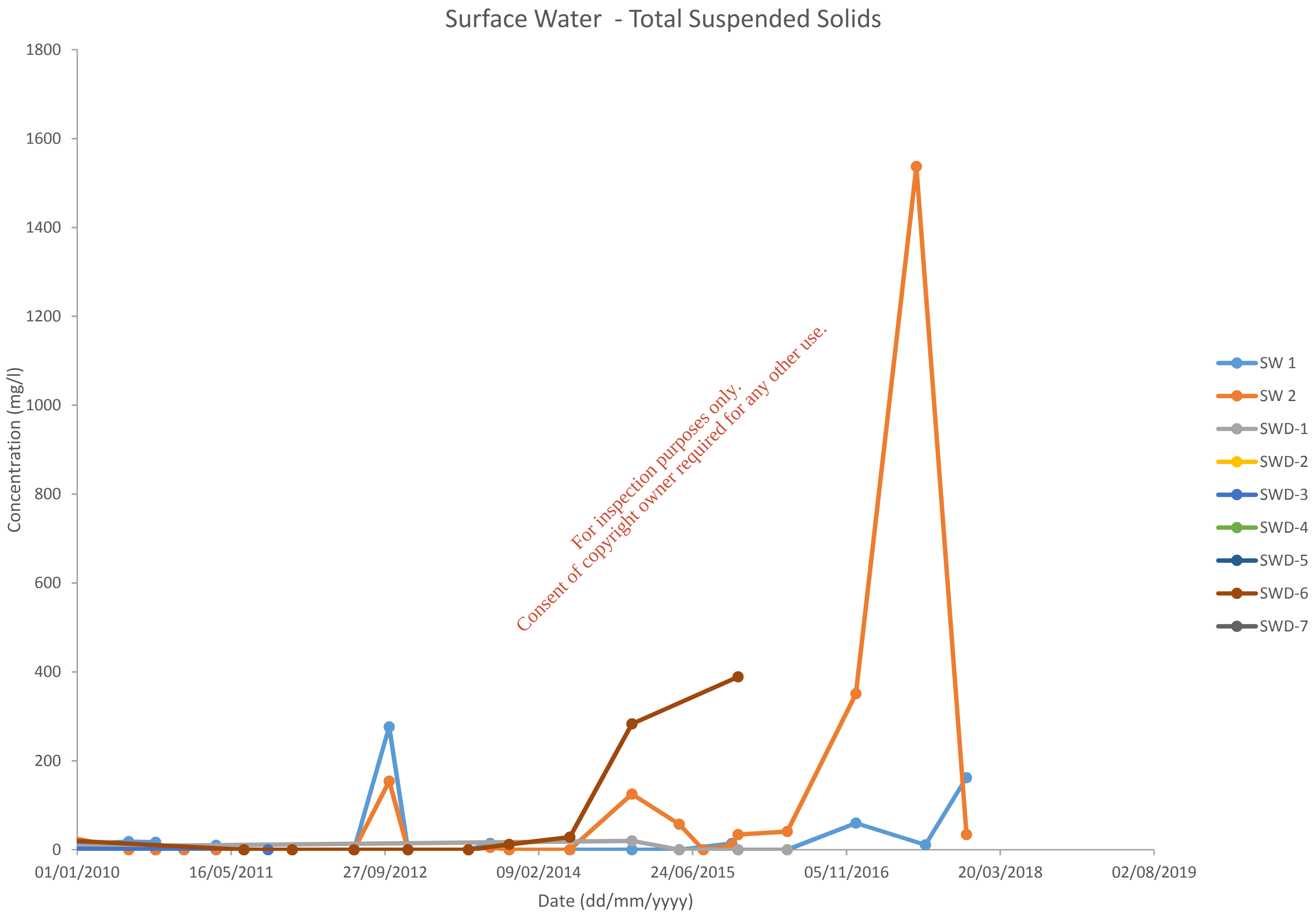
Surface Water Quality Graphs

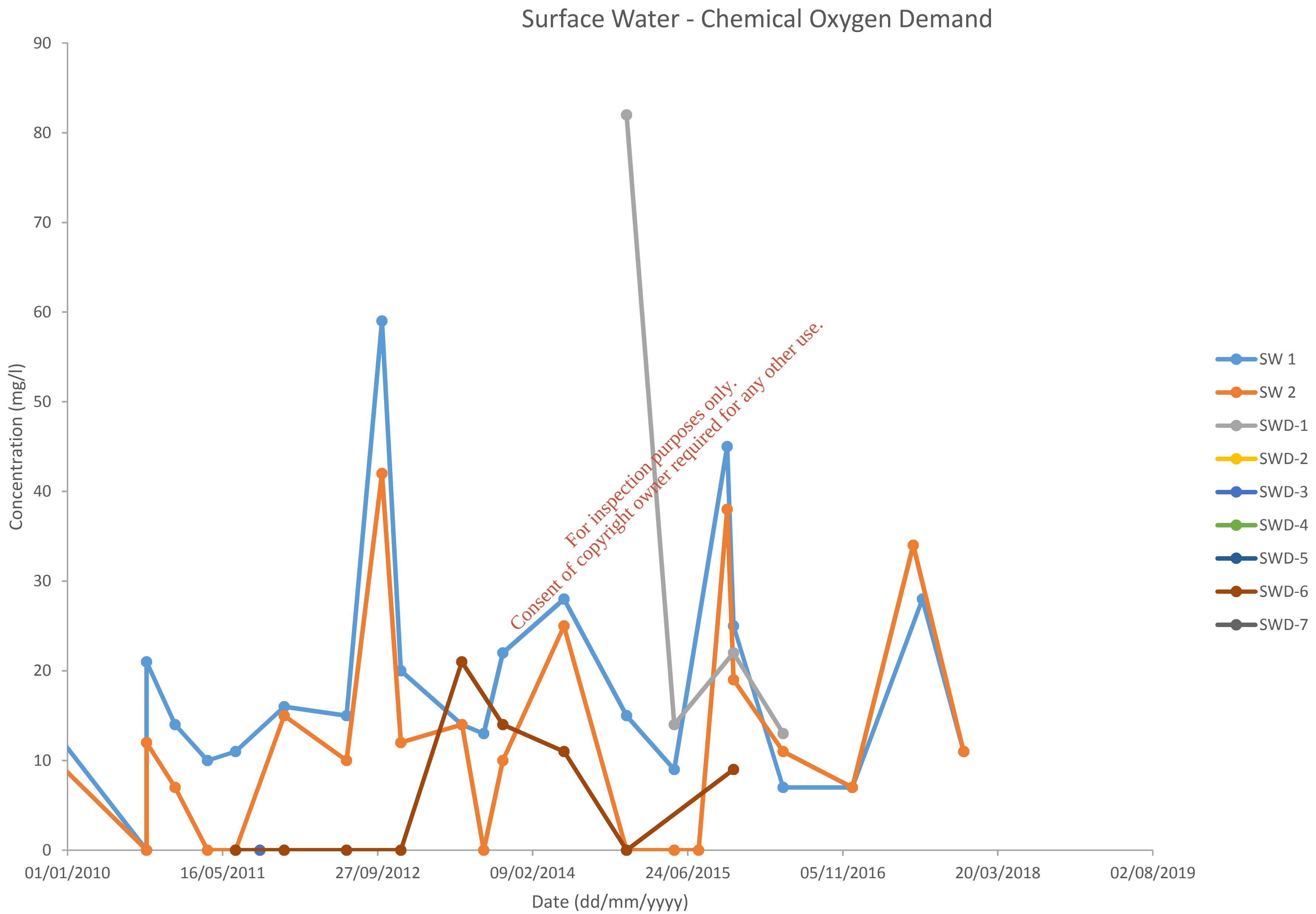

Surface Water - Chloride
Concentration (mg/l)
70
60
50
40
30
20
10
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6
SWD-7


Surface Water- Sulphate
600
500
400
300
200
100
0
Concentration (mg/l)
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6
SWD-7


Surface Water - pH
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
pH
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6
SWD-7

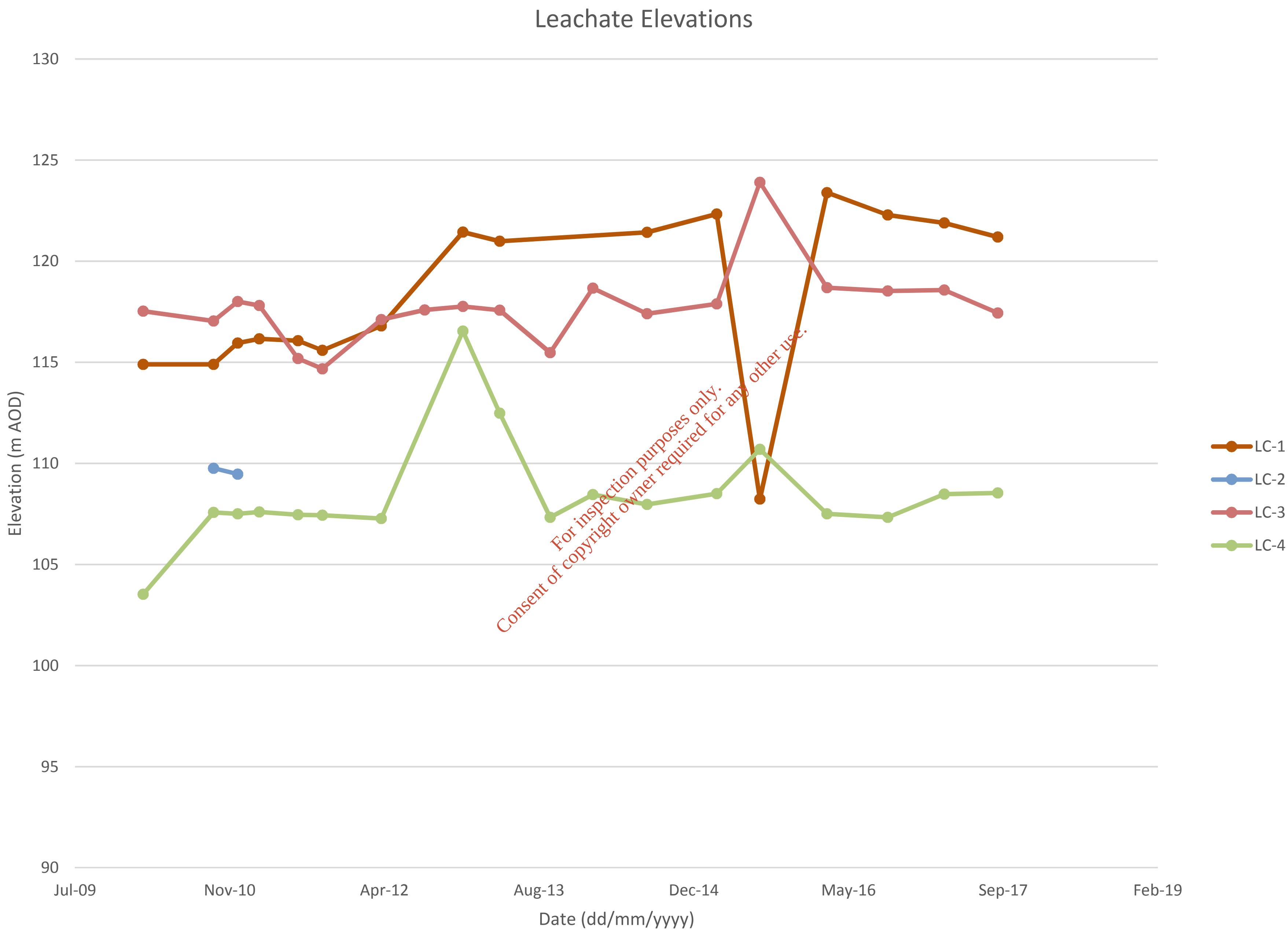

Surface Water- Ammoniacal Nitrogen (NH4 as N)
Concentration (mg/l)
3
2.5
2
1.5
1
0.5
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6


Surface Water - Total Suspended Solids
Concentration (mg/l)
1800
1600
1400
1200
1000
800
600
400
200
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6
SWD-7


Surface Water - Chemical Oxygen Demand
Concentration (mg/l)
90
80
70
60
50
40
30
20
10
0
01/01/2010
16/05/2011
27/09/2012
09/02/2014
24/06/2015
05/11/2016
20/03/2018
02/08/2019
Date (dd/mm/yyyy)
SW 1
SW 2
SWD-1
SWD-2
SWD-3
SWD-4
SWD-5
SWD-6
SWD-7

APPENDIX E

Leachate Elevation Graphs


Leachate Elevations
130
125
120
115
110
105
100
95
90
Elevation (m AOD)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Date (dd/mm/yyyy)
LC-1
LC-2
LC-3
LC-4

APPENDIX F

LandSim Model Inputs and Justification

INPUT VALUES	UNIT	INPUT		JUSTIFICTION	
Infiltration					
Infiltration to open waste	mm/yr	Triangular(113.1,252.7,437.9)		Infiltration to open waste assumed to be equivalent to effective rainfall (precipitation - actual evapotranspiration). Input is the range from 2003-2017, with the mean as the most likely value	
Cap design infiltration	mm/yr	NORMAL(50,10)		Assume normal distribution around a mean of 50 mm (used as a typical value for infiltration to a clay cap). Above the maximum infiltration rate of 31.5 mm/yr specified in the EPA Manual on Landfill Site Design (EPA, 2000) for a capped landfill and is, therefore, conservative.	
		Offset of filling (from 2003)		Approx years of filling	
Cell 1	years		0		6
Cell 2	years	included with cell 1		included with cell 1	
Cell 3 (including extension)	years	included with cell 1		included with cell 1	
Cell 4	years		10		6
Cell 5 a and b	years	included with cell 1		included with cell 1	
Cell 6	years		15		2
Cell 7a	years		25		2
Cell 7b	years		27		2
Cell 8	years		17		1
Cell 9	years		19		1
Cell 10a	years		21		2
Cell 10b	years		22		2
Cell 11	years		23		1
PE cap?	y/n	n		Compacted soils material used for capping and restoration. No polyethylene (PE) cap to degrade.	
Infiltration to grassland	mm/yr	not required if PE cap not modelled			
Start of cap degradation (years from end of waste disposal)	years	not required if PE cap not modelled			
End of cap degradation (years from end of waste disposal)	years	not required if PE cap not modelled			
Management Control period	years		20,000		
Cell Geometry					
Cells 1, 2, 3 and 5 (combined) - length at base	m		175	Assumes base is 50 m narrower than the top (top length 225 m).	
Cells 1, 2, 3 and 5 (combined) - width at base	m		200	Assumes base is 50 m narrower than the top (top width 225 m).	
Cells 1, 2, 3 and 5 (combined) - basal area	ha		3.5	Calculated from values above	
Cells 1, 2, 3 and 5 (combined) - top area	ha		5.625	Approximation of total top area of cells if represented as a rectangle. Total top area is approximately 56,250 m2 (which equates to 225 m x 250 m).	
Cells 1, 2, 3 and 5 (combined) - waste thickness	m	UNIFORM(16.5,29.5)		Previous modelled values. Checked against current surface at approx. 135 m AOD with assumption of 1 m of capping and basal elevation of all cells is 104.5 m AOD, gives a maximum of 29.5 m.	
Cells 1, 2, 3 and 5 (combined) - Head of leachate when surf	m	SINGLE(16.5)		Lowest waste thickness	
Cell 4 (combined) - length at base	m		75	Measured from proposed cell layout	
Cell 4 (combined) - width at base	m		125	Measured from proposed cell layout	
Cell 4 (combined) - basal area	ha		0.9375	Calculated from values above	
Cell 4 (combined) - top area	ha		1.875	Approximation of total top area of cells if represented as a rectangle (250 m x 75 m)	
Cell 4 (combined) - waste thickness	m	UNIFORM(16.5,29.5)		Assuming the same basal elevation of 104.5 mAOD and a similar restoration level to cells 1, 2 ,3 and 5 (up to 134 m AOD before 1 m of capping)	
Cell 4 (combined) - Head of leachate when surface water b	m	SINGLE(16.5)		Lowest thickness of waste used is as cells 1,2, 3 and 5 (16.5 m). Located on south-western part of the site with similar relative surrounding land and landfill design elevations to the first cells.	
Cell 6 - length at base	m		50	Measured from proposed cell layout	
Cell 6 - width at base	m		175	Measured from proposed cell layout	
Cell 6 - basal area	ha		0.875	Calculated from values above	
Cell 6 - top area	ha		2.500	Approximation of total top area of cells if represented as a rectangle (250 m x 100 m)	
Cell 6 - waste thickness	m	UNIFORM(16.5,29.5)		Assuming the same basal elevation of 104.5 mAOD and a similar restoration level to cells 1, 2 ,3 and 5 (up to 134 m AOD before 1 m of capping)	
Cell 6- Head of leachate when surface water breakout occu	m	SINGLE(16.5)		Lowest thickness of waste used is as cells 1,2, 3 and 5 (16.5 m). Located on south-western part of the site with similar relative surrounding land and landfill design elevations to the first cells.	
Cell 7a - length at base	m		60	Measured from proposed cell layout	
Cell 7a - width at base	m		115	Measured from proposed cell layout	
Cell 7a - basal area	ha		0.69	Calculated from values above	
Cell 7a - top area	ha		1.925	Approximation of total top area of cells if represented as a rectangle (110 m x 175 m)	
Cell 7a - waste thickness	m	UNIFORM(16.5,29.5)		Assuming the same basal elevation of 104.5 mAOD and a similar restoration level to cells 1, 2 ,3 and 5 (up to 134 m AOD before 1 m of capping)	
Cell 7a- Head of leachate when surface water breakout occ	m	SINGLE(16.5)		Lowest thickness of waste used is as cells 1,2, 3 and 5 (16.5 m). Located on south-western part of the site with similar relative surrounding land and landfill design elevations to the first cells.	
Cell 7b - length at base	m		60	Measured from proposed cell layout	
Cell 7b - width at base	m		125	Measured from proposed cell layout	
Cell 7b - basal area	ha		0.75	Calculated from values above	
Cell 7b - top area	ha		2.000	Approximation of total top area of cells if represented as a rectangle (100 m x 200 m)	
Cell 7b - waste thickness	m	UNIFORM(16.5,29.5)		Assuming the same basal elevation of 104.5 mAOD and a similar restoration level to cells 1, 2 ,3 and 5 (up to 134 m AOD before 1 m of capping)	
Cell 7b- Head of leachate when surface water breakout occ	m	SINGLE(16.5)		Lowest thickness of waste used is as cells 1,2, 3 and 5 (16.5 m). Located on south-western part of the site with similar relative surrounding land and landfill design elevations to the first cells.	
Cell 8 - length at base	m		85	Measured from proposed cell layout - assumed to be a rectangle of equivalent area)	
Cell 8 - width at base	m		85	Measured from proposed cell layout - assumed to be a rectangle of equivalent area)	
Cell 8 - basal area	ha		0.723	Calculated from values above	
Cell 8 - top area	ha		1.563	Approximation of total top area of cells if represented as a rectangle (125 m x 125 m)	
Cell 8 - waste thickness	m	UNIFORM(10.5,19.5)		Max assumes a basal elevation of 104.5 m AOD and a maximum restoration level of around 125 m to be in line with neighbouring land. Minimum is based on the distance between the designed base of the cell and the lowest elevation at the edge of the cell.	
Cell 8- Head of leachate when surface water breakout occu	m	SINGLE(10.5)		Distance between the designed base of the cell and the lowest elevation at the edge of the cell is approx. 10.5 m.	

INPUT VALUES	UNIT	INPUT		JUSTIFICATION
Cell 9 - length at base	m		125	Measured from proposed cell layout
Cell 9 - width at base	m		100	Measured from proposed cell layout
Cell 9 - basal area	ha		1.25	Calculated from values above
Cell 9 - top area	ha		2.2	Approximation of total top area of cells if represented as a rectangle (200 m x 110 m)
Cell 9 - waste thickness	m	UNIFORM(10.5,19.5)		Max assumes a basal elevation of 104.5 m AOD and a maximum restoration level of around 125 m to be in line with neighbouring land. Minimum is based on the distance between the designed base of the cell and the lowest elevation at the edge of the cell.
Cell 9 - Head of leachate when surface water breakout occu	m	SINGLE(10.5)		Distance between the designed base of the cell and the lowest elevation at the edge of the cell is approx. 10.5 m.
Cell 10a - length at base	m		110	Measured from proposed cell layout
Cell 10a - width at base	m		60	Measured from proposed cell layout
Cell 10a - basal area	ha		0.66	Calculated from values above
Cell 10a - top area	ha		2.625	Approximation of total top area of cells if represented as a rectangle (175 m x 150 m)
Cell 10a - waste thickness	m	UNIFORM(13.5,19.5)		Max assumes a basal elevation of 104.5 m AOD and a maximum restoration level of around 125 m to be in line with neighbouring land. Minimum is based on the distance between the designed base of the cell and the lowest elevation at the edge of the cell.
Cell 10a - Head of leachate when surface water breakout o	m	SINGLE(13.5)		Distance between the designed base of the cell and the lowest elevation at the edge of the cell is approx. 13.5 m.
Cell 10b - length at base	m		125	Measured from proposed cell layout
Cell 10b - width at base	m		60	Measured from proposed cell layout
Cell 10b - basal area	ha		0.75	Calculated from values above
Cell 10b - top area	ha		1.75	Approximation of total top area of cells if represented as a rectangle (175 m x 100 m)
Cell 10b - waste thickness	m	UNIFORM(13.5,19.5)		Max assumes a basal elevation of 104.5 m AOD and a maximum restoration level of around 125 m to be in line with neighbouring land. Minimum is based on the distance between the designed base of the cell and the lowest elevation at the edge of the cell.
Cell 10b - Head of leachate when surface water breakout o	m	SINGLE(13.5)		Distance between the designed base of the cell and the lowest elevation at the edge of the cell is approx. 13.5 m.
Cell 11 - length at base	m		50	Measured from proposed cell layout
Cell 11 - width at base	m		125	Measured from proposed cell layout
Cell 11 - basal area	m		0.625	Calculated from values above
Cell 11 - top area	m		1.3125	Approximation of total top area of cells if represented as a rectangle (75 m x 175 m)
Cell 11 - waste thickness	m	UNIFORM(5,15)		Maximum assuming a basal elevation of 119 m AOD and a similar restoration level to cells 1-5 (134 m AOD before 1 m of capping). Minimum is based on the distance between the designed base of the cell and the lowest elevation at the edge of the cell.
Cell 11 - Head of leachate when surface water breakout oc	m	SINGLE(5)		Distance between the designed base of the cell and the lowest elevation at the edge of the cell is approx. 5 m.
Waste porosity	fraction	UNIFORM(0.1,0.2)		A typical range for an inert waste
Waste dry density	kg/l	TRIANGULAR(1.25,1.5,1.75)		Values used for inert waste in ARUP models (ARUP report table 8.6)
Waste field capacity	fraction	TRIANGULAR(0.118,0.15,0.2)		Values used for inert waste in ARUP models (ARUP report table 8.6)
Leachate Inventory				
Sulphate				
Substance to be treated as List 1?	y/n	n		Sulphate is not classified as a hazardous (list 1) substance
Concentration	mg/l		4500	For currently operational and future cells - 3 x WAC limits
	mg/l		1500	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l	TRIANGULAR(0.36,4.27,39.5)		Distribution from the PDF created from the data collected in upgradient Loughshinny borehole BH12 during the period 2010 to 2017
Half life	years		1,000,000,000	assume no degradation
Chloride				
Substance to be treated as List 1?	y/n	n		Chloride is not classified as a hazardous (list 1) substance
Concentration	mg/l		1380	For currently operational and future cells - 3 x WAC limits
			460	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l	TRIANGULAR(1,4.2,32.5)		Distribution from the PDF created from the data collected in upgradient Loughshinny borehole BH12 during the period 2010 to 2017
Half life	years		1,000,000,000	assume no degradation
Antimony				
Substance to be treated as List 1?	y/n	n		Antimony is not classified as a hazardous (list 1) substance
Concentration	mg/l		0.3	For currently operational and future cells - 3 x WAC limits
			0.1	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l		0	Assume not present as unlikely in geology and no data
Half life	years		1,000,000,000	assume no degradation
Selenium				
Substance to be treated as List 1?	y/n	n		Selenium is not classified as a hazardous (list 1) substance
Concentration	mg/l		0.12	For currently operational and future cells - 3 x WAC limits
			0.04	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l		0	Assume not present as unlikely in geology and no data
Half life	years		1,000,000,000	assume no degradation
Molybdenum				
Substance to be treated as List 1?	y/n	n		Molybdenum is not classified as a hazardous (list 1) substance
Concentration	mg/l		0.6	For currently operational and future cells - 3 x WAC limits
			0.2	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l		0	Assume not present as unlikely in geology and no data
Half life	years		1,000,000,000	assume no degradation
Arsenic				
Substance to be treated as List 1?	y/n	y		Arsenic is classified as a hazardous (list 1) substance
Concentration	mg/l		0.18	For currently operational and future cells - 3 x WAC limits
			0.06	For all completed cells - WAC Co percolation test value
Concentration in background water quality	mg/l	TRIANGULAR(0.00125, 0.00125,0.0102)		Distribution from the PDF created from the data collected in upgradient Loughshinny borehole BH12 during the period 2010 to 2017
Half life	years		1,000,000,000	assume no degradation
Drainage System				
Specified head				
Head on EBS	m	Various		Set to 0.5 m below breakout level of each cell. Assumed leachate management will be required in future due to very low K liner and that this will be managed to at least 0.5 m below point where breakout will occur.

INPUT VALUES	UNIT	INPUT	JUSTIFICTION
Engineered Barrier			
Type		Single clay EBS	Unchanged from ARUP 2010 models - most closely represents the 1 m of low permeability clay that is, or will be, emplaced on the base and sides of all cells. No basal or sidewall drainage engineering.
Design thickness	m	1	Unchanged from ARUP 2010 models - Minimum designed thickness
Moisture content	fraction	UNIFORM(0.13,0.22)	Range of values from CQA tests performed on liner layers in Cells 2 to 5. Assumed source and properties will remain similar for future materials.
Hydraulic conductivity	m/s	LogTri(1.4e-11,2.2e-10,1e-7)	Min from lowest test data (cells 2-5), most likely from the geometric mean of the test data, max from highest value permitted by the permit (<1 x 10-7 m/s)
Longitudinal dispersivity	m	0.1	Unchanged from ARUP 2010 models - 10% of barrier thickness
Retardation in clay liner	y/n	y	
Pathway density	kg/l	UNIFORM(1,2.4)	Unchanged from ARUP 2010 models - ConSim suggested input parameter density of a clay
Kd			
Sulphate	unitless	SINGLE(0)	Unretarded
Chloride	unitless	SINGLE(0)	Unretarded
Antimony	unitless	SINGLE(251)	Unchanged from ARUP 2010 models - Allison, J.D. and Allison, T.L. (2005). Partition Coefficients for Metals in surface water, soil and waste. U.S. Environmental Protection Agency, Office of Research and Development, Washington
Selenium	unitless	SINGLE(9.5)	Unchanged from ARUP 2010 models - from ConSim suggested input parameters
Molybdenum	unitless	SINGLE(110)	Unchanged from ARUP 2010 models - from ConSim suggested input parameters
Arsenic	unitless	UNIFORM(117,249.6)	Unchanged from ARUP 2010 models - from ConSim suggested input parameters
Unsaturated pathway			
Namurian (all except cell 6 and 7a)			
Length	m	UNIFORM(0.01,6)	Ground beneath the site that is above the water table. Leachate and groundwater elevation data from Jan 2010 to Nov 2017 indicates that groundwater beneath the western part of the site is near basal levels (BH8a and BH9)and about 6 m below basal level in the east of the site (98.5 m AOD, BH11a). 1 cm used to represent limited unsaturated zone in the east.
Moisture Content	fraction	SINGLE(0.1)	Unchanged from ARUP 2010 models - no new data to update these values
Hydraulic conductivity	m/s	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)	Unchanged from ARUP 2010 models - no new data to update these values
Retardation in unsaturated zone	y/n	y	
Pathway density	kg/l	UNIFORM(1.6,2.68)	Unchanged from ARUP 2010 models - ConSim suggested input parameter density of a sandstone
Kd	unitless		Values as used for clay barrier
Longitudinal dispersivity	m	UNIFORM(0.001,0.6)	10% of pathway length
Loughshinny (cells 6 and 7a)			
Length	m	UNIFORM(2.5,6.5)	Ground beneath the site that is above the water table. Groundwater elevation data from Jan 2010 to Nov 2017 indicates that groundwater in the Loughshinny Formation is typically around 98 m AOD to 102 m AOD. Landfill cell base level will be at least 104.5 mAOD.
Moisture Content	fraction	UNIFORM(0.1,0.3)	Estimated range
Hydraulic conductivity	m/s	LOGTRIANGULAR(0.0000231,0.0001,0.0004)	Same values as used for the Loughshinny aquifer pathway
Retardation in unsaturated zone	y/n	y	
Pathway density	kg/l	UNIFORM(1.74,2.79)	ConSim suggested input parameter density of a limestone
Kd	unitless		Values as used for clay barrier
Longitudinal dispersivity	m	UNIFORM(0.25,0.65)	10% of pathway length
Vertical Pathway			
Saturated deposits above aquifer			
Length	m	UNIFORM(10,60)	Unchanged from ARUP 2010 models - Thickness of the saturated Namurian beneath the site from site investigation data.
Porosity	fraction	UNIFORM(0.34,0.61)	Unchanged from ARUP 2010 models
Longitudinal dispersivity	m	UNIFORM(1,6)	10% of pathway length
Retardation in unsaturated zone	y/n	y	
Pathway density	kg/l	UNIFORM(1.6,2.68)	Unchanged from ARUP 2010 models - ConSim suggested input parameter density of a sandstone (conservative value selected to represent sandstones and siltstones)
Kd	unitless		Values as used for clay barrier
Aquifer Pathway			
Loughshinny Formation & saturated Namurian deposits			
Pathway Width	m	Various	Set to width of cell perpendicular to groundwater flow direction
Calculate mixing zone?	y/n	y	
Aquifer thickness	m	UNIFORM(30,50)	Unchanged from ARUP 2010 model
Relative vertical dispersivity	unitless	UNIFORM(1,1.5)	Unchanged from ARUP 2010 model
Conductivity	m/s	LOGTRIANGULAR(0.0000231,0.0001,0.0004)	Unchanged from ARUP 2010 model from site investigation data. Used to calculate Dacry flux
Regional gradient	unitless	UNIFORM(0.0028,0.0045)	From groundwater elevations in the Loughshinny Formation across the site (June and September 2017). Used to calculate Dacry flux
DARCY FLUX	m/s	UNIFORM(1.04e-7,1.12e-6)	Range used by calculating lowest k times highest gradient, and highest k times lowest gradient
Pathway porosity	fraction	LOGTRIANGULAR(0.01,0.025,0.05)	Unchanged from ARUP 2010 model - typical values for Irish limestone
Pathway density		UNIFORM(1.74,2.79)	Unchanged from ARUP 2010 models - ConSim suggested input parameter density of a limestone
Longitudinal dispersivity	m	UNIFORM(7.5,55)	10% of longest and shortest distanced between a part of the landfill and the downgradient receptor (edge of permit boundary), which is measured from plans as between 75 m and 550 m
Transvers dispersivity	m	UNIFORM(2.25,16.5)	30% of longitudinal dispersivity

APPENDIX G

LandSim Model Inputs, Results and Graphs

Calculation Settings

Number of iterations: 501

Results calculated using sampled PDFs

Full Calculation

Clay Liner:

Retarded values used for simulation

No Biodegradation

Unsaturated Pathway:

Retarded values used for simulation

No Biodegradation

Saturated Vertical Pathway:

Retarded values used for simulation

No Biodegradation

Aquifer Pathway:

Retarded values used for simulation

No Biodegradation

Timeslices at: 30, 100, 300, 1000

Decline in Contaminant Concentration in Leachate

Arsenic — Non-Volatile
c (kg/l): -0.0862 — m (kg/l): 0.0415

Chloride — Non-Volatile
c (kg/l): 0.2919 — m (kg/l): 0.0298

Selenium — Non-Volatile
c (kg/l): -0.062 — m (kg/l): 0.1063

Sulphate — Non-Volatile
c (kg/l): 0.1209 — m (kg/l): 0.0166

Antimony — Non-Volatile
c (kg/l): 0 — m (kg/l): 0

Molybdenum — Non-Volatile
c (kg/l): 0 — m (kg/l): 0

Background Concentrations of Contaminants

Justification for Contaminant Properties

See justification sheet

All units in milligrams per litre

Arsenic	TRIANGULAR(0.00125,0.00125,0.0102)
Chloride	TRIANGULAR(1,4.2,32.5)
Sulphate	TRIANGULAR(0.36,4.27,39.5)

Phase: Cells 1,2,3 and 5

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	6

Justification for Specified Infiltration

See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	200
Cell length (m):	175
Cell top area (ha):	5.625
Cell base area (ha):	3.5
Number of cells:	1
Total base area (ha):	3.5
Total top area (ha):	5.625
Head of Leachate when surface water breakout occurs (m)	SINGLE(16.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(16.5,29.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry

See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.06)
	Substance to be treated as List 1
Chloride	SINGLE(460)
	Data are spot measurements of Leachate Quality
Selenium	SINGLE(0.04)
	Data are spot measurements of Leachate Quality
Sulphate	SINGLE(1500)
	Data are spot measurements of Leachate Quality
Antimony	SINGLE(0.1)
	Data are spot measurements of Leachate Quality
Molybdenum	SINGLE(0.2)
	Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate
See justifications sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(16)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner
Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry
See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties
See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties
See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species
See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(342.5,517.5)
Pathway width (m):	SINGLE(200)

Phase: Cell 4

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	6

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	125
Cell length (m):	75
Cell top area (ha):	1.875
Cell base area (ha):	0.9375
Number of cells:	1
Total base area (ha):	0.9375
Total top area (ha):	1.875
Head of Leachate when surface water breakout occurs (m)	SINGLE(16.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(16.5,29.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18)
	Substance to be treated as List 1
Chloride	SINGLE(1380)
	Data are spot measurements of Leachate Quality
Selenium	SINGLE(0.12)
	Data are spot measurements of Leachate Quality
Sulphate	SINGLE(4500)
	Data are spot measurements of Leachate Quality
Antimony	SINGLE(0.3)
	Data are spot measurements of Leachate Quality
Molybdenum	SINGLE(0.6)
	Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate

See justification sheet

Drainage Information

Fixed Head.

Head on EBS is given as (m): SINGLE(16)

Justification for Specified Head

See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(267.5,342.5)
Pathway width (m):	SINGLE(125)

Phase: Cell 6

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	2

Justification for Specified Infiltration

See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	175
Cell length (m):	50
Cell top area (ha):	2.5
Cell base area (ha):	0.875
Number of cells:	1
Total base area (ha):	0.875
Total top area (ha):	2.5
Head of Leachate when surface water breakout occurs (m)	SINGLE(16.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(16.5,29.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry

See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(16)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Loughshinny pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(2.5,6.5)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.1,0.3)
Pathway Density (kg/l):	UNIFORM(1.74,2.79)

Justification for Unsat Zone Geometry
See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.31e-005,0.0001,0.0004)

Justification for Unsat Zone Hydraulics Properties
See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.25,0.65)

Justification for Unsat Zone Dispersion Properties
See justifications sheet

Retardation parameters for Loughshinny pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species
See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(425,475)
Pathway width (m):	SINGLE(175)

Phase: Cell 7a

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	2

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	115
Cell length (m):	60
Cell top area (ha):	1.925
Cell base area (ha):	0.69
Number of cells:	1
Total base area (ha):	0.69
Total top area (ha):	1.925
Head of Leachate when surface water breakout occurs (m)	SINGLE(16.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(16.5,29.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate

See justification sheet

Drainage Information

Fixed Head.

Head on EBS is given as (m): SINGLE(16)

Justification for Specified Head

See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Loughshinny pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(2.5,6.5)
Flow Model:	porous medium
Pathway moisture content (fraction):	UNIFORM(0.1,0.3)
Pathway Density (kg/l):	UNIFORM(1.74,2.79)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.31e-005,0.0001,0.0004)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.25,0.65)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Loughshinny pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(320,380)
Pathway width (m):	SINGLE(115)

Phase: Cell 7b

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	2

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	125
Cell length (m):	60
Cell top area (ha):	2
Cell base area (ha):	0.75
Number of cells:	1
Total base area (ha):	0.75
Total top area (ha):	2
Head of Leachate when surface water breakout occurs (m)	SINGLE(16.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(16.5,29.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(16)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner
Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e+007)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(250,310)
Pathway width (m):	SINGLE(125)

Phase: Cell 8

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	1

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	85
Cell length (m):	85
Cell top area (ha):	1.563
Cell base area (ha):	0.7225
Number of cells:	1
Total base area (ha):	0.7225
Total top area (ha):	1.563
Head of Leachate when surface water breakout occurs (m)	SINGLE(10.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(10.5,19.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(10)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justification sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justification sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justification sheet

Retardation parameters for clay liner
Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justification sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(147.5,232.5)
Pathway width (m):	SINGLE(85)

Phase: Cell 9

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	1

Justification for Specified Infiltration

See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	100
Cell length (m):	125
Cell top area (ha):	2.2
Cell base area (ha):	1.25
Number of cells:	1
Total base area (ha):	1.25
Total top area (ha):	2.2
Head of Leachate when surface water breakout occurs (m)	SINGLE(10.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(10.5,19.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry

See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(1.2) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(10)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justifications sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justifications sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justifications sheet

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justifications sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry
See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties
See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties
See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species
See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(127.5,252.5)
Pathway width (m):	SINGLE(100)

Phase: Cell 10a

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	2

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	60
Cell length (m):	110
Cell top area (ha):	2.625
Cell base area (ha):	0.66
Number of cells:	1
Total base area (ha):	0.66
Total top area (ha):	2.625
Head of Leachate when surface water breakout occurs (m)	SINGLE(13.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(13.5,19.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18)
	Substance to be treated as List 1
Chloride	SINGLE(1380)
	Data are spot measurements of Leachate Quality
Selenium	SINGLE(0.12)
	Data are spot measurements of Leachate Quality
Sulphate	SINGLE(4500)
	Data are spot measurements of Leachate Quality
Antimony	SINGLE(0.3)
	Data are spot measurements of Leachate Quality
Molybdenum	SINGLE(0.6)
	Data are spot measurements of Leachate Quality

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(13)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justifications sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justifications sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justifications sheet

Retardation parameters for clay liner
Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justifications sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.001,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-005)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(230,340)
Pathway width (m):	SINGLE(60)

Phase: Cell 10b

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113.1,252.7,437.9)
End of filling (years from start of waste deposit):	2

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	60
Cell length (m):	125
Cell top area (ha):	1.75
Cell base area (ha):	0.75
Number of cells:	1
Total base area (ha):	0.75
Total top area (ha):	1.75
Head of Leachate when surface water breakout occurs (m)	SINGLE(13.5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(13.5,19.5)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(13)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justifications sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justifications sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justifications sheet

Retardation parameters for clay liner
Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justifications sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(102.5,227.5)
Pathway width (m):	SINGLE(60)

Phase: Cell 11

Infiltration Information

Cap design infiltration (mm/year):	NORMAL(50,10)
Infiltration to waste (mm/year):	TRIANGULAR(113,252.7,437.9)
End of filling (years from start of waste deposit):	1

Justification for Specified Infiltration
See justification sheet

Duration of management control (years from the start of waste disposal): 20000

Cell dimensions

Cell width (m):	125
Cell length (m):	50
Cell top area (ha):	1.313
Cell base area (ha):	0.625
Number of cells:	1
Total base area (ha):	0.625
Total top area (ha):	1.313
Head of Leachate when surface water breakout occurs (m)	SINGLE(5)
Waste porosity (fraction)	UNIFORM(0.1,0.2)
Final waste thickness (m):	UNIFORM(5,15)
Field capacity (fraction):	TRIANGULAR(0.118,0.15,0.2)
Waste dry density (kg/l)	TRIANGULAR(1.25,1.5,1.75)

Justification for Landfill Geometry
See justifications sheet

Source concentrations of contaminants

All units in milligrams per litre

Declining source term

Arsenic	SINGLE(0.18) *Substance to be treated as List 1*
Chloride	SINGLE(1380) *Data are spot measurements of Leachate Quality*
Selenium	SINGLE(0.12) *Data are spot measurements of Leachate Quality*
Sulphate	SINGLE(4500) *Data are spot measurements of Leachate Quality*
Antimony	SINGLE(0.3) *Data are spot measurements of Leachate Quality*
Molybdenum	SINGLE(0.6) *Data are spot measurements of Leachate Quality*

Justification for Species Concentration in Leachate
See justification sheet

Drainage Information

Fixed Head.
Head on EBS is given as (m): SINGLE(4.5)

Justification for Specified Head
See justifications sheet

Barrier Information

There is a single clay barrier

Justification for Engineered Barrier Type
See justifications sheet

Design thickness of clay (m):	SINGLE(1)
Density of clay (kg/l):	UNIFORM(1,2.4)
Pathway moisture content (fraction):	UNIFORM(0.13,0.22)

Justification for Clay: Liner Thickness
See justifications sheet

Hydraulic conductivity of liner (m/s):	LOGTRIANGULAR(1.4e-011,2.2e-010,1e-007)
Pathway longitudinal dispersivity (m):	SINGLE(0.1)

Justification for Clay: Hydraulics Properties
See justifications sheet

Retardation parameters for clay liner

Uncertainty in Kd (l/kg):	
Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Liner Kd Values by Species
See justifications sheet

Namurian pathway parameters

Modelled as unsaturated pathway

Pathway length (m):	UNIFORM(0.01,6)
Flow Model:	porous medium
Pathway moisture content (fraction):	SINGLE(0.1)
Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Justification for Unsat Zone Geometry

See justifications sheet

Pathway hydraulic conductivity values (m/s):	LOGTRIANGULAR(2.82e-008,1.53e-007,4.54e-007)

Justification for Unsat Zone Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m):	UNIFORM(0.001,0.6)

Justification for Unsat Zone Dispersion Properties

See justifications sheet

Retardation parameters for Namurian pathway

Modelled as unsaturated pathway

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Kd Values by Species

See justifications sheet

Aquifer Pathway Dimensions for Phase

Pathway length (m):	UNIFORM(155,205)
Pathway width (m):	SINGLE(125)

Saturated Namurian material above the aquifer pathway parameters

Modelled as vertical pathway.

Pathway length (m):	UNIFORM(10,60)
Pathway porosity (fraction):	UNIFORM(0.34,0.61)

Justification for Vertical Path Geometry
See justifications sheet

Pathway dispersivity (m):	UNIFORM(1,6)

Justification for Vertical Path Dispersion Details
See justifications sheet

Retardation parameters for Saturated Namurian material above the aquifer pathway
Modelled as vertical pathway.

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Retardation parameters for Saturated Namurian material above the aquifer pathway	
Chloride	SINGLE(0)
Retardation parameters for Saturated Namurian material above the aquifer pathway	
Selenium	SINGLE(9.5)
Retardation parameters for Saturated Namurian material above the aquifer pathway	
Sulphate	SINGLE(0)
Retardation parameters for Saturated Namurian material above the aquifer pathway	
Antimony	SINGLE(251)
Retardation parameters for Saturated Namurian material above the aquifer pathway	
Molybdenum	SINGLE(110)
Retardation parameters for Saturated Namurian material above the aquifer pathway	

Justification for Vertical Path Kd Values by Species
See justifications sheet

Pathway Density (kg/l):	UNIFORM(1.6,2.68)

Loughshinny pathway parameters

Modelled as aquifer pathway.

Mixing zone (m):

Calculated. Aquifer Thickness: UNIFORM(30,50)

Justification for Aquifer Geometry

See justifications sheet

Darcy flux (m/s): UNIFORM(1.04e-007,1.12e-006)

Pathway porosity (fraction): LOGTRIANGULAR(0.01,0.025,0.05)

Justification for Aquifer Hydraulics Properties

See justifications sheet

Pathway longitudinal dispersivity (m): UNIFORM(7.5,55)

Pathway transverse dispersivity (m): UNIFORM(2.25,16.5)

Justification for Aquifer Dispersion Details

See justifications sheet

Retardation parameters for Loughshinny pathway

Modelled as aquifer pathway.

Uncertainty in Kd (l/kg):

Arsenic	UNIFORM(117,249.6)
Chloride	SINGLE(0)
Selenium	SINGLE(9.5)
Sulphate	SINGLE(0)
Antimony	SINGLE(251)
Molybdenum	SINGLE(110)

Justification for Aquifer Kd Values by Species

See justifications sheet

Pathway Density (kg/l): UNIFORM(1.74,2.79)

Concentration of Arsenic in groundwater [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.00158086
10% of values less than 0.00174944
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00816314
Minimum 0.00125621 Maximum 0.00992919
Mean 0.00431222 Std. Dev. 0.00210794 Variance 4.44342E-006

Concentration of Chloride in groundwater [mg/l]

At 30 years

05% of values less than 3.20186
10% of values less than 4.63805
50% of values less than 12.1225
90% of values less than 24.7448
95% of values less than 26.6824

Minimum 1.68155	Maximum 45.5194	
Mean 13.3618	Std. Dev. 7.5485	Variance 56.9798

At 100 years

05% of values less than 4.82158
10% of values less than 5.91075
50% of values less than 16.5524
90% of values less than 31.6388
95% of values less than 42.2595

Minimum 1.97223	Maximum 87.4847	
Mean 18.7253	Std. Dev. 11.891	Variance 141.395

At 300 years

05% of values less than 9.44762
10% of values less than 11.2793
50% of values less than 22.3818
90% of values less than 42.0256
95% of values less than 54.4925

Minimum 5.95188	Maximum 90.3025	
Mean 25.5585	Std. Dev. 13.859	Variance 192.072

At 1000 years

05% of values less than 8.32975
10% of values less than 9.45006
50% of values less than 19.5638
90% of values less than 34.2147
95% of values less than 40.3887

Minimum 4.79203	Maximum 63.2492	
Mean 21.1777	Std. Dev. 10.2312	Variance 104.678

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9426
90% of values less than 23.7815
95% of values less than 25.6975

Minimum 1.48353	Maximum 31.4577	
Mean 12.9047	Std. Dev. 7.13788	Variance 50.9493

Concentration of Selenium in groundwater [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 1.03407E-017
95% of values less than 3.93217E-015

Minimum 0	Maximum 3.26067E-007	
Mean 7.27771E-010	Std. Dev. 1.46038E-008	Variance 2.13272E-016

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 5.08618E-013
90% of values less than 6.39589E-006
95% of values less than 3.03147E-005

Minimum 0	Maximum 0.000413647	
Mean 7.05612E-006	Std. Dev. 3.39819E-005	Variance 1.15477E-009

At infinity

05% of values less than 4.50179E-006
10% of values less than 8.61796E-006
50% of values less than 4.98116E-005
90% of values less than 0.000237829
95% of values less than 0.000385209

Minimum 8.65168E-007	Maximum 0.00102719	
Mean 9.67363E-005	Std. Dev. 0.000143062	Variance 2.04667E-008

Concentration of Sulphate in groundwater [mg/l]

At 30 years

05% of values less than 3.25058
10% of values less than 4.2374
50% of values less than 14.9981
90% of values less than 28.9358
95% of values less than 32.9235

Minimum 0.47837	Maximum 136.107	
Mean 16.371	Std. Dev. 11.8301	Variance 139.951

At 100 years

05% of values less than 5.99193
10% of values less than 8.43023
50% of values less than 26.0421
90% of values less than 67.9575
95% of values less than 93.3744

Minimum 1.63865	Maximum 243.904	
Mean 34.2979	Std. Dev. 32.023	Variance 1025.47

At 300 years

05% of values less than 19.4458
10% of values less than 23.9856
50% of values less than 45.3718
90% of values less than 116.329
95% of values less than 151.955

Minimum 8.92807	Maximum 261.273	
Mean 59.7204	Std. Dev. 42.0922	Variance 1771.76

At 1000 years

05% of values less than 19.1577
10% of values less than 23.1408
50% of values less than 42.4925
90% of values less than 101.733
95% of values less than 128.421

Minimum 11.1609	Maximum 221.658	
Mean 53.0258	Std. Dev. 34.2296	Variance 1171.67

At infinity

05% of values less than 3.14251
10% of values less than 4.28012
50% of values less than 14.1186
90% of values less than 26.9536
95% of values less than 29.7058

Minimum 0.59035	Maximum 37.4642	
Mean 14.9782	Std. Dev. 8.55998	Variance 73.2733

Concentration of Antimony in groundwater [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 3.78959E-019
50% of values less than 5.41154E-016
90% of values less than 6.97733E-007
95% of values less than 1.52921E-005

Minimum 0	Maximum 0.000663771	
Mean 6.29382E-006	Std. Dev. 4.32325E-005	Variance 1.86905E-009

Concentration of Molybdenum in groundwater [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 2.87543E-016
10% of values less than 1.00308E-015
50% of values less than 9.12533E-007
90% of values less than 0.00111842
95% of values less than 0.00164463

Minimum 0	Maximum 0.00840307	
Mean 0.000290033	Std. Dev. 0.000782509	Variance 6.12321E-007

Phase: Cells 1,2,3 and 5

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.0015405
10% of values less than 0.00174532
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00430447 Std. Dev. 0.0021105 Variance 4.4542E-006

Phase: Cells 1,2,3 and 5

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.28382
10% of values less than 4.65521
50% of values less than 12.5312
90% of values less than 25.0047
95% of values less than 27.2789
Minimum 1.68155 Maximum 82.8914
Mean 13.8443 Std. Dev. 8.71348 Variance 75.9248

At 100 years

05% of values less than 3.84705
10% of values less than 5.32916
50% of values less than 14.9881
90% of values less than 28.9823
95% of values less than 34.368
Minimum 1.68156 Maximum 127.203
Mean 17.197 Std. Dev. 12.8386 Variance 164.829

At 300 years

05% of values less than 5.84478
10% of values less than 8.78334
50% of values less than 19.3285
90% of values less than 33.8151
95% of values less than 41.8345
Minimum 2.13006 Maximum 83.1533
Mean 20.8312 Std. Dev. 11.3094 Variance 127.903

At 1000 years

05% of values less than 7.19286
10% of values less than 8.56191
50% of values less than 18.4479
90% of values less than 31.4288
95% of values less than 35.87
Minimum 2.86331 Maximum 52.1305
Mean 19.6143 Std. Dev. 9.29645 Variance 86.424

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9427
90% of values less than 23.7815
95% of values less than 25.6977
Minimum 1.48353 Maximum 31.4588
Mean 12.9055 Std. Dev. 7.13788 Variance 50.9494

Phase: Cells 1,2,3 and 5

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 1.51444E-017
Minimum 0 Maximum 2.36103E-008
Mean 6.9887E-011 Std. Dev. 1.09322E-009 Variance 1.19513E-018

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 6.63654E-009
95% of values less than 1.08488E-006
Minimum 0 Maximum 0.000353562
Mean 2.11436E-006 Std. Dev. 1.94061E-005 Variance 3.76597E-010

At infinity

05% of values less than 9.78709E-007
10% of values less than 6.59154E-006
50% of values less than 6.2891E-005
90% of values less than 0.000255597
95% of values less than 0.000387585
Minimum 8.62219E-018 Maximum 0.00146819
Mean 0.000111184 Std. Dev. 0.000163998 Variance 2.68954E-008

Phase: Cells 1,2,3 and 5

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 3.28553
10% of values less than 4.26082
50% of values less than 15.3154
90% of values less than 29.5465
95% of values less than 35.015
Minimum 0.47837 Maximum 258.778
Mean 17.9575 Std. Dev. 18.5622 Variance 344.555

At 100 years
05% of values less than 4.454
10% of values less than 6.22043
50% of values less than 21.3507
90% of values less than 54.6024
95% of values less than 78.9196
Minimum 0.47837 Maximum 404.826
Mean 29.0961 Std. Dev. 35.6738 Variance 1272.62

At 300 years
05% of values less than 11.8795
10% of values less than 15.4454
50% of values less than 34.0426
90% of values less than 80.5147
95% of values less than 100.993
Minimum 0.628844 Maximum 240.895
Mean 42.1622 Std. Dev. 30.5681 Variance 934.409

At 1000 years
05% of values less than 14.8262
10% of values less than 18.2263
50% of values less than 36.405
90% of values less than 79.0353
95% of values less than 98.7312
Minimum 3.39657 Maximum 145.335
Mean 42.5251 Std. Dev. 25.381 Variance 644.194

At infinity
05% of values less than 3.23522
10% of values less than 4.3223
50% of values less than 14.2113
90% of values less than 27.0662
95% of values less than 29.8234
Minimum 0.662879 Maximum 37.525
Mean 15.0745 Std. Dev. 8.55388 Variance 73.1689

Phase: Cells 1,2,3 and 5

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.98492E-018
90% of values less than 9.49379E-011
95% of values less than 4.94915E-008

Minimum 0	Maximum 0.000337841	
Mean 1.50941E-006	Std. Dev. 1.73698E-005	Variance 3.01712E-010

Phase: Cells 1,2,3 and 5

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At infinity
05% of values less than 0
10% of values less than 0
50% of values less than 4.18432E-014
90% of values less than 4.43924E-005
95% of values less than 0.000574732
Minimum 0 Maximum 0.00685459
Mean 9.05312E-005 Std. Dev. 0.000478237 Variance 2.28711E-007

Phase: Cell 4

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172

Minimum 0.00125615	Maximum 0.00992919	
Mean 0.00429963	Std. Dev. 0.00210893	Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172

Minimum 0.00125615	Maximum 0.00992919	
Mean 0.00429963	Std. Dev. 0.00210893	Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172

Minimum 0.00125615	Maximum 0.00992919	
Mean 0.00429963	Std. Dev. 0.00210893	Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172

Minimum 0.00125615	Maximum 0.00992919	
Mean 0.00429963	Std. Dev. 0.00210893	Variance 4.44759E-006

At infinity

05% of values less than 0.00156728
10% of values less than 0.00179847
50% of values less than 0.00398983
90% of values less than 0.00744669
95% of values less than 0.0081435

Minimum 0.00125615	Maximum 0.00992919	
Mean 0.00431887	Std. Dev. 0.00211012	Variance 4.45259E-006

Phase: Cell 4

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.4343
10% of values less than 4.53664
50% of values less than 11.9696
90% of values less than 24.4906
95% of values less than 26.0673

Minimum 1.48893	Maximum 41.8706	
Mean 13.1441	Std. Dev. 7.35262	Variance 54.061

At 100 years

05% of values less than 4.54444
10% of values less than 5.51302
50% of values less than 16.0859
90% of values less than 33.6558
95% of values less than 42.1639

Minimum 1.97265	Maximum 107.722	
Mean 18.8431	Std. Dev. 13.9112	Variance 193.522

At 300 years

05% of values less than 7.42313
10% of values less than 10.3708
50% of values less than 22.5984
90% of values less than 45.3176
95% of values less than 54.7819

Minimum 3.06035	Maximum 102.815	
Mean 25.8437	Std. Dev. 15.1593	Variance 229.805

At 1000 years

05% of values less than 8.87657
10% of values less than 10.2178
50% of values less than 20.6779
90% of values less than 36.4847
95% of values less than 42.4591

Minimum 3.15633	Maximum 76.3543	
Mean 22.5056	Std. Dev. 11.0626	Variance 122.381

At infinity

05% of values less than 3.17452
10% of values less than 4.51883
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6974

Minimum 1.48373	Maximum 31.4568	
Mean 12.9051	Std. Dev. 7.1376	Variance 50.9453

Phase: Cell 4

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 9.97791E-018
95% of values less than 3.0505E-016

Minimum 0	Maximum 3.71255E-007	
Mean 7.70754E-010	Std. Dev. 1.65913E-008	Variance 2.75271E-016

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 7.74668E-019
90% of values less than 7.55919E-007
95% of values less than 1.41328E-005

Minimum 0	Maximum 0.00100056	
Mean 8.64312E-006	Std. Dev. 6.09149E-005	Variance 3.71062E-009

At infinity

05% of values less than 3.33807E-007
10% of values less than 1.33517E-006
50% of values less than 2.96954E-005
90% of values less than 0.000167398
95% of values less than 0.000325672

Minimum 2.31765E-017	Maximum 0.00170304	
Mean 7.84694E-005	Std. Dev. 0.000162862	Variance 2.65241E-008

Phase: Cell 4

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.07033
10% of values less than 4.23138
50% of values less than 14.6358
90% of values less than 27.4246
95% of values less than 30.7173

Minimum 0.478444	Maximum 104.572	
Mean 15.6195	Std. Dev. 9.91954	Variance 98.3972

At 100 years

05% of values less than 4.66835
10% of values less than 6.62906
50% of values less than 22.9817
90% of values less than 72.9263
95% of values less than 116.454

Minimum 0.714862	Maximum 323.351	
Mean 34.6503	Std. Dev. 39.7414	Variance 1579.38

At 300 years

05% of values less than 9.19775
10% of values less than 17.6727
50% of values less than 47.9306
90% of values less than 124.587
95% of values less than 149.439

Minimum 1.70075	Maximum 296.503	
Mean 59.9055	Std. Dev. 47.3031	Variance 2237.58

At 1000 years

05% of values less than 16.1573
10% of values less than 22.0626
50% of values less than 45.8212
90% of values less than 107.047
95% of values less than 128.438

Minimum 3.36788	Maximum 238.482	
Mean 56.0682	Std. Dev. 37.5188	Variance 1407.66

At infinity

05% of values less than 3.13009
10% of values less than 4.27812
50% of values less than 14.1266
90% of values less than 26.9126
95% of values less than 29.7437

Minimum 0.75455	Maximum 38.0369	
Mean 15.0458	Std. Dev. 8.57352	Variance 73.5053

Phase: Cell 4

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At infinity
05% of values less than 0
10% of values less than 0
50% of values less than 5.18761E-017
90% of values less than 2.71964E-008
95% of values less than 3.35605E-006
Minimum 0 Maximum 0.000723613
Mean 5.86231E-006 Std. Dev. 4.85036E-005 Variance 2.3526E-009

Phase: Cell 4

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 3.5782E-018	
Mean 7.14212E-021	Std. Dev. 1.59862E-019	Variance 2.55559E-038

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 3.32524E-011
90% of values less than 0.00052999
95% of values less than 0.00171388

Minimum 0	Maximum 0.0215872	
Mean 0.000324732	Std. Dev. 0.00151485	Variance 2.29476E-006

Phase: Cell 6

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.0015653
10% of values less than 0.00179847
50% of values less than 0.00398983
90% of values less than 0.00744669
95% of values less than 0.00831532
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00432639 Std. Dev. 0.00212681 Variance 4.5233E-006

Phase: Cell 6

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9039	Std. Dev. 7.13788	Variance 50.9493

At 100 years

05% of values less than 4.5883
10% of values less than 5.34422
50% of values less than 15.4075
90% of values less than 31.177
95% of values less than 37.5531

Minimum 1.68155	Maximum 95.5855	
Mean 17.622	Std. Dev. 11.6354	Variance 135.382

At 300 years

05% of values less than 6.96655
10% of values less than 9.90225
50% of values less than 22.5914
90% of values less than 43.6998
95% of values less than 50.9557

Minimum 1.72749	Maximum 92.6965	
Mean 25.0959	Std. Dev. 14.3146	Variance 204.908

At 1000 years

05% of values less than 7.3346
10% of values less than 8.81718
50% of values less than 19.7922
90% of values less than 33.8799
95% of values less than 39.2626

Minimum 3.2633	Maximum 64.8577	
Mean 21.0976	Std. Dev. 10.3671	Variance 107.476

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48361	Maximum 31.4569	
Mean 12.9043	Std. Dev. 7.13778	Variance 50.9479

Phase: Cell 6

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 4.81476E-018
95% of values less than 4.07863E-015

Minimum 0	Maximum 3.27843E-007	
Mean 1.25357E-009	Std. Dev. 1.88367E-008	Variance 3.54821E-016

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 2.61019E-017
90% of values less than 2.80256E-006
95% of values less than 2.14517E-005

Minimum 0	Maximum 0.00178028	
Mean 1.15232E-005	Std. Dev. 9.47271E-005	Variance 8.97323E-009

At infinity

05% of values less than 4.09524E-008
10% of values less than 2.46883E-007
50% of values less than 7.56419E-006
90% of values less than 7.8952E-005
95% of values less than 0.000138035

Minimum 7.00851E-017	Maximum 0.00160337	
Mean 3.16564E-005	Std. Dev. 9.04512E-005	Variance 8.18142E-009

Phase: Cell 6

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811
Minimum 0.47837 Maximum 37.408
Mean 14.8657 Std. Dev. 8.5662 Variance 73.3797

At 100 years
05% of values less than 5.37009
10% of values less than 7.05721
50% of values less than 21.8674
90% of values less than 60.5292
95% of values less than 79.4287
Minimum 1.57478 Maximum 300.486
Mean 30.5226 Std. Dev. 31.5047 Variance 992.546

At 300 years
05% of values less than 11.23
10% of values less than 16.987
50% of values less than 46.0518
90% of values less than 112.106
95% of values less than 152.724
Minimum 2.91796 Maximum 286.859
Mean 57.3988 Std. Dev. 43.8122 Variance 1919.51

At 1000 years
05% of values less than 15.8291
10% of values less than 19.5552
50% of values less than 41.3408
90% of values less than 99.1023
95% of values less than 125.122
Minimum 5.41247 Maximum 218.085
Mean 50.9628 Std. Dev. 33.9457 Variance 1152.31

At infinity
05% of values less than 3.10441
10% of values less than 4.25608
50% of values less than 14.0502
90% of values less than 26.9876
95% of values less than 29.6815
Minimum 0.563229 Maximum 37.4083
Mean 14.9608 Std. Dev. 8.56167 Variance 73.3021

Phase: Cell 6

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.05353E-016
90% of values less than 2.0574E-007
95% of values less than 4.77854E-006

Minimum 0	Maximum 0.00233817	
Mean 1.0407E-005	Std. Dev. 0.000118747	Variance 1.41007E-008

Phase: Cell 6

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 4.68302E-009
90% of values less than 0.000812589
95% of values less than 0.00196152

Minimum 0	Maximum 0.0267602	
Mean 0.000388068	Std. Dev. 0.00176134	Variance 3.10233E-006

Phase: Cell 7a

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.0015653
10% of values less than 0.00174944
50% of values less than 0.00398983
90% of values less than 0.00745558
95% of values less than 0.00819883
Minimum 0.00125848 Maximum 0.0105282
Mean 0.00432592 Std. Dev. 0.00212322 Variance 4.50808E-006

Phase: Cell 7a

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48352 Maximum 31.4568
Mean 12.9039 Std. Dev. 7.13789 Variance 50.9494

At 100 years

05% of values less than 4.32781
10% of values less than 5.34785
50% of values less than 14.8996
90% of values less than 31.6363
95% of values less than 40.009
Minimum 1.94289 Maximum 79.9927
Mean 17.7234 Std. Dev. 12.6134 Variance 159.099

At 300 years

05% of values less than 8.00542
10% of values less than 10.1575
50% of values less than 23.8348
90% of values less than 47.6605
95% of values less than 56.8143
Minimum 2.52612 Maximum 109.385
Mean 27.1489 Std. Dev. 16.7674 Variance 281.146

At 1000 years

05% of values less than 8.20788
10% of values less than 10.4236
50% of values less than 20.8167
90% of values less than 36.1739
95% of values less than 43.8398
Minimum 4.1322 Maximum 72.1493
Mean 22.5894 Std. Dev. 11.5482 Variance 133.362

At infinity

05% of values less than 3.17445
10% of values less than 4.51384
50% of values less than 11.9425
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48353 Maximum 31.4569
Mean 12.9053 Std. Dev. 7.13736 Variance 50.9419

Phase: Cell 7a

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 4.11163E-017
Minimum 0 Maximum 2.90959E-006
Mean 5.83354E-009 Std. Dev. 1.29991E-007 Variance 1.68976E-014

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 1.66912E-017
90% of values less than 3.94608E-006
95% of values less than 1.89604E-005
Minimum 0 Maximum 0.0024052
Mean 1.48987E-005 Std. Dev. 0.000149555 Variance 2.23668E-008

At infinity

05% of values less than 4.5212E-008
10% of values less than 2.23441E-007
50% of values less than 1.03287E-005
90% of values less than 9.40674E-005
95% of values less than 0.000140038
Minimum 1.78117E-017 Maximum 0.00160731
Mean 3.88937E-005 Std. Dev. 0.000113964 Variance 1.29878E-008

Phase: Cell 7a

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811
Minimum 0.47837 Maximum 37.408
Mean 14.8657 Std. Dev. 8.56621 Variance 73.3799

At 100 years

05% of values less than 4.20171
10% of values less than 5.94173
50% of values less than 20.9295
90% of values less than 66.7322
95% of values less than 89.2024
Minimum 0.47837 Maximum 243.536
Mean 30.8576 Std. Dev. 35.0077 Variance 1225.54

At 300 years

05% of values less than 11.9211
10% of values less than 19.1941
50% of values less than 47.9846
90% of values less than 132.448
95% of values less than 172.059
Minimum 0.747776 Maximum 331.925
Mean 64.5714 Std. Dev. 53.0631 Variance 2815.69

At 1000 years

05% of values less than 18.0295
10% of values less than 23.2336
50% of values less than 45.2386
90% of values less than 111.071
95% of values less than 143.943
Minimum 3.11832 Maximum 249.918
Mean 57.6504 Std. Dev. 40.3479 Variance 1627.96

At infinity

05% of values less than 3.06791
10% of values less than 4.2676
50% of values less than 14.1958
90% of values less than 27.1418
95% of values less than 29.9963
Minimum 0.480717 Maximum 38.4572
Mean 14.9904 Std. Dev. 8.6005 Variance 73.9687

Phase: Cell 7a

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 4.09171E-017
90% of values less than 3.00122E-007
95% of values less than 3.87769E-006

Minimum 0	Maximum 0.00467887	
Mean 1.77667E-005	Std. Dev. 0.000242081	Variance 5.86032E-008

Phase: Cell 7a

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 4.63953E-009
90% of values less than 0.00100425
95% of values less than 0.00263775

Minimum 0	Maximum 0.0241198	
Mean 0.000465537	Std. Dev. 0.00183839	Variance 3.37967E-006

Phase: Cell 7b

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.0016063
10% of values less than 0.00180371
50% of values less than 0.00399791
90% of values less than 0.00747345
95% of values less than 0.00821119
Minimum 0.0012623 Maximum 0.0116577
Mean 0.00434959 Std. Dev. 0.00214072 Variance 4.58269E-006

Phase: Cell 7b

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9039	Std. Dev. 7.13789	Variance 50.9494

At 100 years

05% of values less than 3.86299
10% of values less than 5.30664
50% of values less than 14.6985
90% of values less than 29.2637
95% of values less than 38.8486

Minimum 1.96739	Maximum 95.9871	
Mean 17.3309	Std. Dev. 11.945	Variance 142.683

At 300 years

05% of values less than 6.71771
10% of values less than 10.6486
50% of values less than 23.8077
90% of values less than 45.6528
95% of values less than 55.0464

Minimum 2.5451	Maximum 112.282	
Mean 26.4979	Std. Dev. 16.008	Variance 256.256

At 1000 years

05% of values less than 8.15131
10% of values less than 9.8401
50% of values less than 20.8711
90% of values less than 36.4679
95% of values less than 42.3045

Minimum 3.47735	Maximum 81.0707	
Mean 22.3051	Std. Dev. 11.3209	Variance 128.162

At infinity

05% of values less than 3.17445
10% of values less than 4.51391
50% of values less than 11.9466
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48354	Maximum 31.4569	
Mean 12.9044	Std. Dev. 7.13787	Variance 50.9492

Phase: Cell 7b

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 2.11127E-016
95% of values less than 2.42397E-013

Minimum 0	Maximum 3.84302E-006	
Mean 1.54032E-008	Std. Dev. 1.95531E-007	Variance 3.82324E-014

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 9.9804E-017
90% of values less than 1.11715E-005
95% of values less than 0.000111121

Minimum 0	Maximum 0.00342891	
Mean 2.83167E-005	Std. Dev. 0.000183501	Variance 3.36728E-008

At infinity

05% of values less than 7.89279E-008
10% of values less than 2.85622E-007
50% of values less than 9.60448E-006
90% of values less than 0.000106862
95% of values less than 0.000142967

Minimum 1.27785E-015	Maximum 0.00081258	
Mean 3.6362E-005	Std. Dev. 6.7264E-005	Variance 4.52445E-009

Phase: Cell 7b

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811

Minimum 0.47837	Maximum 37.408	
Mean 14.8657	Std. Dev. 8.56621	Variance 73.3799

At 100 years

05% of values less than 4.2374
10% of values less than 5.90336
50% of values less than 19.5327
90% of values less than 66.5374
95% of values less than 88.9672

Minimum 0.710567	Maximum 296.367	
Mean 29.4821	Std. Dev. 32.1836	Variance 1035.79

At 300 years

05% of values less than 8.82001
10% of values less than 16.6131
50% of values less than 47.7755
90% of values less than 127.086
95% of values less than 168.187

Minimum 2.84549	Maximum 313.549	
Mean 61.8985	Std. Dev. 49.9917	Variance 2499.17

At 1000 years

05% of values less than 17.5147
10% of values less than 21.7175
50% of values less than 45.0985
90% of values less than 104.659
95% of values less than 135.723

Minimum 4.49115	Maximum 252.702	
Mean 55.8872	Std. Dev. 38.6153	Variance 1491.14

At infinity

05% of values less than 3.06952
10% of values less than 4.22406
50% of values less than 14.1764
90% of values less than 26.8741
95% of values less than 29.715

Minimum 0.54786	Maximum 37.4097	
Mean 14.9788	Std. Dev. 8.5712	Variance 73.4654

Phase: Cell 7b

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 2.95715E-016
90% of values less than 2.20101E-006
95% of values less than 6.36931E-005

Minimum 0	Maximum 0.0041869	
Mean 3.29818E-005	Std. Dev. 0.000238297	Variance 5.67855E-008

Phase: Cell 7b

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 5.26887E-014	
Mean 1.09859E-016	Std. Dev. 2.3558E-015	Variance 5.54981E-030

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.52506E-008
90% of values less than 0.00154483
95% of values less than 0.00437837

Minimum 0	Maximum 0.0352992	
Mean 0.000634963	Std. Dev. 0.0022874	Variance 5.23218E-006

Phase: Cell 8

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.0015653
10% of values less than 0.00177523
50% of values less than 0.00398984
90% of values less than 0.00745558
95% of values less than 0.00814172
Minimum 0.00125691 Maximum 0.00992919
Mean 0.0043198 Std. Dev. 0.00210905 Variance 4.44808E-006

Phase: Cell 8

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9047	Std. Dev. 7.13717	Variance 50.9392

At 100 years

05% of values less than 4.32346
10% of values less than 5.34655
50% of values less than 14.6985
90% of values less than 29.7008
95% of values less than 37.1257

Minimum 1.77597	Maximum 96.8681	
Mean 16.9325	Std. Dev. 11.2853	Variance 127.357

At 300 years

05% of values less than 6.97437
10% of values less than 10.0098
50% of values less than 22.5871
90% of values less than 47.4465
95% of values less than 58.0583

Minimum 1.91729	Maximum 112.176	
Mean 26.1542	Std. Dev. 16.5496	Variance 273.888

At 1000 years

05% of values less than 7.36572
10% of values less than 9.31693
50% of values less than 18.9603
90% of values less than 34.3022
95% of values less than 40.1931

Minimum 2.82395	Maximum 72.6556	
Mean 20.8791	Std. Dev. 10.6208	Variance 112.801

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9039	Std. Dev. 7.13789	Variance 50.9495

Phase: Cell 8

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 3.59118E-015	
Mean 7.16802E-018	Std. Dev. 1.60442E-016	Variance 2.57416E-032

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 5.96171E-018
95% of values less than 2.22022E-016

Minimum 0	Maximum 2.54103E-005	
Mean 5.15563E-008	Std. Dev. 1.1353E-006	Variance 1.2889E-012

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 3.95782E-019
90% of values less than 6.6222E-007
95% of values less than 8.35314E-006

Minimum 0	Maximum 0.00116002	
Mean 1.00121E-005	Std. Dev. 7.27458E-005	Variance 5.29195E-009

At infinity

05% of values less than 1.7855E-009
10% of values less than 5.03876E-008
50% of values less than 9.59511E-006
90% of values less than 8.40433E-005
95% of values less than 0.000129625

Minimum 0	Maximum 0.000584939	
Mean 3.53081E-005	Std. Dev. 7.17735E-005	Variance 5.15143E-009

Phase: Cell 8

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811

Minimum 0.47837	Maximum 37.408	
Mean 14.8683	Std. Dev. 8.56812	Variance 73.4127

At 100 years

05% of values less than 4.21445
10% of values less than 5.99193
50% of values less than 20.1782
90% of values less than 57.5221
95% of values less than 89.5748

Minimum 0.998105	Maximum 250.559	
Mean 28.2986	Std. Dev. 29.8858	Variance 893.158

At 300 years

05% of values less than 7.30762
10% of values less than 12.8033
50% of values less than 46.3652
90% of values less than 136.05
95% of values less than 172.624

Minimum 1.97689	Maximum 350.402	
Mean 61.9962	Std. Dev. 54.755	Variance 2998.11

At 1000 years

05% of values less than 12.4971
10% of values less than 18.894
50% of values less than 41.9147
90% of values less than 107.739
95% of values less than 142.303

Minimum 3.17543	Maximum 298.735	
Mean 54.1671	Std. Dev. 39.7617	Variance 1580.99

At infinity

05% of values less than 3.07614
10% of values less than 4.19789
50% of values less than 13.9835
90% of values less than 26.8794
95% of values less than 29.6811

Minimum 0.486096	Maximum 37.4376	
Mean 14.8797	Std. Dev. 8.56505	Variance 73.36

Phase: Cell 8

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 2.88083E-017
90% of values less than 4.08688E-008
95% of values less than 1.58365E-006

Minimum 0	Maximum 0.00265756	
Mean 1.17759E-005	Std. Dev. 0.000130389	Variance 1.70014E-008

Phase: Cell 8

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 5.73201E-013	
Mean 1.14412E-015	Std. Dev. 2.56087E-014	Variance 6.55806E-028

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 4.96409E-011
90% of values less than 0.000448071
95% of values less than 0.00124502

Minimum 0	Maximum 0.0148069	
Mean 0.000299681	Std. Dev. 0.00126495	Variance 1.60009E-006

Phase: Cell 9

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.00156531
10% of values less than 0.00176374
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00815006
Minimum 0.00125789 Maximum 0.00992919
Mean 0.00431197 Std. Dev. 0.00211448 Variance 4.47105E-006

Phase: Cell 9

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48352 Maximum 31.4568
Mean 12.9039 Std. Dev. 7.13788 Variance 50.9493

At 100 years

05% of values less than 4.1615
10% of values less than 4.98588
50% of values less than 14.4417
90% of values less than 29.2405
95% of values less than 36.2375
Minimum 1.68156 Maximum 100.304
Mean 17.0532 Std. Dev. 12.408 Variance 153.96

At 300 years

05% of values less than 7.02255
10% of values less than 10.0859
50% of values less than 25.1234
90% of values less than 51.7777
95% of values less than 64.639
Minimum 2.25868 Maximum 129.278
Mean 28.3922 Std. Dev. 18.9522 Variance 359.184

At 1000 years

05% of values less than 8.99172
10% of values less than 10.7709
50% of values less than 22.3244
90% of values less than 40.2672
95% of values less than 47.4382
Minimum 2.2795 Maximum 77.195
Mean 24.1032 Std. Dev. 12.3139 Variance 151.632

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48352 Maximum 31.4568
Mean 12.904 Std. Dev. 7.13786 Variance 50.9491

Phase: Cell 9

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 3.20147E-018
95% of values less than 2.8225E-016

Minimum 0	Maximum 2.83883E-007	
Mean 7.65829E-010	Std. Dev. 1.31052E-008	Variance 1.71747E-016

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 8.20584E-007
95% of values less than 3.69436E-005

Minimum 0	Maximum 0.00884581	
Mean 5.45392E-005	Std. Dev. 0.000522073	Variance 2.7256E-007

At infinity

05% of values less than 3.5474E-008
10% of values less than 2.38619E-006
50% of values less than 0.000189527
90% of values less than 0.00156246
95% of values less than 0.00251819

Minimum 0	Maximum 0.00899689	
Mean 0.000632423	Std. Dev. 0.0012026	Variance 1.44626E-006

Phase: Cell 9

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.1975
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811

Minimum 0.47837	Maximum 37.408	
Mean 14.8657	Std. Dev. 8.56616	Variance 73.3792

At 100 years

05% of values less than 3.89598
10% of values less than 5.49209
50% of values less than 19.5067
90% of values less than 55.9499
95% of values less than 87.8381

Minimum 0.708471	Maximum 298.288	
Mean 28.7818	Std. Dev. 35.3498	Variance 1249.61

At 300 years

05% of values less than 8.94384
10% of values less than 16.2512
50% of values less than 52.2514
90% of values less than 154.835
95% of values less than 197.614

Minimum 1.02444	Maximum 406.189	
Mean 69.7916	Std. Dev. 62.9064	Variance 3957.21

At 1000 years

05% of values less than 19.1898
10% of values less than 24.9002
50% of values less than 52.5662
90% of values less than 136.297
95% of values less than 173.936

Minimum 3.079	Maximum 306.272	
Mean 67.9105	Std. Dev. 48.6511	Variance 2366.93

At infinity

05% of values less than 3.05129
10% of values less than 4.19567
50% of values less than 14.0195
90% of values less than 26.872
95% of values less than 29.9882

Minimum 0.479102	Maximum 37.4098	
Mean 14.8943	Std. Dev. 8.57214	Variance 73.4816

Phase: Cell 9

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 3.52784E-018
90% of values less than 3.4035E-009
95% of values less than 2.96813E-007

Minimum 0 Maximum 0.0011174
Mean 4.94151E-006 Std. Dev. 6.01812E-005 Variance 3.62177E-009

Phase: Cell 9

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.6806E-013
90% of values less than 0.000257006
95% of values less than 0.0015103

Minimum 0	Maximum 0.0167302	
Mean 0.000281262	Std. Dev. 0.00131742	Variance 1.73559E-006

Phase: Cell 10a

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity
05% of values less than 0.00164136
10% of values less than 0.00177523
50% of values less than 0.00418256
90% of values less than 0.00766709
95% of values less than 0.00880934
Minimum 0.00125615 Maximum 0.0147016
Mean 0.00451187 Std. Dev. 0.00226935 Variance 5.14995E-006

Phase: Cell 10a

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.904	Std. Dev. 7.13782	Variance 50.9484

At 100 years

05% of values less than 4.96414
10% of values less than 6.33262
50% of values less than 21.0796
90% of values less than 62.4215
95% of values less than 86.1328

Minimum 1.94289	Maximum 198.178	
Mean 29.7243	Std. Dev. 28.8621	Variance 833.021

At 300 years

05% of values less than 7.74179
10% of values less than 10.6817
50% of values less than 35.3341
90% of values less than 91.3866
95% of values less than 117.677

Minimum 2.03641	Maximum 223.449	
Mean 44.5108	Std. Dev. 34.4396	Variance 1186.08

At 1000 years

05% of values less than 9.03874
10% of values less than 10.9798
50% of values less than 24.8018
90% of values less than 50.7781
95% of values less than 62.961

Minimum 4.30397	Maximum 116.189	
Mean 28.9075	Std. Dev. 17.2383	Variance 297.159

At infinity

05% of values less than 3.17445
10% of values less than 4.51384
50% of values less than 11.9424
90% of values less than 23.7816
95% of values less than 25.6973

Minimum 1.48353	Maximum 31.4568	
Mean 12.9039	Std. Dev. 7.13789	Variance 50.9495

Phase: Cell 10a

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 2.76384E-014	
Mean 5.64904E-017	Std. Dev. 1.23495E-015	Variance 1.5251E-030

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 2.87845E-013
95% of values less than 9.31153E-010

Minimum 0	Maximum 7.77217E-005	
Mean 3.50642E-007	Std. Dev. 4.02927E-006	Variance 1.6235E-011

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 7.6285E-014
90% of values less than 0.000187914
95% of values less than 0.000919858

Minimum 0	Maximum 0.00609784	
Mean 0.000131504	Std. Dev. 0.000533878	Variance 2.85025E-007

At infinity

05% of values less than 2.2528E-009
10% of values less than 1.50304E-008
50% of values less than 3.26604E-006
90% of values less than 5.75028E-005
95% of values less than 0.000102614

Minimum 1.36765E-018	Maximum 0.000684364	
Mean 2.17886E-005	Std. Dev. 5.52688E-005	Variance 3.05464E-009

Phase: Cell 10a

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811

Minimum 0.47837	Maximum 37.408	
Mean 14.866	Std. Dev. 8.56637	Variance 73.3827

At 100 years

05% of values less than 5.38266
10% of values less than 7.76518
50% of values less than 29.4747
90% of values less than 180.71
95% of values less than 267.805

Minimum 1.71519	Maximum 626.046	
Mean 71.4739	Std. Dev. 94.245	Variance 8882.13

At 300 years

05% of values less than 10.5207
10% of values less than 16.1487
50% of values less than 93.5882
90% of values less than 319.473
95% of values less than 389.301

Minimum 3.14022	Maximum 760.953	
Mean 130.14	Std. Dev. 123.393	Variance 15225.9

At 1000 years

05% of values less than 16.8173
10% of values less than 24.3836
50% of values less than 72.0349
90% of values less than 220.476
95% of values less than 270.724

Minimum 3.16655	Maximum 514.258	
Mean 97.3207	Std. Dev. 80.5522	Variance 6488.66

At infinity

05% of values less than 3.06813
10% of values less than 4.19999
50% of values less than 14.0062
90% of values less than 26.8725
95% of values less than 29.7376

Minimum 0.645901	Maximum 37.4084	
Mean 14.8842	Std. Dev. 8.57031	Variance 73.4501

Phase: Cell 10a

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.8373E-015
90% of values less than 7.24734E-005
95% of values less than 0.000633881

Minimum 0	Maximum 0.0113457	
Mean 0.000177712	Std. Dev. 0.00089254	Variance 7.96628E-007

Phase: Cell 10a

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 1.52843E-011	
Mean 3.32781E-014	Std. Dev. 6.84309E-013	Variance 4.68279E-025

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 6.58789E-007
90% of values less than 0.00842387
95% of values less than 0.0157355

Minimum 0	Maximum 0.0781077	
Mean 0.00265253	Std. Dev. 0.00747607	Variance 5.58917E-005

Phase: Cell 10b

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years
05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity
05% of values less than 0.00156728
10% of values less than 0.00177523
50% of values less than 0.00399918
90% of values less than 0.00745558
95% of values less than 0.0081435
Minimum 0.00125631 Maximum 0.00992919
Mean 0.00433195 Std. Dev. 0.0021121 Variance 4.46096E-006

Phase: Cell 10b

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9039	Std. Dev. 7.13789	Variance 50.9494

At 100 years

05% of values less than 4.21264
10% of values less than 5.34418
50% of values less than 16.1921
90% of values less than 35.9605
95% of values less than 52.7083

Minimum 1.68155	Maximum 140.823	
Mean 19.9058	Std. Dev. 16.9614	Variance 287.688

At 300 years

05% of values less than 8.26711
10% of values less than 12.8789
50% of values less than 28.3025
90% of values less than 69.3431
95% of values less than 86.4871

Minimum 2.12989	Maximum 157.405	
Mean 35.4585	Std. Dev. 24.6243	Variance 606.354

At 1000 years

05% of values less than 9.68079
10% of values less than 12.7666
50% of values less than 23.9971
90% of values less than 46.0083
95% of values less than 57.4076

Minimum 2.96897	Maximum 89.8448	
Mean 27.0709	Std. Dev. 14.7308	Variance 216.996

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973

Minimum 1.48352	Maximum 31.4568	
Mean 12.9041	Std. Dev. 7.13778	Variance 50.948

Phase: Cell 10b

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 6.52964E-018
95% of values less than 2.56884E-016

Minimum 0	Maximum 9.37782E-008	
Mean 2.19051E-010	Std. Dev. 4.22498E-009	Variance 1.78505E-017

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 5.08345E-018
90% of values less than 1.54859E-006
95% of values less than 1.83373E-005

Minimum 0	Maximum 0.00146288	
Mean 1.42929E-005	Std. Dev. 9.07641E-005	Variance 8.23812E-009

At infinity

05% of values less than 5.42552E-009
10% of values less than 9.28658E-008
50% of values less than 1.64955E-005
90% of values less than 0.000183662
95% of values less than 0.000299571

Minimum 1.0445E-018	Maximum 0.000880182	
Mean 6.51862E-005	Std. Dev. 0.000121666	Variance 1.48027E-008

Phase: Cell 10b

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811

Minimum 0.47837	Maximum 37.408	
Mean 14.8657	Std. Dev. 8.56621	Variance 73.3799

At 100 years

05% of values less than 4.43322
10% of values less than 6.05449
50% of values less than 21.2709
90% of values less than 87.6125
95% of values less than 125.323

Minimum 0.708471	Maximum 416.869	
Mean 38.0927	Std. Dev. 50.2702	Variance 2527.09

At 300 years

05% of values less than 10.6322
10% of values less than 19.1439
50% of values less than 69.8808
90% of values less than 217.264
95% of values less than 268.674

Minimum 0.958681	Maximum 477.103	
Mean 94.1775	Std. Dev. 82.1252	Variance 6744.54

At 1000 years

05% of values less than 19.3868
10% of values less than 28.8663
50% of values less than 63.1078
90% of values less than 172.49
95% of values less than 215.653

Minimum 4.03382	Maximum 340.881	
Mean 81.8871	Std. Dev. 60.8692	Variance 3705.06

At infinity

05% of values less than 3.06816
10% of values less than 4.2175
50% of values less than 14.019
90% of values less than 26.9136
95% of values less than 29.6846

Minimum 0.479539	Maximum 37.4084	
Mean 14.9065	Std. Dev. 8.57084	Variance 73.4594

Phase: Cell 10b

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.832E-016
90% of values less than 8.5183E-008
95% of values less than 4.11084E-006

Minimum 0	Maximum 0.00204396	
Mean 1.13613E-005	Std. Dev. 0.000103426	Variance 1.06969E-008

Phase: Cell 10b

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 9.07083E-010
90% of values less than 0.0010321
95% of values less than 0.00392489

Minimum 0	Maximum 0.0222707	
Mean 0.000617768	Std. Dev. 0.0022661	Variance 5.1352E-006

Phase: Cell 11

Concentration of Arsenic at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 100 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 300 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At 1000 years

05% of values less than 0.00151645
10% of values less than 0.0017451
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125615 Maximum 0.00992919
Mean 0.00429963 Std. Dev. 0.00210893 Variance 4.44759E-006

At infinity

05% of values less than 0.00156728
10% of values less than 0.00177523
50% of values less than 0.00398236
90% of values less than 0.00744669
95% of values less than 0.00814172
Minimum 0.00125697 Maximum 0.00992919
Mean 0.00430915 Std. Dev. 0.00210825 Variance 4.4447E-006

Phase: Cell 11

Concentration of Chloride at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48352 Maximum 31.4568
Mean 12.9039 Std. Dev. 7.13789 Variance 50.9494

At 100 years

05% of values less than 3.61466
10% of values less than 4.88278
50% of values less than 13.2628
90% of values less than 25.3252
95% of values less than 27.9628
Minimum 1.8811 Maximum 41.5034
Mean 14.2881 Std. Dev. 7.82028 Variance 61.1567

At 300 years

05% of values less than 4.97256
10% of values less than 6.83842
50% of values less than 16.7211
90% of values less than 31.3673
95% of values less than 35.7841
Minimum 2.4789 Maximum 79.0429
Mean 18.4553 Std. Dev. 9.98358 Variance 99.672

At 1000 years

05% of values less than 5.05599
10% of values less than 6.35487
50% of values less than 14.4949
90% of values less than 26.8171
95% of values less than 28.5002
Minimum 2.27674 Maximum 39.8951
Mean 15.6431 Std. Dev. 7.61943 Variance 58.0557

At infinity

05% of values less than 3.17445
10% of values less than 4.51383
50% of values less than 11.9424
90% of values less than 23.7815
95% of values less than 25.6973
Minimum 1.48352 Maximum 31.4568
Mean 12.9039 Std. Dev. 7.13789 Variance 50.9494

Phase: Cell 11

Concentration of Selenium at Phase Monitor Well [mg/l]

At 30 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 5.30398E-019
95% of values less than 2.26486E-017
Minimum 0 Maximum 2.72751E-007
Mean 9.59259E-010 Std. Dev. 1.33726E-008 Variance 1.78827E-016

At 1000 years
05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 3.09927E-008
95% of values less than 9.62375E-007
Minimum 0 Maximum 0.000319464
Mean 4.03045E-006 Std. Dev. 2.80486E-005 Variance 7.86723E-010

At infinity
05% of values less than 1.75642E-012
10% of values less than 1.64626E-009
50% of values less than 4.0154E-006
90% of values less than 4.37558E-005
95% of values less than 7.51754E-005
Minimum 0 Maximum 0.000413707
Mean 1.68198E-005 Std. Dev. 3.98984E-005 Variance 1.59189E-009

Phase: Cell 11

Concentration of Sulphate at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 3.05058
10% of values less than 4.19562
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6811
Minimum 0.47837 Maximum 37.408
Mean 14.8657 Std. Dev. 8.56621 Variance 73.3799

At 100 years

05% of values less than 3.58363
10% of values less than 5.34332
50% of values less than 16.9285
90% of values less than 35.5024
95% of values less than 43.4958
Minimum 0.82205 Maximum 160.573
Mean 19.57 Std. Dev. 14.9046 Variance 222.148

At 300 years

05% of values less than 6.32011
10% of values less than 9.89433
50% of values less than 29.8013
90% of values less than 66.538
95% of values less than 87.2072
Minimum 1.91849 Maximum 228.039
Mean 35.4995 Std. Dev. 27.2611 Variance 743.168

At 1000 years

05% of values less than 8.52203
10% of values less than 12.3373
50% of values less than 27.0764
90% of values less than 54.0258
95% of values less than 66.2904
Minimum 2.86542 Maximum 124.85
Mean 30.4831 Std. Dev. 18.1165 Variance 328.209

At infinity

05% of values less than 3.05058
10% of values less than 4.19584
50% of values less than 13.9835
90% of values less than 26.871
95% of values less than 29.6813
Minimum 0.478772 Maximum 37.408
Mean 14.8672 Std. Dev. 8.56605 Variance 73.3773

Phase: Cell 11

Concentration of Antimony at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0
Minimum 0 Maximum 0
Mean 0 Std. Dev. 0 Variance 0

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 4.69682E-019
90% of values less than 6.64449E-010
95% of values less than 7.4475E-008
Minimum 0 Maximum 0.000416462
Mean 4.47075E-006 Std. Dev. 3.59988E-005 Variance 1.29592E-009

Phase: Cell 11

Concentration of Molybdenum at Phase Monitor Well [mg/l]

At 30 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 100 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 300 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 0	
Mean 0	Std. Dev. 0	Variance 0

At 1000 years

05% of values less than 0
10% of values less than 0
50% of values less than 0
90% of values less than 0
95% of values less than 0

Minimum 0	Maximum 1.40363E-017	
Mean 2.96781E-020	Std. Dev. 6.28121E-019	Variance 3.94537E-037

At infinity

05% of values less than 0
10% of values less than 0
50% of values less than 1.02758E-014
90% of values less than 0.000108435
95% of values less than 0.000405217

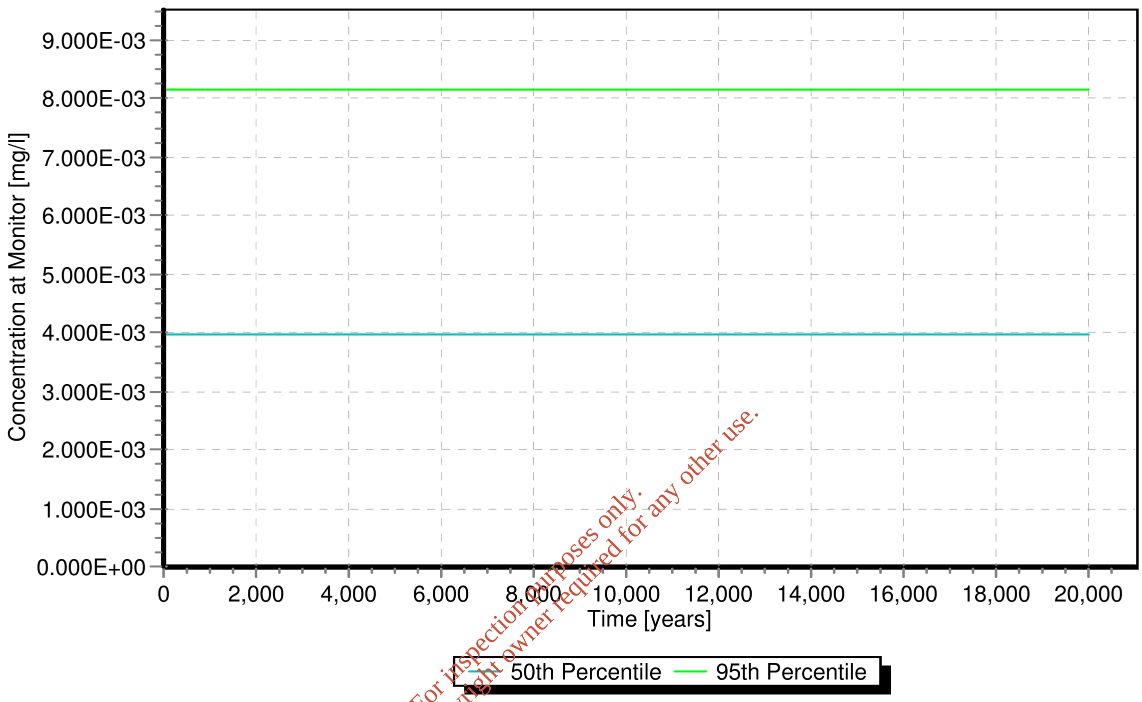
Minimum 0	Maximum 0.00797834	
Mean 0.000113598	Std. Dev. 0.000562183	Variance 3.1605E-007

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cells 1,2,3 and 5, Arsenic Concentration at Monitor [mg/l]



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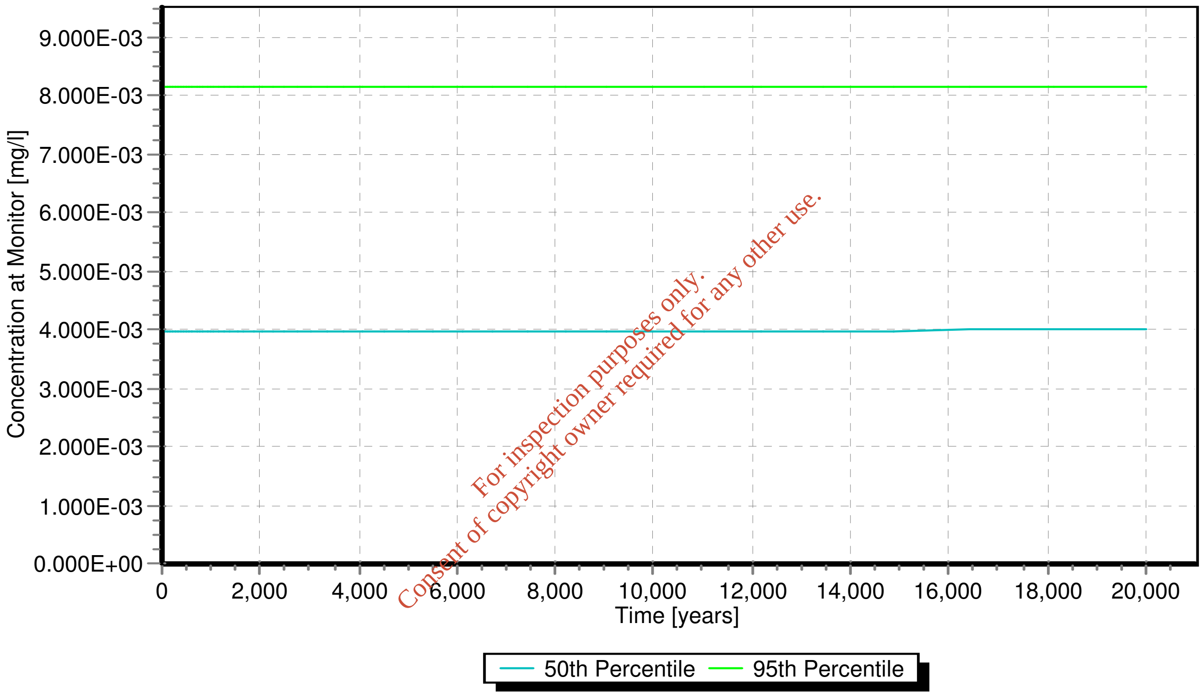
30/04/2018 15:25:12

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 4, Arsenic Concentration at Monitor [mg/l]



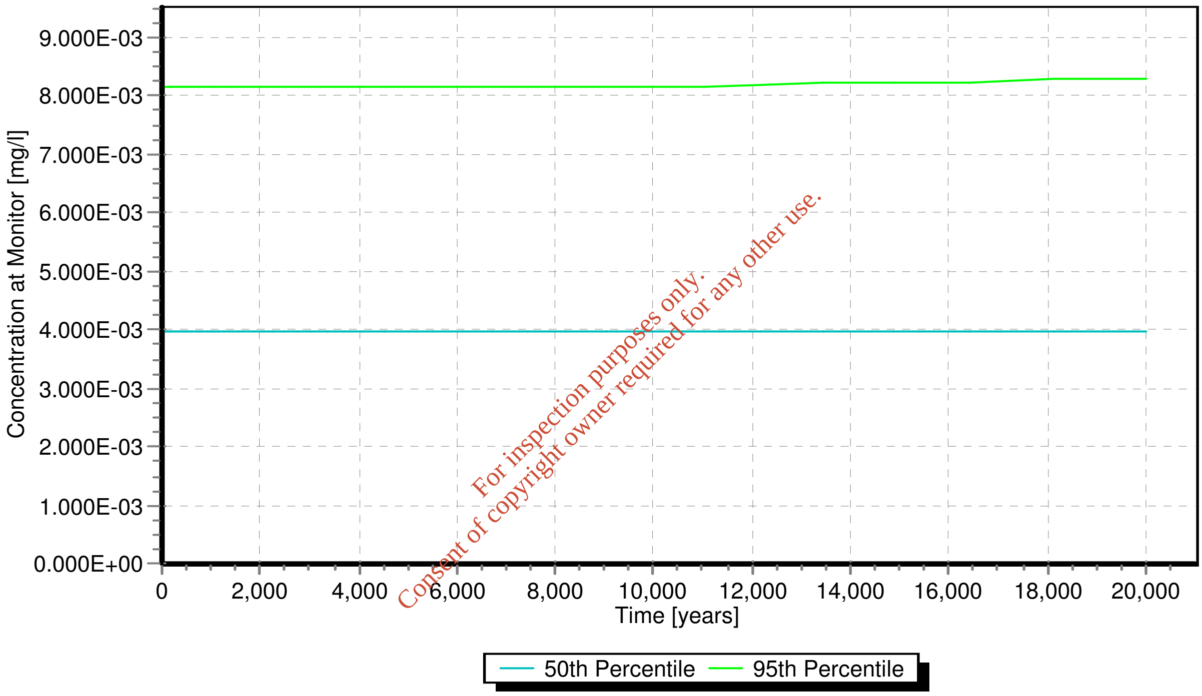
\WAC_v1.sim 30/04/2018 15:25:12

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 6, Arsenic Concentration at Monitor [mg/l]



\WAC_v1.sim

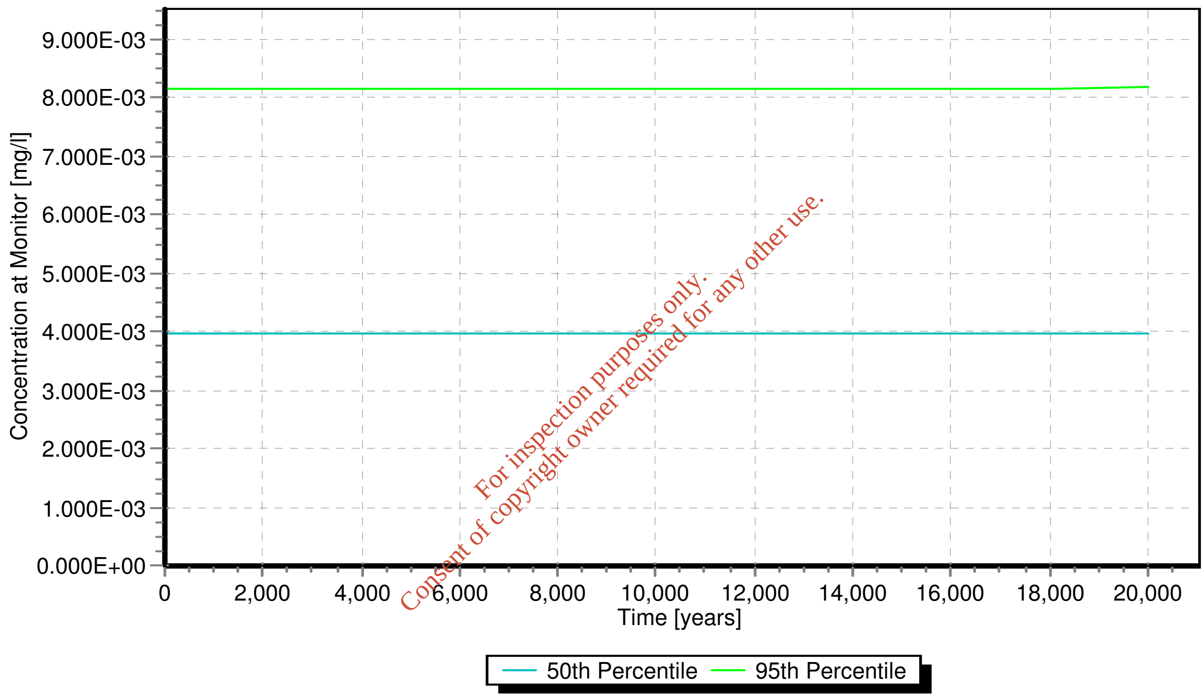
30/04/2018 15:25:12

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 7a, Arsenic Concentration at Monitor [mg/l]



\WAC_v1.sim

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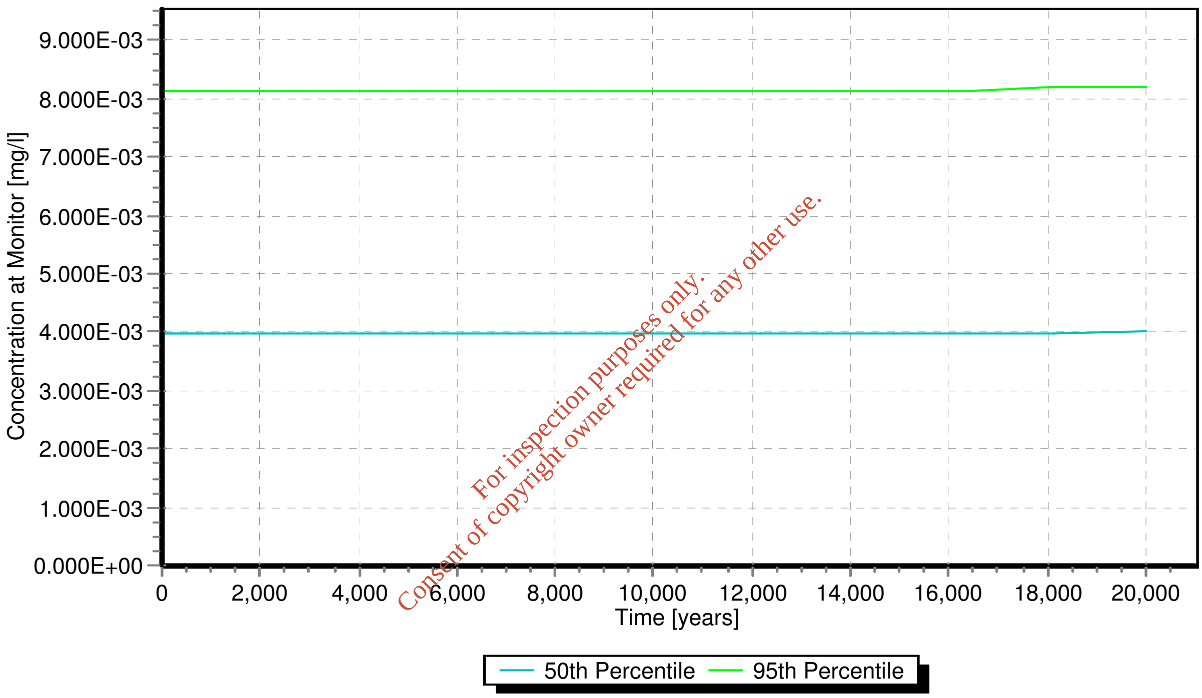
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 7b, Arsenic Concentration at Monitor [mg/l]



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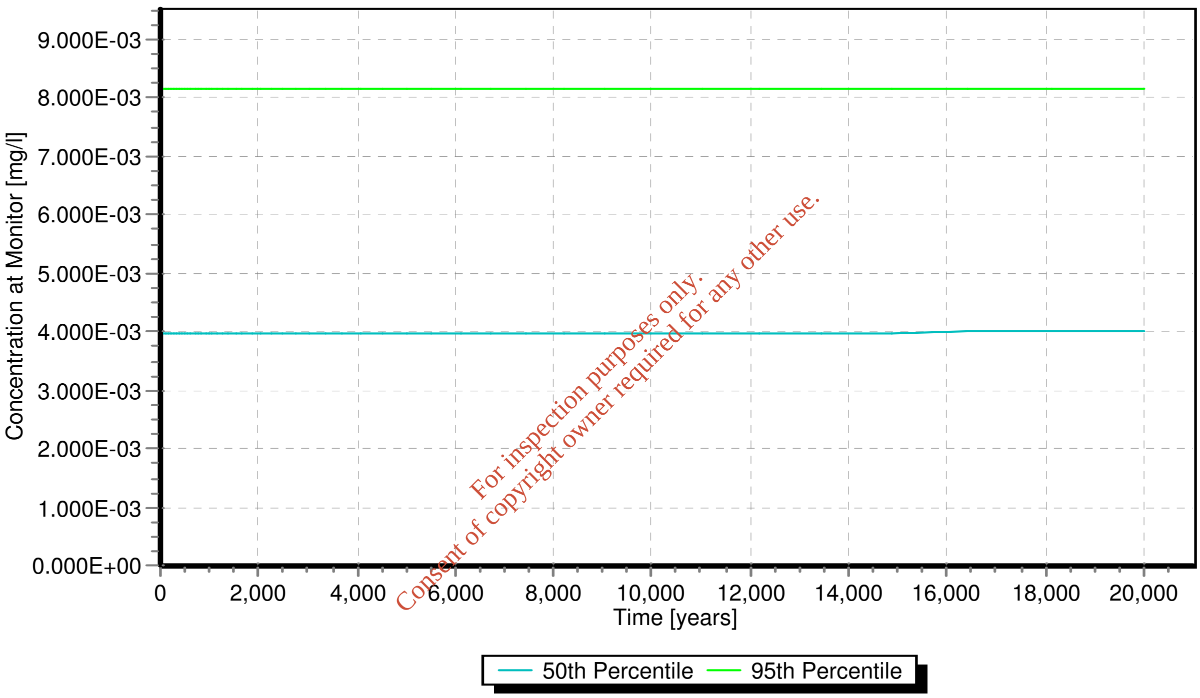
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 8, Arsenic Concentration at Monitor [mg/l]



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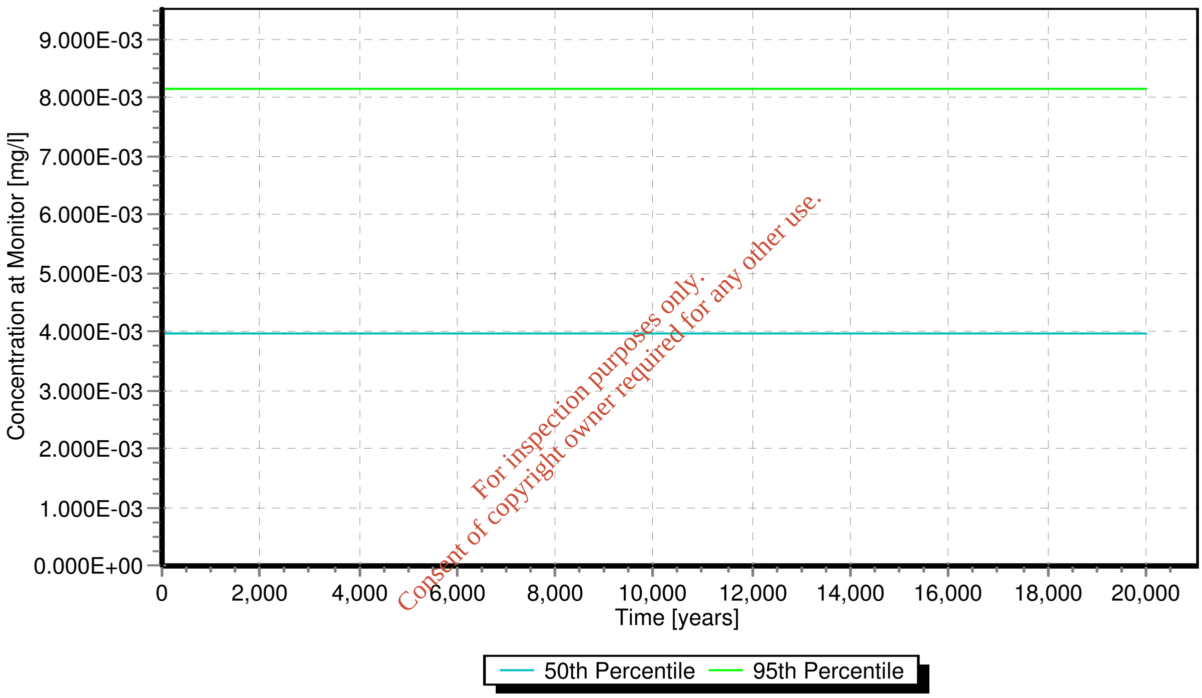
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 9, Arsenic Concentration at Monitor [mg/l]



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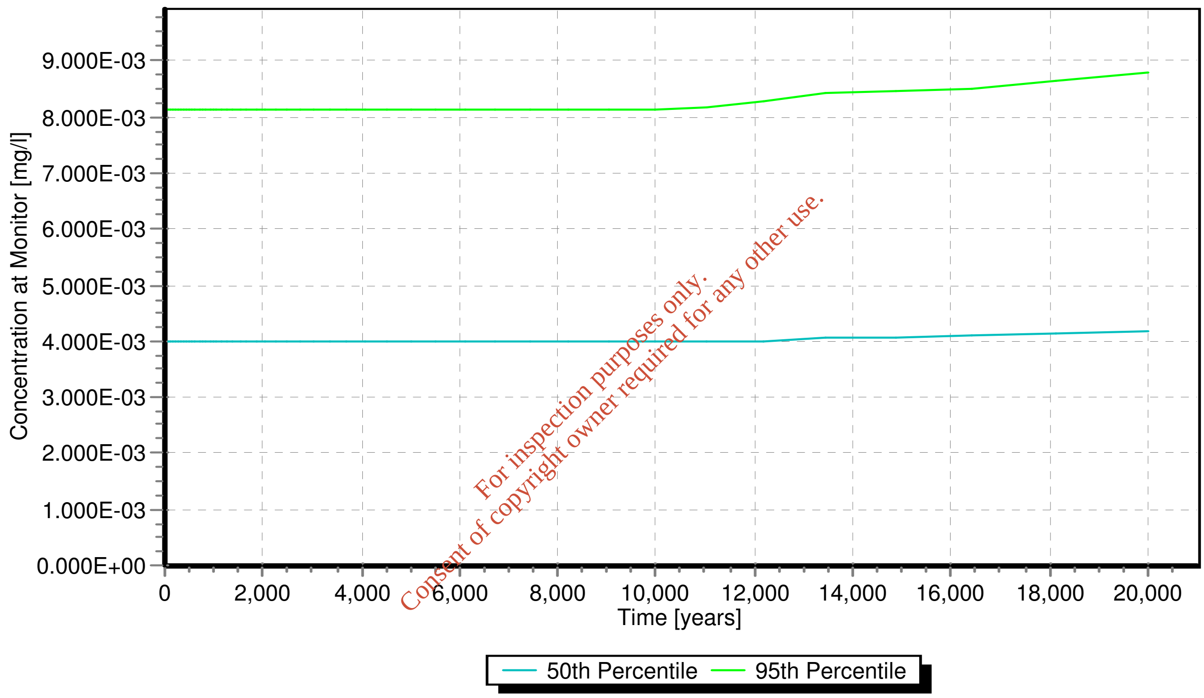
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 10a, Arsenic Concentration at Monitor [mg/l]



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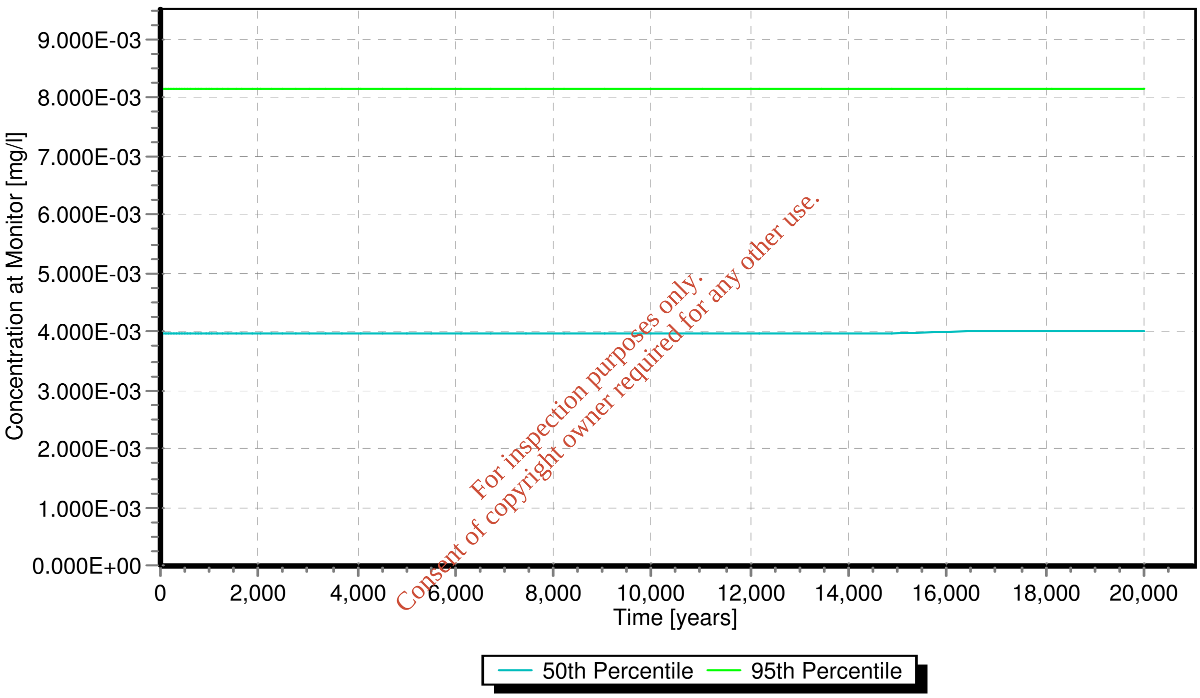
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 10b, Arsenic Concentration at Monitor [mg/l]



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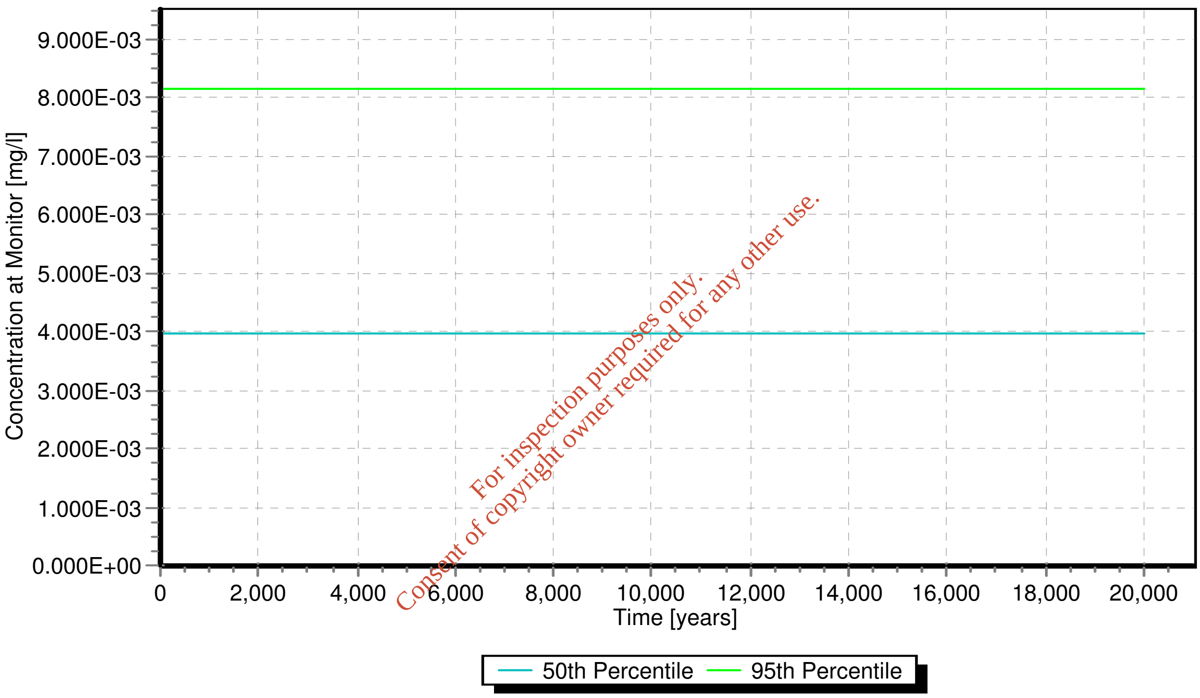
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Cell 11, Arsenic Concentration at Monitor [mg/l]



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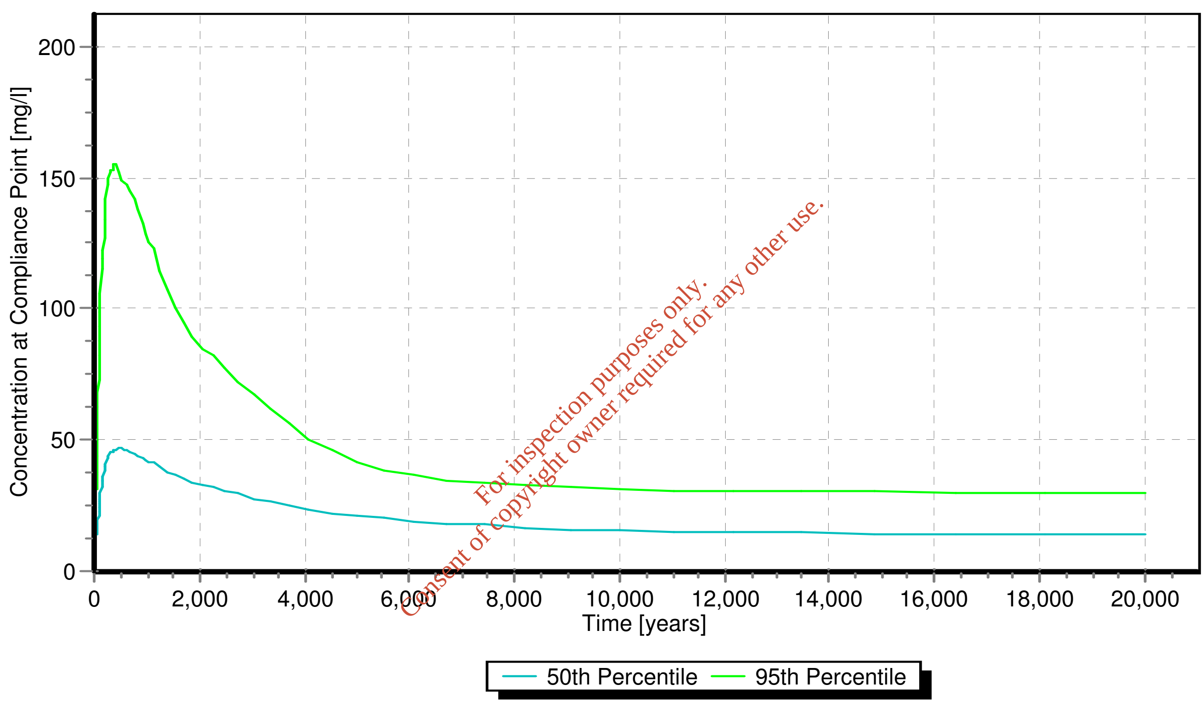
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Sulphate Concentration at Compliance Point [mg/l]



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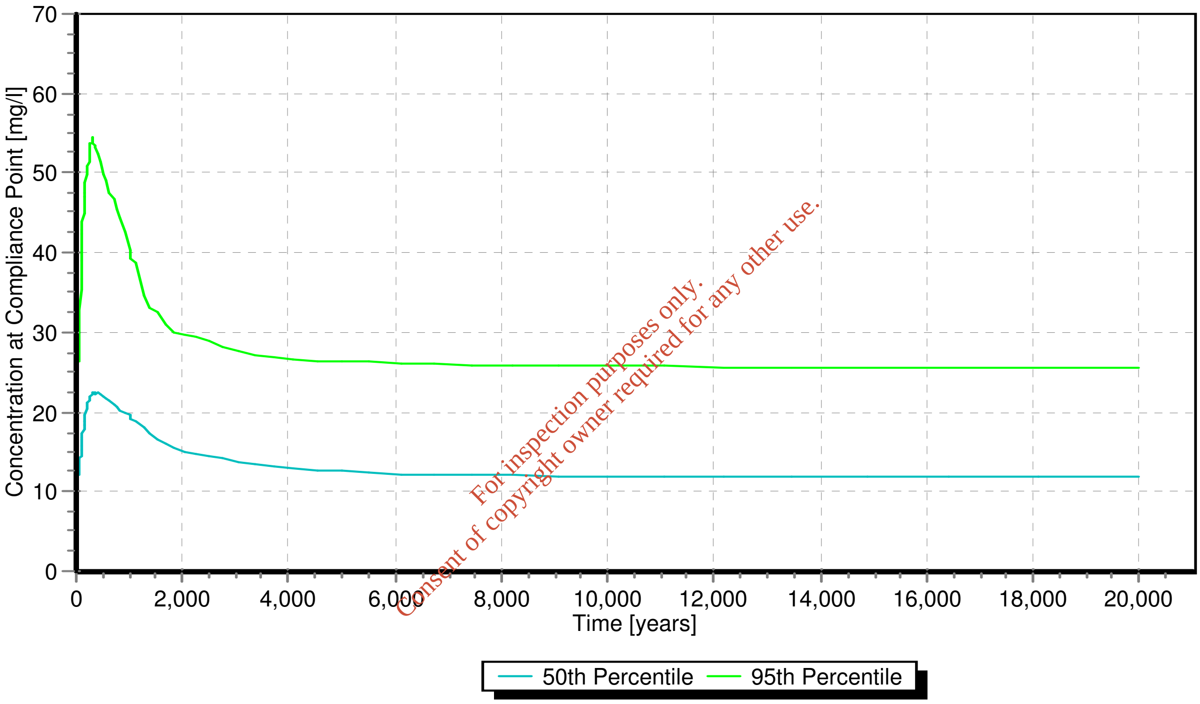
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Chloride Concentration at Compliance Point [mg/l]



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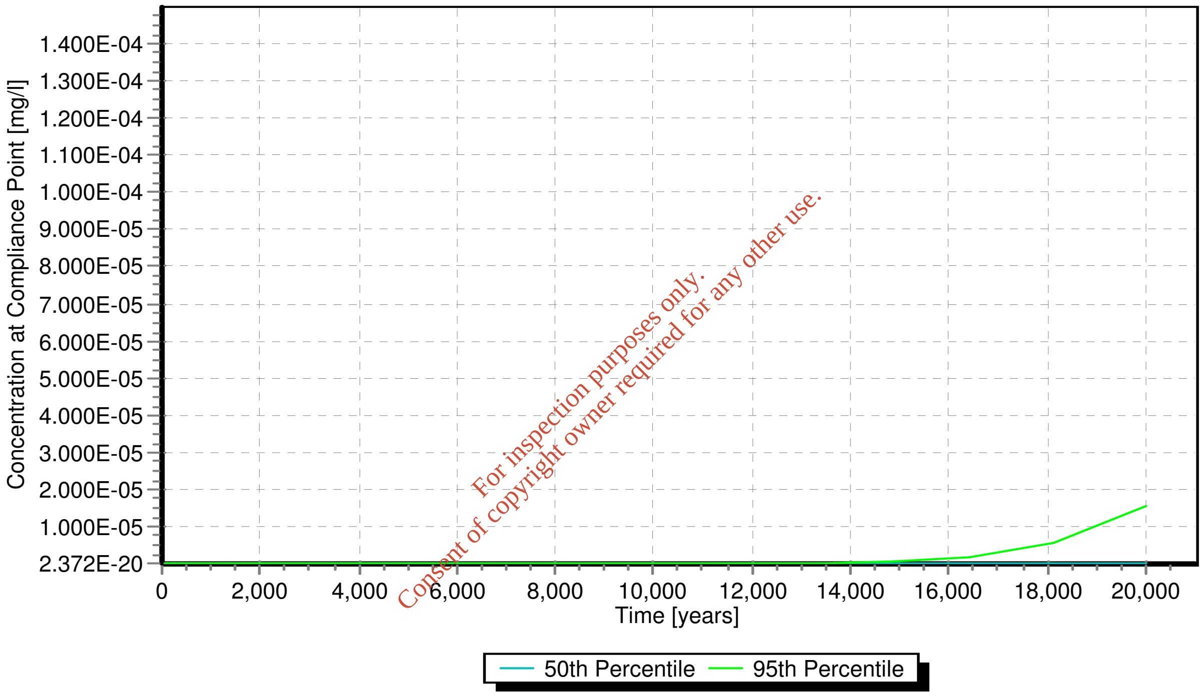
LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Antimony Concentration at Compliance Point [mg/l]



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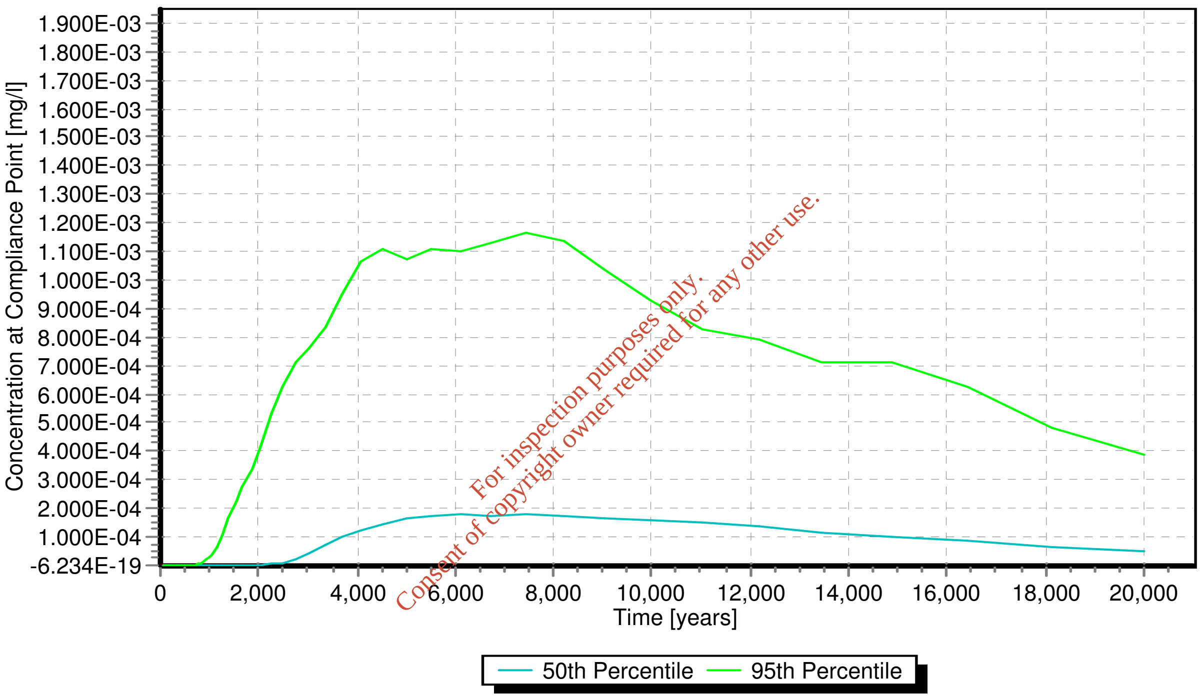
30/04/2018 15:25:12

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Selenium Concentration at Compliance Point [mg/l]



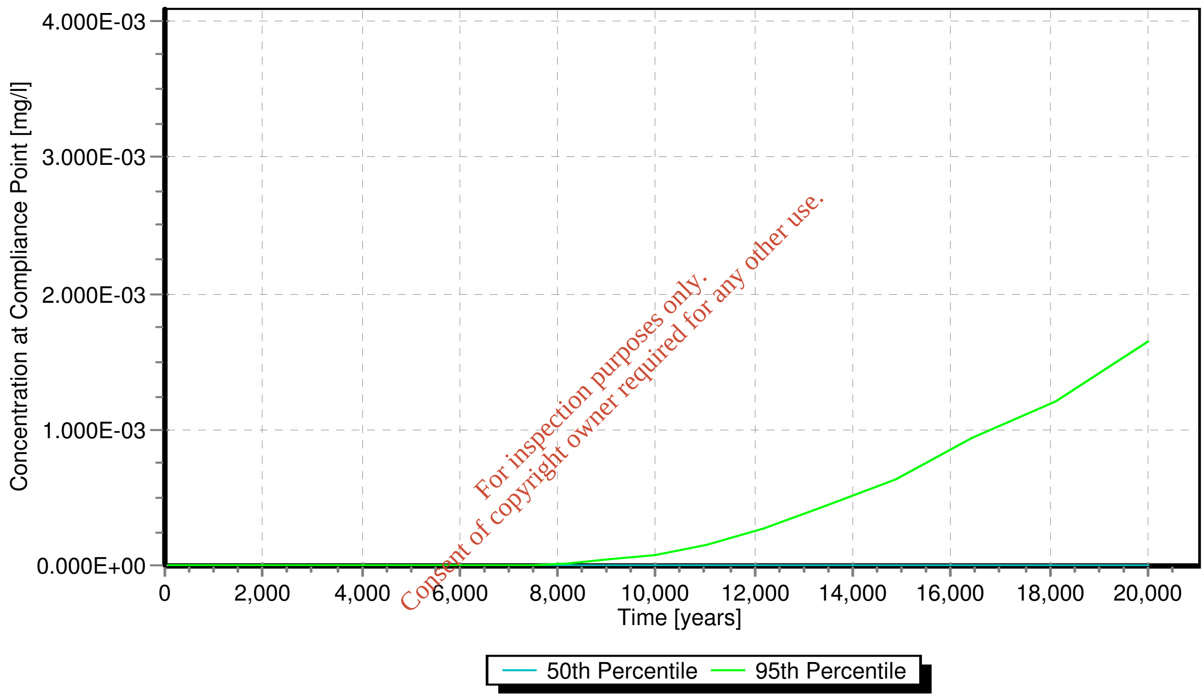
\WAC_v1.sim 30/04/2018 15:25:12

LandSim Version 2.5

Project Name: Great Hollywood

Customer:Integrated Materials Solutions GP Ltd

Results: Molybdenum Concentration at Compliance Point [mg/l]



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ATTACHEMENT 4: FURTHER INFORMATION SUBMITTED 12.11.18

INTEGRATED
MATERIALS
SOLUTIONS

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E info@imsirl.ie

www.integratedmaterialssolutions.ie

Mr Cathal Gahan
Waste Enforcement Section
Environmental Protection Agency
McCumiskey House
Clonskeagh
Dublin 14

Via Eden

12 November 2018 (typo corrected 26/11/18)

Dear Mr Gahan,

RE: Additional information and clarifications in relation to Licence Return LR035174

This letter provides some additional information and clarifications in relation to LR35174 which details a proposed change to waste acceptance limits at the Hollywood Landfill (W0129-02).

Waste Types

As detailed in the further information submitted to the Agency on 6th September 2018; the primary waste types which this application relates to is **Soil & Stone (17 05 04) & Dredging Spoil (17 05 06).**

We believe other types of waste may also be suitable for acceptance under the increased parameters, however these are not being proposed at this time.

Management of Waste

Should the request be approved by the Agency, IMS will update our procedures and materials tracking software in advance of any of the material is accepted at the site. Our tracking system allows wastes and sources to be individually tracked from the source site to the location within the landfill. Specific details which are tracked include:

- Source site & location within site (e.g. Stockpile ref)
- Lab Certificate Reference
- Description of material (e.g. "soil w/ elevated parameters" or "landscaping recovery")
- Location within landfill of material deposit

INTEGRATED MATERIALS SOLUTIONS

The information recorded will allow IMS to track where all material with elevated parameters. Each working cell is subdivided into discrete areas both in plan and elevation. The system ensures that appropriate materials at the correct volumes go to the appropriate places on site. This data can be made available to the Agency when required.

We trust that the enclosed information is satisfactory and if you require any further information please do not hesitate to contact the undersigned.

Yours sincerely,

Cian O'Hora MSc CSci PGeo EurGeol MCIWM MCIWEM
On behalf of IMS

ATTACHEMENT 5: LICENCE RETURN NOTICE

LS Rejection - Notice

Licence: W0129-02 - Integrated Materials Solutions Limited Partnership

Submitted On: 27/11/2018

Licensee Submission LR035174 **Title** Increase to WAC limits - Hydrogeological Risk Assessment

Notification

Dear Mr O'Hora,

The Agency has reviewed your submission LR035174, "Increase to WAC limits - Hydrogeological Risk Assessment" (and all subsequent submissions under RI009681) in relation to the request to increase the Waste Acceptance Criteria for 17 05 04 Soil & Stone and 17 05 06 Dredging Spoil at your facility.

Following a review by the Office of Environmental Enforcement, this request cannot be accommodated under the existing licence, Reg. No. W0129-02.

A Technical Amendment will be required to provide for the proposed changes. The matter requires review and re-submission of the licence alteration change request through the EDEN.

Guidance is available on the EPA website on the steps in the completion of the online web form:

http://www.epa.ie/pubs/advice/licensee/epaguidanceforlicenseesonrequestsforalterationstoinstallationfacility.html

If the alteration is considered to be a significant change and cannot be accommodated by a Technical Amendment, the ELP will notify you of the process for applying for a Review.

Yours sincerely,

Cathal Gahan

Office of Environmental Enforcement, Dublin

Tel: 01-2680100