ARTICLE 14 RESPONSE

Churchtown Landfill Site

IBR1015
Article 14 Response
Final
16 July 2019

rpsgroup.com

Document status

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Final	Article 14 Response	AMcG	DD	DD	16/07/19

Approval for issue

Donal Doyle	[Signature]	16 July 2019

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Prepared for:

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1 ARTICLE 14 COMPLIANCE REQUIREMENTS

The following responses have been numbered as per EPA letter dated 8th March 2019.

1.1 Point 1

Class D1 of the Waste Management Act 1996, as amended, has been identified in the application as the principal class of activity, however, the newspaper notice and site notice state that Class D4 is the principal activity. Clarify which is the principal activity and ensure that appropriate licence application fee has been submitted to the Agency in respect of this activity.

The principal activity is D4 of the Third Schedule.

1.2 Point 2

State whether the purchase of the site, which is the subject of the licence application, has been completed and Donegal County Council is now the owner of the site.

Donegal County Council is the owners of the site.

1.3 Point 3

Submit a drawing showing the site boundary. The site boundary should be outlined as a continuous red line surrounding the entire facility.

Drawing IBR1015/101A Site Boundary is included in Appendix A.

1.4 Point 4

Explain how storm water arising from the site is managed. Include a drawing showing the storm water discharge locations.

The existing landfill was capped with a permanent low permeability clay liner in conjunction with a willow and reed plantation and constructed wetland installed in 2014-2015. A 0.15 to 0.45 metre thick topsoil and 0.5 m clay cap with a permeability of $1x10^{-8}$ m/s was installed at the facility. The willow plantation in situated in the centre and above the capped waste (Zones 1 to 4) with a series of constructed wetlands along western and eastern side of willow plantation (Drawing IBR1015/106). This whole area is contained within a bund and all storm water arising from this area is treated in the willow/ constructed wetland before it is discharged.

All rainfall that fall on the slopes of the landfill is collected in the existing drains which run along the eastern and western boundaries of the site prior to discharge to the River Finn as shown on Drawing IBR1015/106.

1.5 Point 5

Submit the hydrological risk assessment referred to in Attachment E.4 of the application.

The Hydrogeological Risk Assessment is included in Appendix B. \

1.6 Point 6

Provide a drawing that clearly shows the flow of the pumped landfill leachate through the willow plantation and the ponds. Include the locations where the treated landfill leachate discharges to the surface water channels and locations where the treated effluent discharges to the River Finn. Include symbols and grid coordinates (6E,6N) for each discharge location.

Drawing IBR1015/104A and IBR1015/106 are provided in Appendix A. Grid coordinates (6E, 6N) for each discharge location where treated landfill leachate discharges to the surface water channels is giving in the Table 1.1 below.

Table 1.1: Grid Co-ordinates for discharge locations

Table style 1 heading	Grid Co Ordinates	
Discharge Location	**Easting**	**Northing**
Discharge from Willow		
D1	230908.077	395942.728
D3	231069.698	395759.633
Discharge from Pond (ICW)		
D2	231076.621	395754.966
D4	231172.307	395897.031

Please refer to Drawing IBR1015/104A Churchtown Landfill Site Monitoring Locations for updated monitoring location. Treated effluent discharges to surface water channels and subsequently discharge to the River Finn at SW2 and SW5.

Table 1.2: Grid Co-ordinates for surface water locations

Station Purpose	Station Name	Description	Northing	Easting
		Existing		
Surface Water	SW1	Upstream of the waste body in a field drain that subsequently runs adjacent to the landfill along its north eastern boundary.	230934.07	396164.09
Surface Water	SW2	SW2 (stream) is located at the River Finn end of surface water stream that run along the eastern boundary of the site.	231177.01	395895.00
Surface Water	SW3	SW3 is midstream of the facility within the River Finn	231180.26	395840.10
Surface Water	SW4	SW4 (field drain) is located at the River Finn end drain that run along the western boundary of the site.	231026.01	395734.06
Surface Water	SW5	SW5 is also located at the end of field drain and therefore it is not representative of the river quality.	231038.03	395711.08
Surface Water	SW6	Upstream of the facility within the River Finn	230983.00	395705.11
Surface Water	SW7	Downstream of the facility within the River Finn	231248.04	395948.97

1.7 Point 7

Provide monitoring of water quality in the River Finn at locations upstream and downstream of the discharges from the facility. Include a 95% flow rate (m^3/s) in the receiving water.

Surface Water results for 2018 are provided in Appendix C. SW1 and SW2 were dry in September. SW4, SW5 and SW6 were not sampled in January, June and September as the sampling stations were destroyed during the flood in August 2017. Conditions did not allow safe plant access for reinstatement works until the bank was properly established. Annual monitoring at surface water monitoring points SW3 and SW7 was undertaken on 10th September 2018.

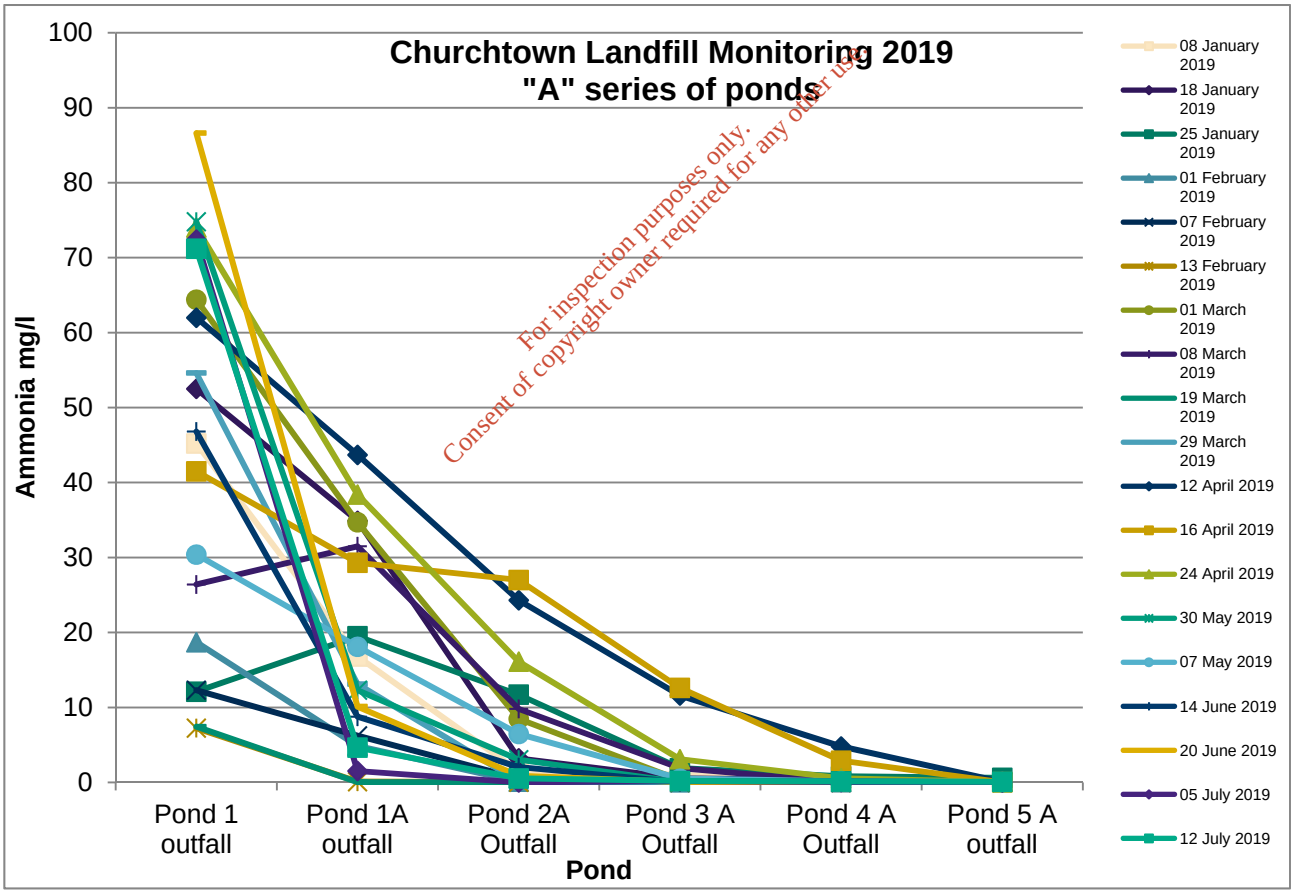
The 95% flow rate (m^3/s) in the receiving water (River Finn) is taken from gauging station at Dreenan Bridge. Please refer to Appropriate Assessment Section 5.4 for further details on 95% flow rate (m^3/s) in the receiving water.

1.8 Point 8

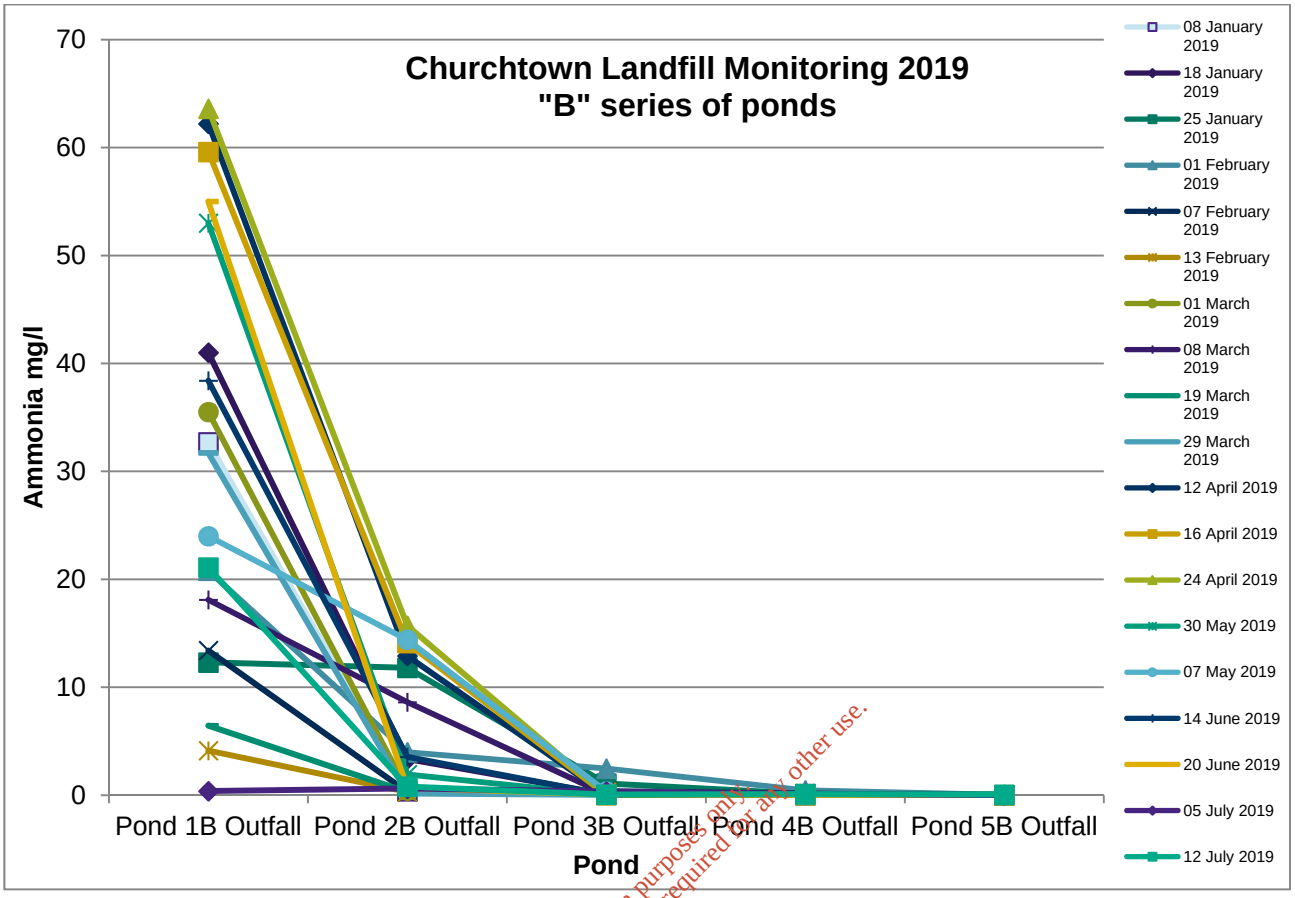
Submit monitoring results of the discharged effluent at all locations where the treated effluent leaves the facility. Include the maximum daily flow rate (m^3/day) for each discharge location.

Monitoring results of the discharged effluent for 2019 are provided in Appendix D. Please refer to Appropriate Assessment Section 3.4.4 for further details on flow rates.

Existing monitoring of D2 and D4 (the two discharge outlets from the ICW) for ammonia for 2019 are shown in Graphs 1 and 2 below. Ammonia concentrations are below the proposed ELV in Pond 5A and 5B.



Graph 1.1 A series ponds



Graph 1.2 B series ponds

Existing monitoring of D1 and D3 (the two discharge outlets from the willow) for ammonia for 2019 is shown in Table 1.3 below. Ammonia concentrations are below the proposed ELV.

Table 1.3: Willow Discharge[1]

Willow Discharge			
Date	**Northern Willow (D1)**	**Southern Willow(D3)**	**Limit**
		Ammonia mg/l	
08/01/2019	0.013	0.358	3
18/01/2019	0.04	0.46	3
25/01/2019	0.06	0.45	3
01/02/2019	0.07	0.65	3
07/02/2019	0.06	0.82	3
13/02/2019	0.07	0.62	3

[1] Irrigation of the northern willow with leachate started in March/April. Maintenance works were undertaken as required. The Southern willow has not been irrigated with leachate this year due to a settlement problem.

Willow Discharge			
01/03/2019	0.011	0.015	3
08/03/2019	0.011	0.126	3
19/03/2019	0.26	0.18	3
29/03/2019	0.852	0.011	3
12/04/2019	0.008	0.006	3
16/04/2019	0.015	0.015	3
24/04/2019	2.48	0.015	3
24/05/2019	0.093	No sample	3
30/05/2019	0.051	0.019	3
07/06/2019	0.016	0.026	3
14/06/2019	0.1	0.015	3
20/06/2019	0.674	0.021	3
26/06/2019	<0.015	No discharge	3
05/07/2019	No discharge	No discharge	3
12/07/2019	<0.015	0.084	3

1.9 Point 9

Submit results of groundwater monitoring referred to in Attachment F.5 of the application.

Groundwater results for 2018 are provided in Appendix E.

1.10 Point 10

Provide details on proposed methods and frequency for removal of heavy metals contained in the detritus and necromass of the wetland system.

Desludging is dependent on the cell number, cell area, and influent loading. The initial wet-land cell will require cleaning out first, however this is not expected for at least 10 years.

Sediment should be removed from the ponds as required when the pool volume has become reduced significantly or the ponds have become eutrophic.

Sediment build up in the wetland will include metals accumulated. The management of sediment will depend on the contamination concentrations and the proposed reuse or disposal. Samples will be taken from the cells for total metal concentration analyses (mg/kg).

Table 1.4: Metals to be analysed (mg/kg)

Metalsr
Boron
Cadmium
Chromium
Copper
Cyanide

Metalsr
Iron
Lead
Magnesium
Manganese
Mercury
Potassium
Sodium
Zinc

1.11 Point 11

The Non-Technical Summary states that Class D4 of the activity would include placement of sludge discards into pits, pond or lagoons. Clarify whether it is proposed to accept any sludge or any other waste from off-site sources.

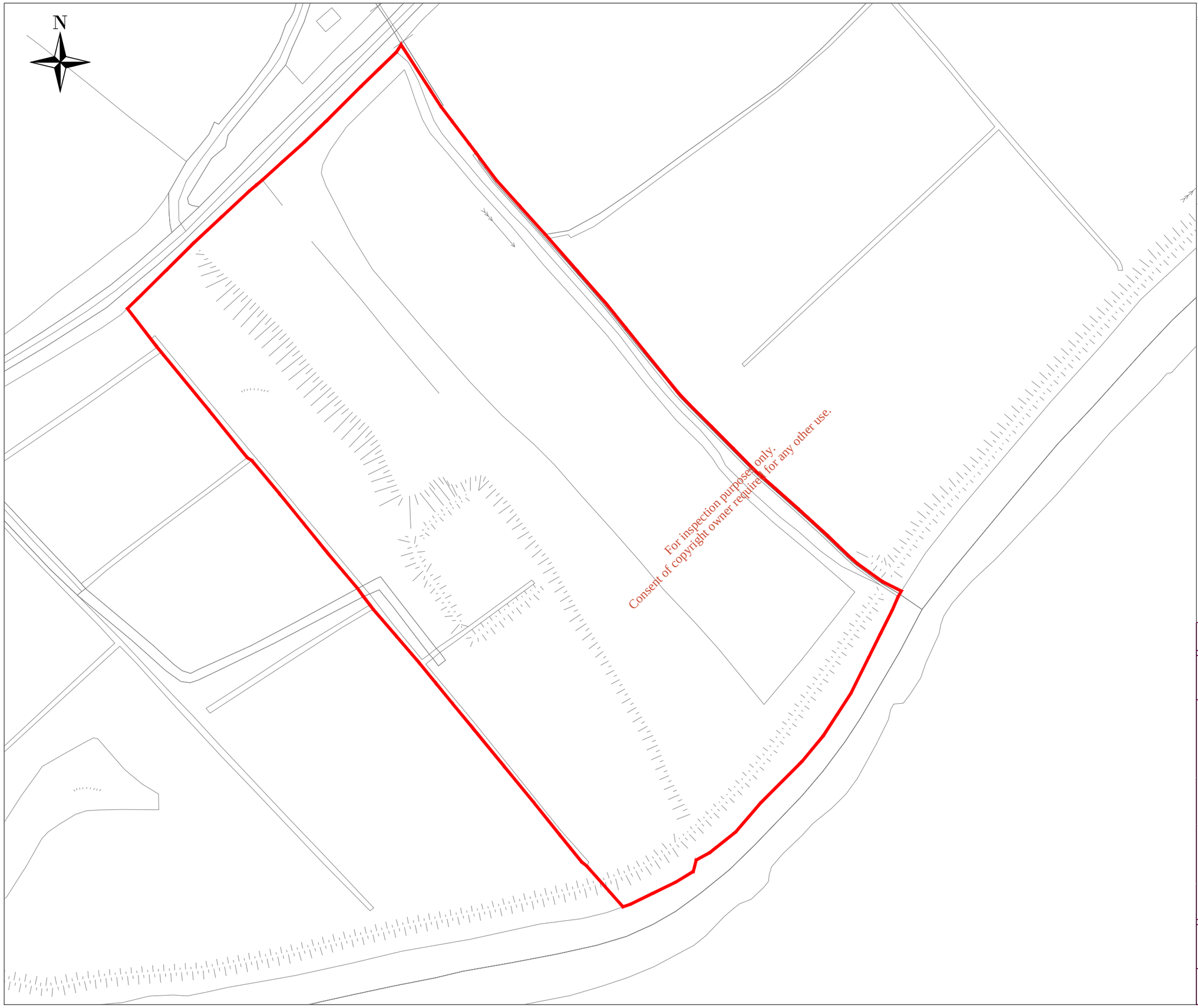
No sludge or any other waste from off-site sources will be accepted on site.

1.12 Natura Impact Statement

A Natura Impact Statement has been completed and is also included in this submission.

Appendix A

Drawing



NOTES

1. Verifying Dimensions.
   The contractor shall verify dimensions against such other drawings or site conditions as pertain to this part of the work.

2. Existing Services.
   Any information concerning the location of existing services indicated on this drawing is intended for general guidance only. It shall be the responsibility of the contractor to determine and verify the exact horizontal and vertical alignment of all cables, pipes, etc. (both underground and overhead) before work commences.

3. Issue of Drawings.
   Hard copies, dwf and pdf will form a controlled issue of the drawing. All other formats (dwg, dxf etc.) are deemed to be an uncontrolled issue and any work carried out based on these files is at the recipients own risk. RPS will not accept any responsibility for any errors arising from the use of these files, either by human error by the recipient, listing of un-dimensioned measurements, compatibility issues with the recipient's software, and any errors arising when these files are used to aid the recipients drawing production, or setting out on site.

4. Datum.

Site Boundary

rev	amendments	drawn	date
A	Topo survey info removed	AMB	May '19

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Client
Comhairle Contae Dhún na nGall
Donegal County Council

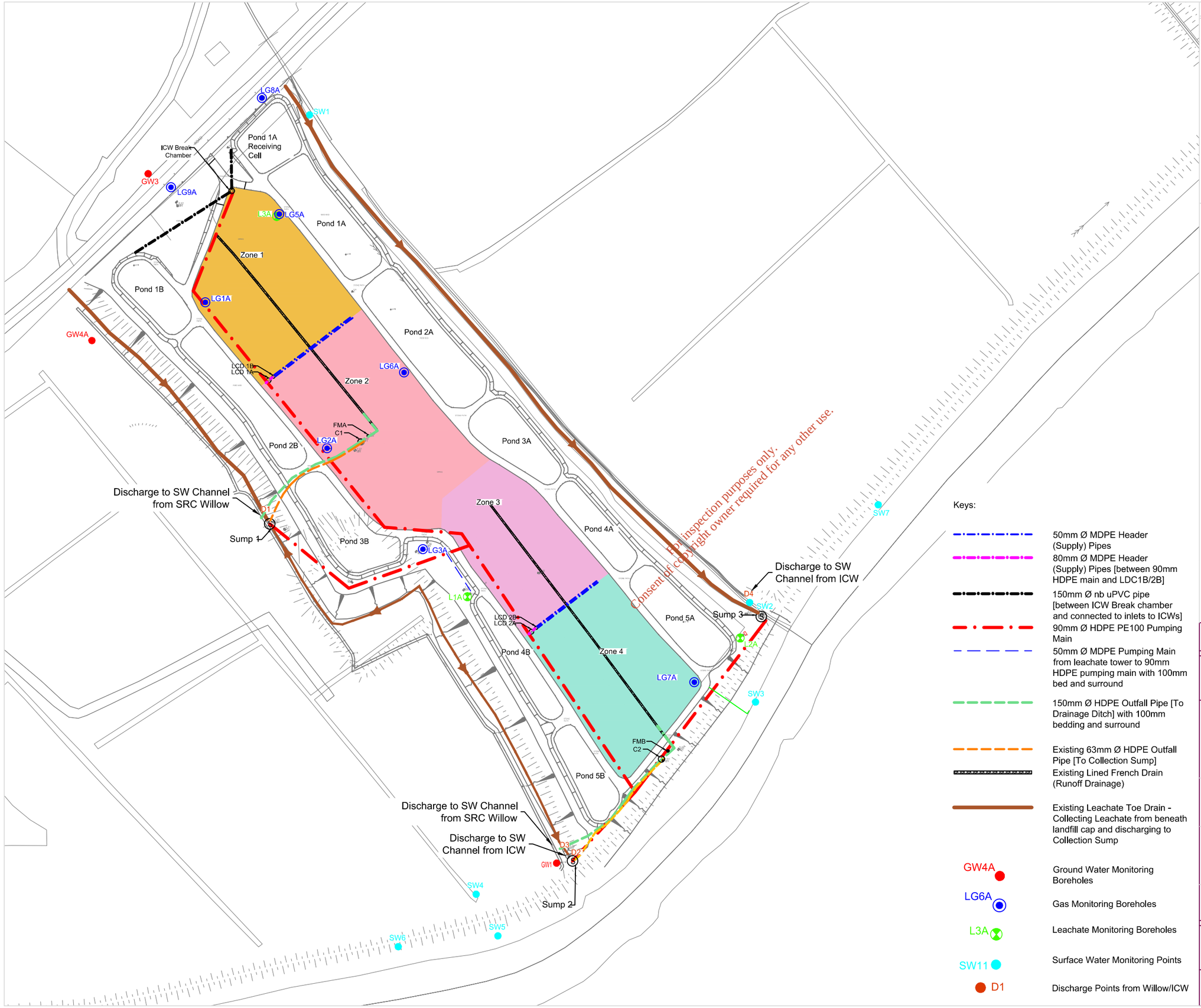
Project
CHURCHTOWN LICENSE REVIEW

Title
SITE BOUNDARY

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:2000

Drawing Number	Rev
IBR1015/101	A

Project Leader	Drawn By	Date	Initial Review
DD	AMB	MAY-2019	AMcG



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4. Datum.

Keys:

- 50mm Ø MDPE Header (Supply) Pipes
- 80mm Ø MDPE Header (Supply) Pipes [between 90mm HDPE main and LDC1B/2B]
- 150mm Ø nb uPVC pipe [between ICW Break chamber and connected to inlets to ICWs]
- 90mm Ø HDPE PE100 Pumping Main
- 50mm Ø MDPE Pumping Main from leachate tower to 90mm HDPE pumping main with 100mm bed and surround
- 150mm Ø HDPE Outfall Pipe [To Drainage Ditch] with 100mm bedding and surround
- Existing 63mm Ø HDPE Outfall Pipe [To Collection Sump]
- Existing Lined French Drain (Runoff Drainage)
- Existing Leachate Toe Drain - Collecting Leachate from beneath landfill cap and discharging to Collection Sump
- GW4A — Ground Water Monitoring Boreholes
- LG6A — Gas Monitoring Boreholes
- L3A — Leachate Monitoring Boreholes
- SW11 — Surface Water Monitoring Points
- D1 — Discharge Points from Willow/ICW

rev	amendments	drawn	date
A	Discharge Points Added	MC	July '19

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Client

Project
Churchtown License Review

Title
Monitoring Locations

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A3	1:2000

Drawing Number	Rev
IBR1015/104	A

Project Leader	Drawn By	Date	Initial Review
DD	AMB	May -2017	AMcG

Precipitation Discharge Routes

- Precipitation Incident to Zones 1 and 2 flows overland to central Collection drain. Water Quality tested at FMA/C1 and discharged to D1 if quality parameters met. otherwise flow diverted to Sump 1 for re-circulation and re-treatment
- Precipitation Incident to Zones 3 and 4 flows overland to central Collection drain. Water Quality tested at FMB/C2 and discharged to D3 if quality parameters met. otherwise flow diverted to Sump 2 for re-circulation and re-treatment
- Precipitation incident to Ponds 1A-5A flows through ponds to discharge at D4
- Precipitation incident to ponds 1B-5B flows through ponds to discharge at D2

SW1
Pond 1A Receiving Cell
GW3
ICW Break Chamber
L3A
Pond 1A
Pond 1B
Zone 1
Precipitation on side slopes run over ground to perimeter SW drainage channel
Pond 2A
GW4A
Precipitation on side slopes run over ground to perimeter SW drainage channel
LCD 1B
LCD 1A
FMA
Pond 2B
C1
Zone 2
Pond 3A
Discharge to SW Channel from SRC Willow
D1
Sump 1
Pond 3B
Zone 3
Pond 4A
SW7
Discharge to SW Channel from ICW
D4
SW2
Sump 3
L1A
LCD 2A
LCD 2B
Pond 4B
Pond 5A
L2A
Zone 4
SW3
FMB
C2
Pond 5B
Discharge to SW Channel from SRC Willow
D3
D2
GW1
Sump 2
Discharge to SW Channel from ICW
SW4
SW5
SW6

DISCHARGE POINTS			
POINT NUMBER	EASTING	NORTHING	DESCRIPTION
1	230908.077	395942.728	D1
2	231076.621	395754.966	D2
3	231069.698	395759.633	D3
4	231172.265	395896.980	D4

NOTES

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4. Datum: Malin Head Ordnance Datum

- 50mm Ø MDPE Header (Supply) Pipes
- 150mm Ø nb uPVC pipe [between ICW Break chamber and connected to inlets to ICWs]
- 80mm Ø MDPE Header (Supply) Pipes [between 90mm HDPE main and LDC1B/2B]
- 90mm Ø HDPE PE100 Pumping Main
- 50mm Ø MDPE Pumping Main from leachate tower to 90mm HDPE pumping main with 100mm bed and surround
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- Existing Lined French Drain (Runoff Drainage)
- Existing Leachate Toe Drain - Collecting Leachate from beneath landfill cap and discharging to Collection Sump
- Pond Flows
- GW4A — Ground Water Monitoring Boreholes
- Leachate Monitoring Boreholes
- SW2 — Surface Water Monitoring Points
- Sump
- D2 — Discharge Points

rev	amendments	drawn	date

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Project
CHURCHTOWN LICENCE REVIEW
-

Title
LEACHATE SYSTEM FLOW DIRECTION

Drawing Status	Sheet Size	Drawing Scale
PRELIMINARY	A1	1:1000

Drawing Number	Rev
IBR1015/106	-

Project Leader	Drawn By	Date	Initial Review
DD	AMB	Jul-2019	JD

Appendix B

Hydrogeological Risk Assessment

Churchtown Landfill

WL62-1

Hydrogeological Risk Assessment

Report for:
Donegal County Council

Date:
11/12/2015

Report No.:
BRE14008Rp001F01

BlueRock Environmental Limited

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Mary's Abbey,

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DOCUMENT INFORMATION

Project Title:	Churchtown Landfill Hydrogeological Risk Assessment
Licence No.: **Project No.:**	EPA Licence WL62-1 BREL Project No. BRE14008
Contract No.:	-
Report Ref.:	BRE14008Rp001
Status:	**Final01**
Client:	Donegal County Council
Client Details:	Ms Julie McMahon Executive Engineer Donegal County Council Laboratory Magherennan Letterkenny Co Donegal
Issued by:	Donegal County Council

Document Production / Approval Record

	Name	Signature	Date	Position	% Input
Prepared by (consultant /professional)	Niall Mitchell		11/12/2015	Hydrogeologist /Chartered Engineer	
Approved by (consultant /professional)	Niall Mitchell		11/12/2015	Hydrogeologist /Chartered Engineer	
Site Approval by					N/A

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The conclusions and recommendations contained in this report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by BREL has not been independently verified by BREL, unless otherwise stated in the report. Where assessments of works or costs identified in this report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

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Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this Report.

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1 EXECUTIVE SUMMARY

- A hydrogeological risk assessment of Churchtown Landfill Site was undertaken by BREL based on previous investigation reports and monitoring data between 2006 and 2015.

- **It is noted that Churchtown Landfill is currently in the process of a new pilot remediation solution involving constructed wetlands and willow plantations. This programme of works is expected to significantly improve the current contaminant conditions presence at the site. Therefore the assessment undertaken within this report is based on previous and recent contaminant conditions and a reassessment of site conditions will be required following a period of 12 months post-completion of the works.**

- Churchtown Landfill is a former solid waste facility where historically waste was landfilled into bunded cells which were excavated from the in-situ cohesive alluvial subsoils. The excavated soils were then used in bund construction. When landfilling ceased at Churchtown the final area of the waste body was approximately 5 hectares and waste body forms a plateau shape compared to the adjacent lands.

- The site is an unlined site historically operated on a dilute and disperses principal, whereby solid waste was tipped directly onto the underlying excavated surface with leachate allowed to percolate directly through the soils with no engineered liner installed. Landfilling began in 1987 and the site ceased operations on the 31st August 2000

- On the 19th May 2000 the Environmental Protection Agency granted the Council a Waste Licence (registration number WL62-1) for the orderly closure, capping and restoration of the landfill facility, in accordance with the Third Schedule of the Waste Management Act, 1996.

- The hydrogeological regime across the landfill comprises two groundwater bodies (*i.e.* one within the waste body and a separate groundwater body within the overburden/shallow bedrock) that are likely to be hydraulically connected. A third groundwater body within the bedrock and flowing under pressurised artesian conditions may also be present based on the conditions encountered within monitoring well BH4. Shallow groundwater interacts with the waste mass and facilitates the generation of leachate.

- Groundwater level variability in the area significantly impacts on leachate levels within the waste body. The correlating increases and reductions in groundwater and leachate levels confirm this scenario with groundwater appearing to intersect the waste body. Groundwater level variations and levels upgradient of the site have a differing signature to groundwater levels closer to the River Finn. This suggests that the river is partially impacting on groundwater downgradient of the landfill.

- Following a review of the preliminary Conceptual Site Model for the site and all available water monitoring data, a revised Conceptual Site Model (CSM) was developed based on available information and monitoring data and identified a number of SPR linkages ranging from Low to Moderate risk to identified sensitive receptors *i.e.* the River Finn and the Raphoe GWB.

- The SPR linkage of concern relates to:
  - ✓ The vertical migration of leachate from the unlined waste cells to the underlying shallow groundwater aquifer which subsequently flows to the River Finn.

- The raw leachate results from the landfill are considered to represent a landfill in the methanogenic stage of decomposition of organic compounds. The leachate is considered to be relatively low strength and the levels, which are reducing over time, are expected to reduce further.

- Groundwater quality data does not indicate any upwards trends over time. This is expected to continue following completion of the current remedial measures. On-going monitoring at BH1

in conjunction with a trend analysis on receipt of sufficient monitoring data over time is recommended.

- Both groundwater and surface water contaminant fluxes from the landfill have the potential to impact on the quality of the River Finn. However, available data suggests that groundwater contaminant fluxes to the river are having a negligible effect on the river downstream of the landfill. It is noted that a more representative downgradient monitoring well is required between the landfill and the river to provide a more accurate determination of this flux. However, it also noted that site access to a suitably located downgradient monitoring may be restricted due to the proximity to the river and soft ground conditions. In relation to surface water discharges, available data suggests that surface water discharges to the river representative the predominant contaminant load to the river. The effects of this loading on the river are considered to be low with significant dilution capacity available within the river itself.

- Based on the water quality data, the landfill does not affect the current status of the River Finn and is in accordance with the WFD objectives.

- The rule of thumb of 100xGTV has not been exceeded in any groundwater monitoring well at the site. The highest Ammoniacal Nitrogen level recorded was 2.63 mg/l in BH1 (February 2009) which is approximately 15 times the GTV. In accordance with the Water Framework Directive (WFD), these levels are not likely to affect the status of the Raphoe GWB nor potentially pose a risk to the objectives of the Water Framework Directive. No groundwater contaminant plume has been identified to-date from the existing groundwater monitoring network.

  The following points are noted:

  - ✓ No groundwater users are located downgradient of the landfill site.
  - ✓ The area of impact from the landfill leachate is considered to be minor relative to the groundwater body catchment area of the Raphoe GWB *i.e.* < 0.01%;
  - ✓ Given the proximity to the landfill to the river, no significant plume, if any, is envisaged.
  - ✓ The strength of the leachate is considered to be relatively low. Clear evidence exists that demonstrates the strength of leachate within the waste body is reducing over time.
  - ✓ No groundwater monitoring well between the waste body and the River Finn exists and therefore the true contaminant groundwater flux to the river is unclear.
  - ✓ The site in its present condition appears to be having a low impact on the quality of the River Finn with surface water discharges from the landfill site drains the dominant pathways for contaminant flux. No impact to the current WFD status of the river is anticipated. Additional monitoring is recommended to ascertain the impact occurring – in particular on completion of the current site restoration/remediation works.

- The site is compliant with the “prevent” or “limit” objective of the WFD and GWD. The prevention of hazardous of substances entering the groundwater system is being met based on available chemical analysis. Limiting the ingress of non-hazardous substances is also being met by the mitigation measures that have been installed to date at the site *i.e.* landfill capping and lining of surface water drains and mitigations currently being installed *i.e.* active leachate treatment by willow plantations and constructed wetlands.

- Corrective actions undertaken to-date at the site includes:

  - ✓ A permanent landfill capping across the entire waste body;
  - ✓ The development of a willow bed plantation and constructed wetlands over the waste body to treat all leachate generated on site and disposal to the River Finn. This system is currently being developed at the site, and,
  - ✓ On-going groundwater and surface water monitoring as per the licence requirements.

  On-going remediation works is still in progress at the site.

- A series of additional recommendations to provide a more representative understanding of the contaminant fluxes to the River Finn have been provided in Section 10.0. It is noted that as the site is actively undergoing remediation works, it is proposed that these recommendations are considered at least 12 months post full completion of the works. A revised CSM will be undertaken at this stage and the proposed recommendations reassessed. In the meantime, the current monitoring programme is considered sufficient as an interim measure until completion of the remediation works.

2 INTRODUCTION

2.1 Introduction

The following hydrogeological risk assessment is intended to satisfy the requirements of Environmental Protection Agency (EPA), relating to a waste management facility at Churchtown, Co Donegal. EPA waste license reference no. WL62-1. A site walkover was undertaken by Niall Mitchell (Hydrogeologist) and Sean Heffernan of BlueRock Environmental Ltd (BREL) on the 10th February 2015.

2.2 Objectives

The objectives of this assessment report include the following:

- To consolidate all available historical reports and geological, hydrogeological and hydrological data relating to the site and its immediate environs;
- To assess and interpret all available water quality data recorded to-date;
- To develop an appropriate Conceptual Site Model (CSM) for the site;
- To assess the site's compliance with the Groundwater Regulations (S.I. No. 9 of 2010);
- To assess the level of risk posed to sensitive receptors;
- To develop an appropriate compliance monitoring programme for the site; and,
- Recommend suitable mitigation measures, if deemed necessary.

2.3 Methodology

This report was prepared in accordance with the following documentation:

- Guidance on the Authorisation of Discharges to Groundwater, EPA, 2011;
- Guidance on the Management of Contaminated Land and Groundwater at EPA Licensed Sites (2013),
- Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites, EPA, 2007; and
- Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels, Environment Agency, 2003.

2.4 Sources of Information

The following sources of information were reviewed as part of this assessment:

- Donegal County Council Annual Environmental Reports (AERs), 2004 to 2013;
- Replacement Wells, Drumaboden and Churchtown Landfill Sites, RPS, May 2005;
- EPA Waste Disposal License Application, Attachment C6 Hydrogeology, Donegal County Council,1999;
- Churchtown Landfill Site Lifford Ground Investigation - 898/2293, Stratex Ltd, 23rd September 1998;
- Geological Survey of Ireland (GSI) online databases and mapping;
- Geology of South Donegal (3) 1:100,000 Scale Bedrock Map Series, Geological Survey of Ireland;
- EPA Inspectors Report, Waste License Register Number 62-1, EPA, 30th September 1998;
- EPA online databases and mapping;
- Irish Soil Information System Online, Teagasc;
- Ordnance Survey of Ireland (OSI) historical mapping;
- GSI, Groundwater Protection Schemes, 1999;
- Donegal Groundwater Protection Scheme, and,

- Fitzsimons, V., Daly, D. and Deakin, J., 2003. GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination. Draft Report, Geological Survey of Ireland.
- Landfill Operational Practice's, EPA, 1997.

2.5 Report Format

This report comprises of an executive summary for chapter 1 and an introductory chapter 2 which discusses sources of information, general objectives of this hydrogeological assessment and a brief overview of historical investigative reports associated with the site.

Chapter 3 discusses the site location, layout and setting.

Chapter 4 includes detailed information on the underlying soils and bedrock.

Chapter 5 is a brief description of the local hydrology, including details of any site specific surface water bodies.

Chapter 6 discusses the hydrogeology of the site and general region, including any boreholes that have been drilled and monitoring wells in place. It discusses historic groundwater levels and flow direction.

Chapter 7 describes briefly the preliminary Source-Path-Receptor model (SPR) for the landfill.

Chapter 8 is comprehensive review of the hydrochemistry monitoring of the site in terms of groundwater, surface water and leachate quality.

Chapters 9 & 10 defines an updated conceptual site model for the landfill using site specific data coupled with the initial SPR model and provides compliance monitoring recommendations.

Chapter 11 provides recommendations for future monitoring, investigation and/or remediation and report conclusions.

2.6 Review of Previous Reports

Report Title 1: Ground Investigation, Churchtown Landfill Site, Stratex Ltd, September 1998

This investigation comprised the drilling of 3 no. boreholes (*i.e.* BH1, BH3 and BH4) using Shell & Auger techniques. The site location for these wells is included in **Appendix B**. Insitu permeability testing was undertaken within each borehole.

Report Title 2: Application for Waste Disposal License (Attachment C6 - Hydrogeology), prepared by Donegal County Council, 1999.

This report provides a general overview of site conditions and background information which is incorporated into this 2015 report in the following sections.

The application identified the main risks posed by the landfill entailed the migration of leachate to both groundwater and surface waters in the vicinity of the landfill. The report confirmed that although the discharge of leachate to groundwater, which provides baseflow to the River Finn, was occurring, the discharge was not impacting on the groundwater resource or on the quality of the river itself.

Proposed mitigation measures for the landfill included:

- Enclosure of the landfill in low permeability graded clay banks constructed around the waste body;
- Increasing the compaction of the waste to reduce the volume of waste and the overall quantity of rainfall infiltrating the site; and,
- Intermediate and temporary capping of inactive waste areas and the phased development and restoration of the site.

Report Title 3: **Replacement Wells Drumaboden & Churchtown Landfill Sites (Report No: 05-135), Glover Site Investigations & RPS, May 2005.**

This report describes a site investigation detailing 2 no. additional boreholes that were drilled at Churchtown Landfill. These new boreholes were installed as replacement gas wells and labelled LG8 and LG9.

Report Title 4**: Site Restoration Contract (Ground Investigation Report) Churchtown Landfill (Job Ref: 14-1170), Ground Check Ltd, February 2015.**

This report describes a ground investigation for a site restoration contract at Churchtown Landfill, Lifford, County Donegal. The report details the following; investigation works undertaken

- 11 no. Shell and Auger boreholes drilled by Dando 200 drilling rig (referenced L1A, LG1A, L2, LG2A, LG2AR, LG3A, LG5A, LG6A, LG7A, LG8 and LG9);
- 1 no. Borehole (BH4) drilled using rotary drilling; and,
- Disturbed samples and water samples were taken from all investigation locations, where possible, and sent for lab analysis.

Report Title 5: Annual Environmental Reports, Churchtown Landfill, Donegal County Council, 2004 - 2015

These reports comprise the Annual Environmental Reports (AERs) prepared by Donegal County Council for the Environmental Protection Agency (EPA). These reports describe the following;

- The waste activities that have taken place on the site during the reporting period, including volumes of waste accepted and their type;
- A summary report on emissions, including details of landfill gas levels, groundwater levels and leachate levels;
- Environmental quality monitoring is also undertaken during the reporting period relative to surface waters, leachate and groundwater;
- The volume of leachate transported/discharged off site in addition to a water balance calculation for the site; and,
- Any significant site works than have taken place on the landfill site during the reporting period are also described.

3 SITE DESCRIPTION

3.1 Site Location

The site is located in County Donegal approximately 3km south west of Lifford and bordered to the northwest by the N15, which is the main Lifford to Ballybofey Road (see **Figure 1**). The landfill facility occupies an area footprint of approximately 9.7 hectares and it is located within the townland of Churchtown, near Lifford, Co. Donegal. The ground to the northeast and southwest of the site is the low lying and gently undulating flood plain of the River Finn, with both areas being used for grazing. The southeastern boundary is bordered by the River Finn. The River Finn delineates the boundary between the North of Ireland and the Republic of Ireland. The main access to the site is from the N15 on the northwestern site boundary. There are fourteen private residences within 500m of the landfill facility, four of which are located across the River Finn in Northern Ireland.

3.2 Topography

The landfill facility is located on the broad alluvial flood plain of the River Finn, approximately 3.18 km upstream of its confluence with the River Mourne (**see Figure 1**). Landfilling activities have raised the elevation of the site by approximately 5 metres above the existing low lying terrain. The landfill currently forms a raised plateau that is bounded by steep clay bunds along the southwest and northwest margins. The surrounding land appears to fall at a gentle gradient from the N15 Lifford Rd towards the River Finn. A clay dyke has been constructed along the bank of the river in order to mitigate seasonal inundation of the surrounding low lying fields. Above the road the topography rises steeply to the top of Croaghan hill at approximately 217mOD.

3.3 Site Layout

Historically waste was landfilled into bunded cells which were excavated from the in-situ cohesive alluvial subsoils. The excavated soils were then used in bund construction. When landfilling ceased at Churchtown the final area of the waste body was approximately 5 hectares and waste body forms a plateau shape compared to the adjacent lands.

A number of remediation works recently commenced on the capped waste at Churchtown as detailed below:

- The existing landfill was capped with a permanent low permeability clay liner in conjunction with a willow and reed plantation and constructed wetland;
- The willow plantation in situated in the centre and above the capped waste (Zones 1 to 4) with a series of constructed wetlands along western and eastern side of willow plantation (see **Figure 2**);
- As of the 9th February 2015 site walk-over undertaken by BREL the willows and reeds were planted but not yet fully grown. Pumping and treatment of leachate was expected to commence in 2015 following completion of the tender for M&E works;
- When the willow plantation is fully grown and working at capacity leachate will be pumped to the plantation before discharged to surface water. If treated leachate levels are unacceptably elevated, the leachate is treated further by circulating via the constructed wetlands before discharging to surface water.

3.4 Site History

Churchtown Landfill is an unlined site, historically operated on a dilute and disperse principal, whereby solid waste is tipped directly onto the underlying excavated surface with leachate allowed to percolate directly through the soils with no engineered liner installed.

Landfilling began in 1987 and the site ceased operations on the 31st August 2000.

Groundwater quality monitoring was originally undertaken at four locations *i.e.* BH1, BH2, BH3 and BH4 as listed in Table F.4.2 in the waste licence which were drilling in August 1998. However, wells

BH1 to BH3 ceased to be utilised for groundwater monitoring, as they are now located within waste. They currently serve as leachate wells (*i.e.* L1, L2 & L3).

Two additional boreholes were drilled in July 2001 *i.e.* Borehole BH1 (downstream) and BH3 (upstream). However, difficulty was encountered during the installation of a second down gradient borehole due to the proximity of the waste body to the river. No borehole logs are available at the time of compiling this report.

Groundwater monitoring is currently undertaken within BH1 and BH3 and BH4. BH3 and BH4 are representative of up gradient water quality and borehole BH1 is representative of down gradient water quality. BH4 was subsequently damaged and was replaced in 2014.

3.5 Leachate Management

The Landfill at Churchtown was originally installed on a dilute and disperse principal, whereby solid waste was deposited directly onto the exposed overburden. This originally allowed untreated leachate to migrate laterally towards the River Finn and vertically into the bedrock aquifer. Vertical migration is considered to be unlikely due to the peat overburden acting as an aquitard.

The landfill was recently capped to prevent further influx of surface water and rainwater into the waste body thereby reducing leachate generation. A permanent low permeability clay liner was installed following closure of the site. As part of the 2014-2015 willow and reed bed construction, a 0.15 to 0.45 metre thick topsoil and 0.5 m clay cap was installed at the facility. In addition, a leachate treatment system was developed and is currently being implemented at the site. A brief description of the system is outlined below and a layout of the system is provided in **Appendix A**.

- Leachate shall be extracted from three pumping stations and distributed around the site via a common 90mm HDPE leachate pumping main located adjacent to an existing site access road as shown on Drawing IBR0514 /PI102. This pumping main will primarily direct leachate to the willow plantation for treatment.
- The Willow Plantation is divided into four zones, with two main irrigation feed points each located centrally between Zone 1 and 2 and Zone 3 and 4 as outlined in the drawings. The connection to willow plantations shall be via 50mm leachate pumping main via an isolating valve, a strainer and a flowmeter as shown on the drawings.
- Treated effluent discharging from Zones 1/2 and Zones 3/4 will be monitored with Ammonia Analysers. Discharge not meeting consent parameters shall activate a motorised valve which in turn shall divert flow back to either Pumping Station 1 or 2 under existing gravity pipework for re-distribution in the willow plantation until the treated effluent reaches acceptable limits. Collected runoff effluent meeting the required parameters is discharged to adjacent surface water drains as shown on the drawings.
- Discharge flow from each monitoring chamber will be recorded and monitored on the SCADA system including leachate applied to the treatment zones, treated flows to surface water drains and flows redirected back to the system for re-distribution and additional treatment.
- The primary treatment method is anticipated to be through application to the willow plantation. Where leachate is available over and above the treatment capacity of the willow plantation (either through seasonal increases in leachate generation, wet/frosty weather conditions or manual operator intervention) leachate will be diverted to the onsite Integrated Constructed Wetlands (ICWs) as a secondary alternative. The system shall also allow the site operator to intervene and permit periodic irrigation of the ICWs when sufficient leachate is available during dry weather which would ordinarily be applied to the willow plantation in order to maintain the ICWs.
- Flow of leachate to ICW's will be controlled on the pumping main with an actuated valve within a precast concrete chamber along with flow measurements via flow meter. Flow of leachate shall be recorded on the PLC /HMI within the primary control panel. Flow of leachate to ICW's shall be via weir chamber and flow split on a 60 / 40 percentage basis, with a nominal maximum limit of 20m^3/day treatment capacity in the ICWs.

- Should the treatment capacity of both the willow plantation and ICWs be reached in any given 24 hour period leachate abstraction and circulation within the site will be stopped until conditions allow treatments to recommence.
- Leachate is monitored at three monitoring wells located within the waste body, designated as L1, L2 and L3. Both leachate levels and leachate quality are monitored in these wells on a regular basis and are discussed in the following sections.

4 GEOLOGY

4.1 Regional & Site Overburden

The regional overburden in the vicinity of the site is described using the Teagasc soil associations for the greater Donegal region. It is a part of the River Alluvium association (Code 05 RIV), which consists of a further 12 sub soil series. The River Alluvium association covers an area of approximately 22.54km^2. The Kilgory series (0500KG) is described as a sandy river alluvium for the region. EPA soil mapping describes the overburden as river alluvium (AlluvMin) underlain by undifferentiated gravelly alluvium subsoils. The regional teagasc soils map is presented in **Figure A, Appendix B.**

A summary of the historical site investigations at the site is provided in **Table 4.1**. Site Investigations undertaken in 1998 by Stratex Ltd recorded shallow river alluvium soils consisting of a soft brownish grey, sandy, clayey, organic Silt directly overlying soft, dark brown, silty Peat.

Underlying the alluvium soils comprises fluvio-glacial layers of slightly gravelly sands with interspersed gravel horizons with occasional thin bands of greenish grey sandy silts. A summary of the borehole logs is provided in **Table 4.2** and borehole logs provided in **Appendix C**. Boreholes BH1, BH2 and BH3 are located within the waste and describe the thickness of the waste body as ranging between 4.8m and 6.8m thick. On the basis of the ground investigation records, the general stratigraphy of the site is summarised sequentially below:

- Silty Alluvium
- Peat
- Sands with gravel horizons and silt bands
- Gravels / Boulders
- Bedrock (PSSAMITE)

Company	Date	Boreholes Drilled
Stratex Ltd	23rd Sept 1998	3 overburden wells (BH1, BH2 & BH3) and 1 bedrock well (BH4)
RPS	May 2005	Gas monitoring wells LG8 & LG9
Ground Check Ltd	December 2014	1 Bedrock monitoring well (BH4 replacement), two leachate points (L1A & L2) and 9 landfill gas wells.

Table 4.1 Summary of Site Investigation Activities

4.2 Regional Bedrock Geology

Churchtown landfill is mapped as being underlain by three bedrock formations. (see **Figure B, Appendix B**).

- The Claudy Formation which consists of psammitic schists with intercalated coarse psammite and pebbly grit units, thin marble lenses and quartzite is mapped in the southwestern quadrant of the site;
- A Marble Unit; and,
- The Aghyaran & Killygordon Limestone Formation which comprises Figureitic marble. Quartzite and psammite.

The formation is bounded to the northwest by the Pettigoe-Lough Foyle fault which trends in a northeast – southwest direction. The strata are internally complex and folded along a general southwest to northeast trend compression axis coincident with the strike of the regional (Pettigoe-Lough Foyle) fault plane.

The complex structure of the rocks and the development of an interior schistosity results from several phases of folding and refolding is associated with a number of orogenic events, the last of which took place during the Variscan Orogeny. Site investigation boreholes at the site recorded bedrock in the initial BH4 borehole was described as a psammite with Schist recorded in the replacement BH4 in 2015.

5 HYDROLOGY

5.1 Site Hydrology

The major surface water feature at Churchtown landfill is the River Finn which borders the south-eastern boundary of the site. It rises in Lough Finn and flows east through a deep mountain valley to Ballybofey and Stranorlar (on opposite sides of the river) and on to the confluence with the River Mourne at Lifford, 3.18 km to the northeast of the site. All surface water flow in the area is towards the River Finn. There are a number of natural drainage features which drain surface water from the surrounding fields into this river. No formal drainage system is provided on the site however the two land drains that run the length of the northeastern and southwestern sides of the landfill direct surface water, and any leachate emitting from the waste body, into the River Finn.

The River Finn is prone to seasonal flooding, and because of this, a clay levee has been constructed on the southeastern border of the waste body to prevent inundation during periods of high water levels.

Leachate from the landfill drains through a number of collection toe drains and into a collection chamber on the southeast corner of the waste. Leachate is currently allowed to disperse to ground until completed of the Mechanical & Electrical (M&E) works for the new treatment facility at the site. The plan is for future leachate to be treated on site and discharged directly into the River Finn via the drain at SW3. There are a total of 6 surface water sampling locations at Churchtown landfill (see **Figure 3**). SW1 and SW2 are located within the drain on the northeastern site boundary and SW4 and SW5 within a drain along the southwestern site boundary. Surface water runoff discharges from the site between SW4 and SW5 before discharging into the River Finn. SW6 is an upstream monitoring point within the River Finn. SW3 is located halfway along the landfill boundary within the river and SW7 is a downstream compliance point within the river.

Visual evidence of potential leachate impact on the surface waters in the vicinity of the landfill was observed during the site walkover as is evident in **Photo 5.1.** However, this impact is likely to have been caused prior to current works being undertaken at the site with no observed leachate breakout from the site noted post completed capping works. As mentioned above, leachate will not be contained at the site until completion of the M&E works.

Photo 5.1 Surface water Drain to southwest of waste body

Flows within the River Finn, in proximity to Churchtown landfill, were not available at this time of this report. However, EPA flow readings both upstream and downstream of the site are summarised below:

Station Number	Station Name	Easting	Northing	Distance to Site (km)	Catchment Area (m^2)	DWF (m^3/sec)	95th % flow (m^3/sec)
1042	DREENAN	215257	394583	15.4	353	0.33	0.42
1043	BALLYBOFEY	213511	394674	17	319	0.3	0.4

Table 5.1 River Finn Flows

5.2 Surface Water WFD Status

Work completed for the Water Framework Directive has assigned 'Status' to surface waters and groundwater (www.wfdireland.ie - watermaps). Churchtown landfill is located within the River Finn Surface Water Body (IE_XB_01_1_3) and has been assigned an overall status of 'Poor', specifically with an overall ecological and macroinvertebrate status of 'Poor'. It has been designated an overall physic-chemical status of 'High'. The overall objective status for the River Finn Waterbody is 'Restore_2021', *i.e.* restore the river body to pre-pollution status. The Q-rating of the river is currently rates as Q3 *i.e.* poor quality.

5.3 Designated Protected Areas

The River Finn is a designated Special Area of Conservation (SAC), selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [3110] Oligotrophic Waters containing very few minerals;
- [4010] Wet Heath;
- [7130] Blanket Bogs (Active)*
- [7140] Transition Mires
- [1106] Atlantic Salmon (Salmo salar)
- [1355] Otter (Lutra lutra)

The Finn system is one of Ireland's premier salmon waters. This SAC comprises almost the entire freshwater element of the River Finn and its tributaries the Corlacky, the Reelan sub-catchment, the Sruhamboy, Elatagh, Cummirk and Glashagh, and also includes Lough Finn, where the river rises.

6 HYDROGEOLOGY

6.1 Aquifer Classification

The site is underlain by Churchtown Groundwater Body (GWB) which is within the larger Raphoe GWB. It is likely the Churchtown GWB was delineated based on the presence of Churchtown landfill. No information is currently available on Churchtown GWB from the GSI; however it is likely to be similar to the Raphoe GWB. The vast majority (~85%) of the Raphoe GWB is underlain by a Locally Important (LI) aquifer which is moderately productive only in local zones. The remaining areas are underlain by a Poorly Productive (Pl) aquifer which is generally unproductive except for local zones. The majority of the site is underlain by a locally important aquifer with the southwestern quadrant mapped as Poorly Productive (See **Figure C, Appendix A**).

Groundwater yields in the Raphoe GWB range from 2–330 m^3/day (based on 6 wells within the GWB). Groundwater flux is expected to occur in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3m thick, a zone of interconnected fissuring around 10-15m thick, and a zone of isolated poorly connected fissuring typically less than 150m.

The underlying geology of the site, which is identified as relatively impermeable psammites and schists is expected to significantly reduce the downward movement of leachate from the landfill mass. It is therefore expected that leachate moving from the waste body is likely to migrate horizontally along the weathered boundary of the bedrock and in the direction of the nearest major water body, the River Finn.

6.2 Aquifer Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater. This means that vulnerability relates to the permeability and thickness of the subsoils, which will dictate the ability of surface waters percolating through to any underlying groundwater bodies. A detailed description of the groundwater vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons et al, 2003). A groundwater vulnerability map can be viewed online (http://www.gsi.ie/Mapping).

The majority of the Raphoe GWB is classified as Extreme vulnerability, due to the high percentage of thin subsoil and rock outcrops. Where subsoil is thicker, such as in the valleys, the vulnerability is mainly high, with occasional small areas of Moderate that are associated with areas of deeper deposits.

Churchtown landfill is predominantly mapped y the GSI as **High** vulnerability with **Extreme** vulnerability mapped in the western region of the site where bedrock was anticipated to be close to surface. However, it is noted that depth to bedrock within BH4 in the western region of the landfill recorded bedrock at a depth of approximately 8.0 metres which represents a **Moderate** vulnerability classification.

6.3 Groundwater WFD Status

Work completed for the Water Framework Directive has assigned 'Status' to surface waters and groundwater (www.wfdireland.ie - watermaps). The landfill is located within the Raphoe GWB (IE_NW_G_054) that has been assigned an overall 'Good Status' (www.wfdireland.ie). It been assigned an overall objective status of 'Protect'. Overall the GWB has been given a risk status of 2b, *i.e.* 'Not at Risk'.

6.4 Background Groundwater Quality

There is no background groundwater quality available for the Churchtown GWB, however limited hydrochemical information is available for the larger Raphoe GWB which has similar geology to Churchtown GWB. The hydrochemical signature is that of calcareous Precambrian Marbles. Generally a CaHCO3 signature. Alkalinity (mg/l as CaCO3): range of 112-428; mean of 274 (22 data points) Total Hardness (mg/l): range of 180-436; mean of 311 (22 data points) Conductivity (µS/cm): range of 414-814; mean of 667 (22 data points).

6.5 Local Groundwater Usage and Source Protection Area

There are no source protection areas within 5km of the site, however there are three water wells within 2km of the site, as mapped by the GSI (https://www.gsi.ie/Mapping). A table describing these nearby water wells can be seen below in **Table 6.1**. Well locations are outlined on **Figure E, Appendix B.**

Well Code	Easting	Northing	Total Depth (m)	Depth to Rock	Yield (m^3/day)	Yield Class
2039SEW016	228790	396260	3.6	1.8	21.8	Poor
2039SEW019	229530	398030	5.2	1.8	16.4	Poor
2339SWW001	231520	397460	3.1	1.2	3.1	Poor

Table 6.1 Groundwater wells within 2km of Churchtown landfill

All local residences (within 500m) do not use private groundwater wells and are fed from the mains water supply at Lifford.

6.6 Recharge Rainfall

Diffuse recharge occurs via rainfall percolating through the subsoil and rock outcrops. Due to the low permeability of some subsoil deposits and the aquifers, a high proportion of the effective rainfall will quickly discharge to the streams in the GWB. The reasonably high stream density is reflects the high proportion of surface runoff as opposed to recharge. The GSI has mapped the average groundwater recharge to be 151-200 mm/yr. Average monthly gridded rainfall data was sourced from Met Éireann and is presented in **Table 6.2**.

J	F	M	A	M	J	J	A	S	O	N	D	Annual (mm)
162.2	189.9	71.6	33.4	86.8	48.6	86.0	95.3	23.0	131.4	134.4	150.5	1213.1

Table 6.2 Long term mean monthly rainfall data (mm) (*Met Éireann)*

The closest synoptic station to the site is at Malin Head, 105 km to the northeast, where average potential evapotranspiration (PE) is 538.38 mm/yr. This value is used as a best estimate of the site PE. Actual evapotranspiration (AE) is estimated by multiplying PE by 0.95, to allow for the reduction in evapotranspiration during periods when a soil moisture deficit is present (Water Framework Directive, 2004). Actual evapotranspiration is therefore 511.46 mm yr^{-1} (0.95 PE). The GSI estimated recharge across the site ranging between 51 and 100 mm/year.

The Effective Rainfall (ER) for the site is determined from:

$$ER = AAR - AE$$

$$= 1213.1 \text{ mm yr}^{-1} - 538.38 \text{ mm yr}^{-1}$$

$$\mathbf{ER = 674.72 \text{ mm yr}^{-1}}$$

6.7 Groundwater Monitoring Wells

As mentioned previously, groundwater level monitoring is undertaken within monitoring wells BH1 and BH3 and BH4. BH3 and BH4 are considered representative of up gradient water quality and borehole BH1 is partially representative of down gradient water quality. BH4 was damaged and was subsequently replaced, in the same location, in 2014.

Details of each monitoring is summarised below in **Table 6.3**.

Borehole ID	Well Screen Horizon	Ground Level	Total Depth as per borehole log	Screen Depth	Water Strike	Depth to bedrock	Well Head Level
		mOD[1]	mbgl[2]	mbgl	mbgl	mbgl	mOD
BH1	Overburden	2.74	11.0	5.0-11.0	4.0 & 8.0	N/A	3.47
BH3	Overburden	8.23	31.0	N/A	N/A	26.0	8.72
BH4	-	2.45	9.0	N/A - 9.0	4.3 & 8.2	8.2	2.89
BH4 (replaced)	Bedrock	-	12.0	9.5 – 11.0	7.0 & 9.0	7.9	-

Table 6.3 Monitoring Well Details

6.8 Groundwater Levels & Flow Direction

Groundwater levels in the monitoring boreholes have been recorded on a quarterly basis since 2004. Based on the topography of the land, with a high point to the northwest and a major surface water feature of the River Finn to the southeast it is likely the groundwater flow is in a southeasterly direction with the river acting as a hydraulic boundary.

Interpreted groundwater data from the three groundwater monitoring confirms groundwater flow direction to the southeast. A number of irregularities with the groundwater levels are possibly associated with errors in recording the data. A figure providing groundwater levels is outlined below in **Figure 6.1.**

A review of groundwater levels over time indicates the following:

- Water levels recorded within **BH3,** located to the northwest and upgradient of the site**,** are consistently above BH4 and BH1 are represents upgradient groundwater levels. The monitoring well log reports an installation within the overburden; however a log note provided by Kirk McClure Morton records a total depth of 31 mbgl with bedrock encountered at 26 mbgl. No indication of the installation details of these well. The levels vary between 2.7 and 7.3 mOD. The variations over time do not appear to correlate with rainfall data. Noticeable increased in levels were recorded between December 2007 (3.0 mOD) and January 2008 (7.25 mOD) with no corresponding increase noted in the downgradient monitoring wells. The increased level remained relatively sustained until August 2008 when a sharp reduction on levels is noted. The levels appear to be broadly increasing over time since commencement of monitoring in 2006. This well should not be confused with BH3 historically drilled in the centre of the site which was installed within the overburden and was subsequently decommissioned.

[1] mOD – metres Ordnance Datum
[2] mbgl = metres below ground level

- Water levels within monitoring well **BH4** remained relatively consistent over time and indicate artesian conditions during particular periods. No levels have been recorded at this location since 2009. Levels recorded range between 1.6 and 2.5 mOD. The installation of the original well is unclear; however the replacement well in 2014 is installed within the bedrock. No data trends have been recorded to-date within the replaced monitoring well. However, artesian conditions were observed during the site visit in February 2015.

- Water levels within monitoring well **BH1**, located in proximity to the River Finn, and partially down gradient to the landfill, recorded levels ranging between -2.0 to 2.1 mOD. The well is installed within the overburden only. A noticeable decrease in levels was recorded between December 2007 and January 2008 with levels falling from 1.6 to -0.5 mOD. The levels continued to fall to a low of -2.0 in July 2008 before rapidly rising to 1.5 mOD in September 2008. The rational for these reductions is unclear. The sudden drop in levels corresponds with sudden increases in levels in BH3 during the same period between December 2007 and January 2008.

- Hydraulic gradients across the site based on recorded water levels range between 0.002 and 0.019 which are considered to be relatively low.

A review of leachate monitoring at Churchtown Landfill was also undertaken. The graphed data is provided in **Figure 6.2**.

- Leachate levels within well L3, located in the northern corner of the site, range between 3.6 and 6.0 mOD. A notable jump in levels was recorded between November 2007 and January 2008 ranging up to 2.1 metres. This corresponds with the sudden increase in upgradient groundwater levels in BH3. The highest levels recorded in L3 (*i.e.* 6.0 mOD) were 1.23 metres below the capping layer of the landfill. No notable downward trend is evident in leachate levels in L3.

- Leachate levels within well L1, located in the central region of the landfill, ranged between 2.5 and 5.7 mOD. A notable reduction in levels were recorded between late 2007 and mid 2008 corresponding with a fall in levels in downgradient monitoring well BH1. The highest recent level recorded in L1 (*i.e.* 5.1 mOD) remains 2.2 m below the capping layer of the landfill in this area.

- Leachate levels within well L2, located in the northeastern corner of the waste body, ranged between 1.2 and 4.5 mOD. A notable fall in levels was recorded between November 2007 and April 2008 corresponding strongly with a fall in levels in downgradient groundwater monitoring well, BH1. The highest recorded level of 4.5 mOD remains 1.65 metres below the top of the landfill cap.

In summary, it would appear that groundwater level variability in the area significantly impacts on leachate levels within the waste body. The correlating increases and reductions in groundwater levels and leachate levels confirm this theory with groundwater appearing to intersect the waste body. Groundwater level variations and levels upgradient of the site have a differing signature to groundwater levels closer to the River Finn which suggests that the river is partially impacting on groundwater levels downgradient of the landfill, as expected.

6.9 Permeability

3 no. in-situ permeability tests were undertaken by Stratex Ltd in 1998 within BH1, BH3 and BH4. The coefficient of permeability recorded were 3.3 x 10^{-6} m/s (BH1), 4.0 x 10^{-6} m/s (BH3) and 2.6 x 10^{-3} m/s (BH4)

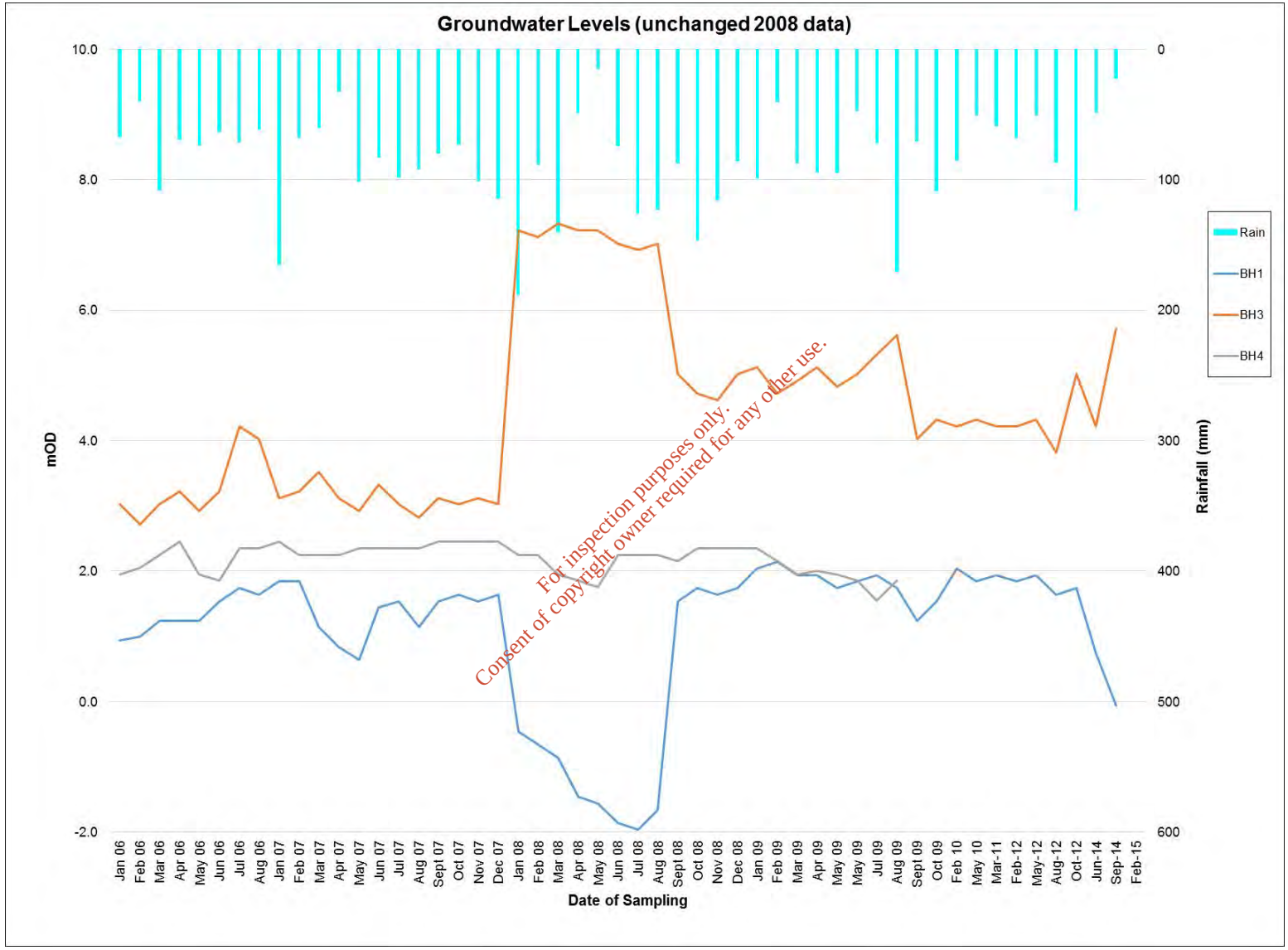


Figure 6.1 Groundwater Levels

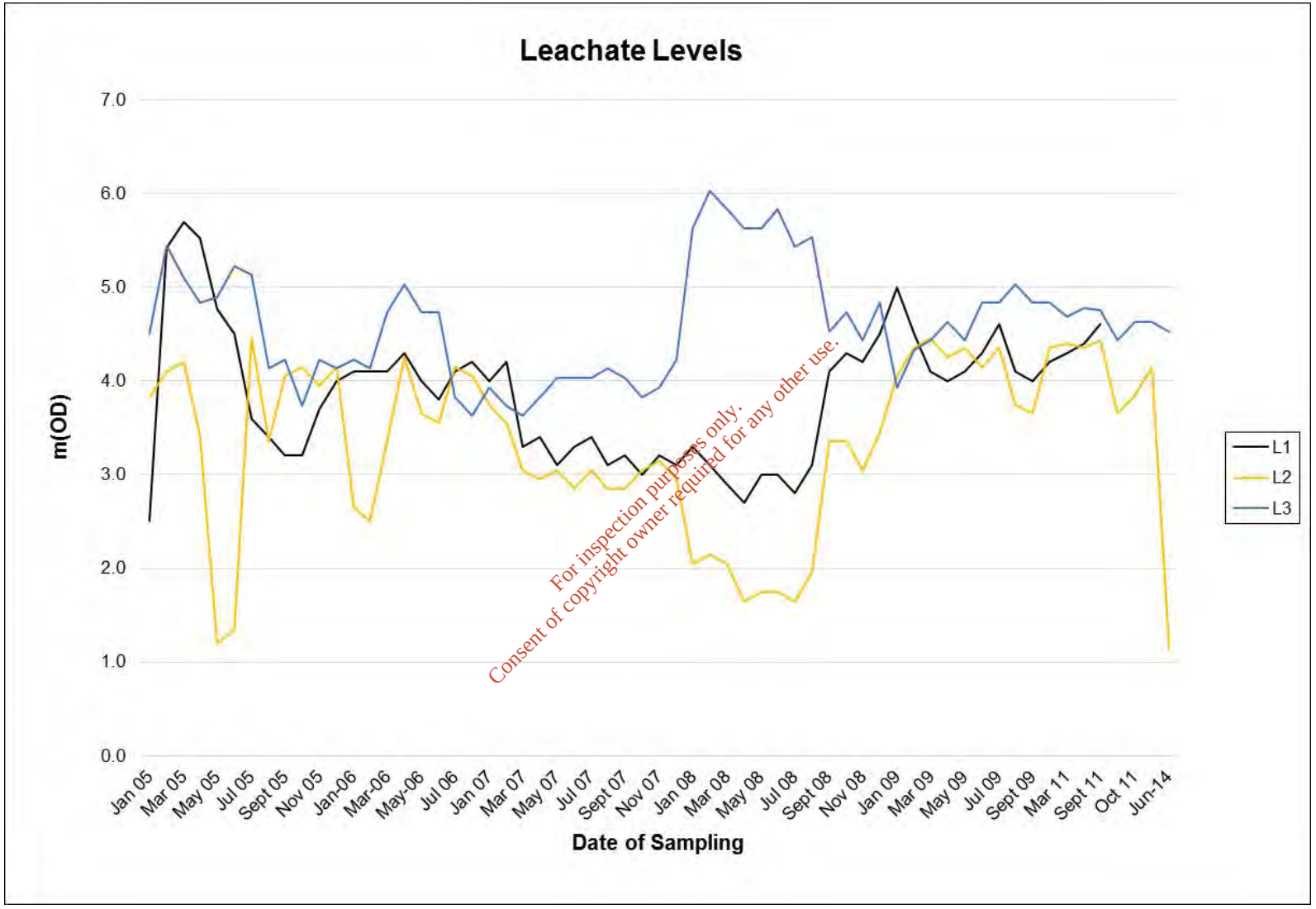


Figure 6.2 Leachate Levels

7 PRELIMINARY S-P-R

The hydrogeological impact assessment is guided by the source-pathway-receptor model. The S-P-R model is used to identify the sources of water and potential contaminants, the environmental assets affected by such, and the pathways by which water and contaminants reach those receptors. **Table 7.1** shows the preliminary S-P-R model for the site which can be refined as the assessment evolves and more information is acquired.

Sources	Pathways	Receptors	Risk
Leachate	Groundwater	River Finn	High
	Leachate vertical migration to groundwater		High
		Groundwater	Low to Moderate
	Leachate horizontal migration to surface water	River Finn	High

Table 7.1 Preliminary S-P-R

The landfill at Churchtown was not originally developed on a containment basis *i.e.* there is no engineered liner below the landfill. The waste body has been capped since but there is likely to be strong potential for leachate generation and leakage from within the waste.

Originally there was very little mitigation measures controlling potential leachate discharge to groundwater. However, recent improvement to the landfill infrastructure will mitigate the risk of leachate migration detailed in Section 3.5.

Give the proximity of the landfill to the River Finn, the interpreted groundwater flow direction to the river and the fact that groundwater downgradient of the landfill is not used (nor can be used) as a potable drinking supply, the Raphoe GWB is not considered to be a sensitive receptor at risk

8 HYDROCHEMISTRY

Hydrochemical data was acquired from previous reports supplied by Donegal County Council (DCC) and EPA Annual Environmental Reports (2004-2013) available online. As required under the Waste Licence for Churchtown landfill (*i.e.* WL62-1) groundwater monitoring has been and currently is undertaken at monitoring well locations as set out in the current waste licence. The schedule of the current waste licence requires the monitoring of particular parameters on a quarterly or annual basis.

8.1 Monitoring Locations & Frequency

Monitoring is undertaken within three groundwater boreholes three leachate boreholes (located within the waste) and seven surface water monitoring stations. A table of monitoring locations is presented below in **Table 8.1**. In addition, future monitoring points for the Willow Plantation and Integrated Constructed Wetland system will be included for the site.

Location	Upstream/Downstream	Screened Horizon	Easting	Northing
BH1	Downgradient	Overburden/Groundwater	231,072	395,752
BH3	Upgradient	Overburden/Groundwater	230,840	396,127
BH4	Upgradient	Bedrock/Groundwater	230,818	296,041
L1	Waste	Waste/Leachate	230,999	395,925
L2	Waste	Waste/Leachate	231,169	395,887
L3	Waste	Waste/Leachate	230,931	396,142
SW1	Upstream	Surface Water	230,934	396,164
SW2	Southwest Drain	Surface Water	231,177	395,895
SW3	Adjacent	Surface Water	231,180	395,840
SW4	Southeast Drain	Surface Water	231,026	395,734
SW5	Adjacent	Surface Water	231,038	395,711
SW6	Upstream	Surface Water	230,983	295,705
SW7	Downstream	Surface Water	231,248	395,949

Table 8.1 Monitoring Locations

Leachate monitoring wells, L1, L2 and L3 (formerly BH1, BH2 and BH3), were originally designated as groundwater monitoring wells. These were reassigned as leachate wells due to their installation within the actual waste body. BH1 and BH3 were subsequently re-drilled outside of the waste for groundwater monitoring purposes.

The frequencies of groundwater and leachate monitoring are presented in **Table 8.2.**

Quarterly	Annually
Visual Inspection/Odour, Groundwater levels, Ammoniacal Nitrogen, Chloride, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, Potassium, Sodium, TON, TOC, Nitrate, Nitrite, Phenols.	Boron, Cadmium, Calcium, Chromium, Copper, Cyanide, Fluoride, Iron, Lead, List I & II organic substances, Manganese, Magnesium, Mercury, Sulphate, Total Alkalinity, Total Phosphorous, Residue on evaporation, Zinc, Faecal Coliforms, Total Coliforms

Table 8.2 Parameters and Frequency of Groundwater Monitoring

The list of parameters and monitoring frequency for surface water is seen below in **Table 8.3.**

Quarterly	Annually
COD, Chloride, Ammoniacal Nitrogen, BOD, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, TSS, Chlorine, Copper, Nitrate, Nitrite, Phenols, Zinc	Cadmium, Calcium, Chromium, Iron, Lead, List I & II organics, Magnesium, Manganese, Mercury, Potassium, Sulphate, Sodium, Total Alkalinity, Total Phosphorous, TON.

Table 8.3 Parameters and Frequency of Surface Water Monitoring

8.2 Human Health & Environmental Risk Assessment Framework

Groundwater concentrations have been compared to the 2010 Groundwater Regulations Target Trigger Value (*i.e.* GTV) in addition to the Environmental Protection Agency Interim Guideline Values (IGV) for Groundwater as presented in EPA interim report "Towards Setting Guideline Values for the Protection of Groundwater in Ireland" 2002. The IGVs have been selected on the basis of the lowest of either the drinking water standards, historical environmental quality standards for surface water or GSI trigger values and are therefore highly conservative and protective of all groundwater receptors.

There are currently no published generic assessment criteria for groundwater derived specifically to be protective of human health via direct contact. However it can be assumed that if water is considered safe for human consumption then there are no risks from direct contact. The 2007 Drinking Water Regulations were utilised for this purpose.

All surface water levels have been compared to the 2009 Surface Water Regulations and the 1998 Salmonid Regulations. The leachate sample results were compared with licence limits as assigned by the EPA.

8.3 Leachate Quality

Leachate quality can vary during the lifetime of landfill sites depending on the phase of decomposition. In terms of the overall suite of parameters analysed, raw leachate results from the Churchtown landfill have been compared to "Typical Leachate Composition of 30 Samples from UK/Irish Landfills accepting mainly Domestic Waste" (Landfill Operational Practices) and are within the maximum concentrations.

As is evident from **Figures 8.1 to 8.3** leachate quality data from all leachate monitoring wells recorded a reducing trend over time. The reduction in levels are most noticeable within L3 with Ammoniacal Nitrogen, Electrical Conductivity and Chloride levels all significantly reduced since pre-capping works. Slightly increasing EC and Ammoniacal Nitrogen levels are noted in L2 since 2012.

In summary, the raw leachate results from the landfill are considered to represent a landfill in the methanogenic stage of decomposition of organic compounds. The leachate is considered to be relatively low strength and the levels, which are reducing over time, are expected to reduce further.

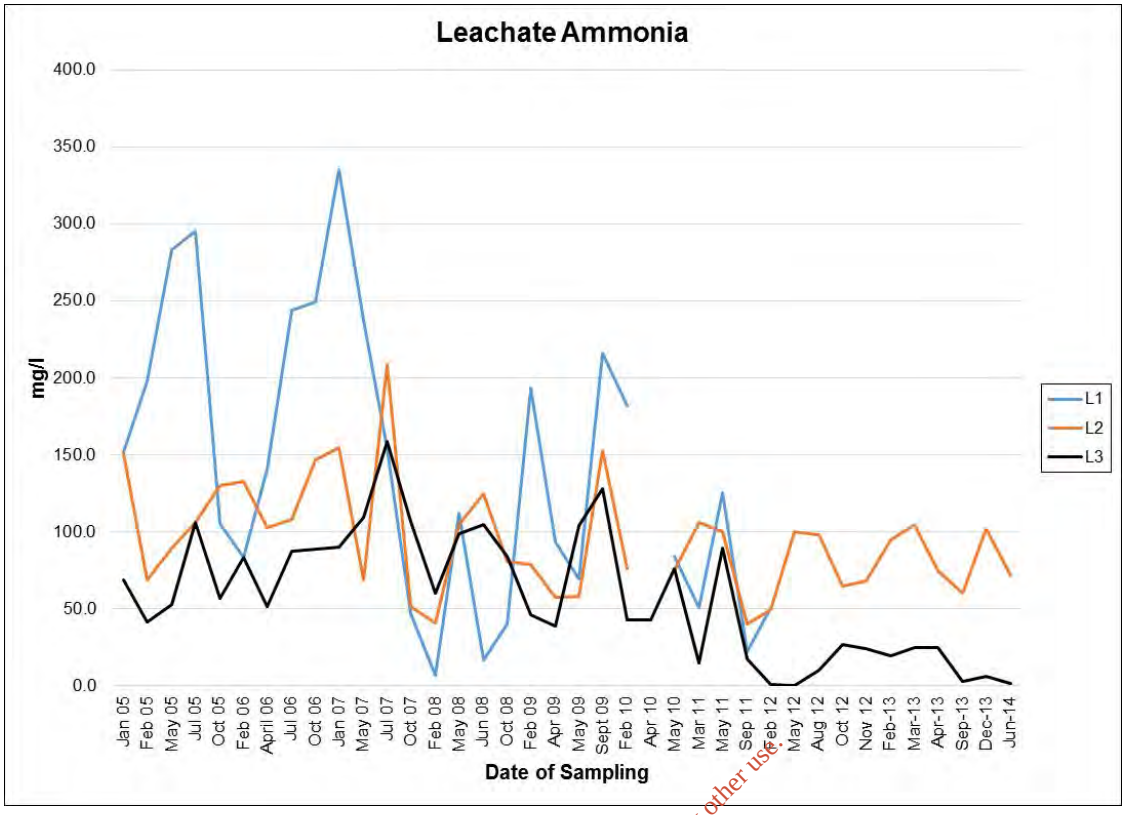


Figure 8.1 Ammoniacal Nitrogen Levels - Leachate

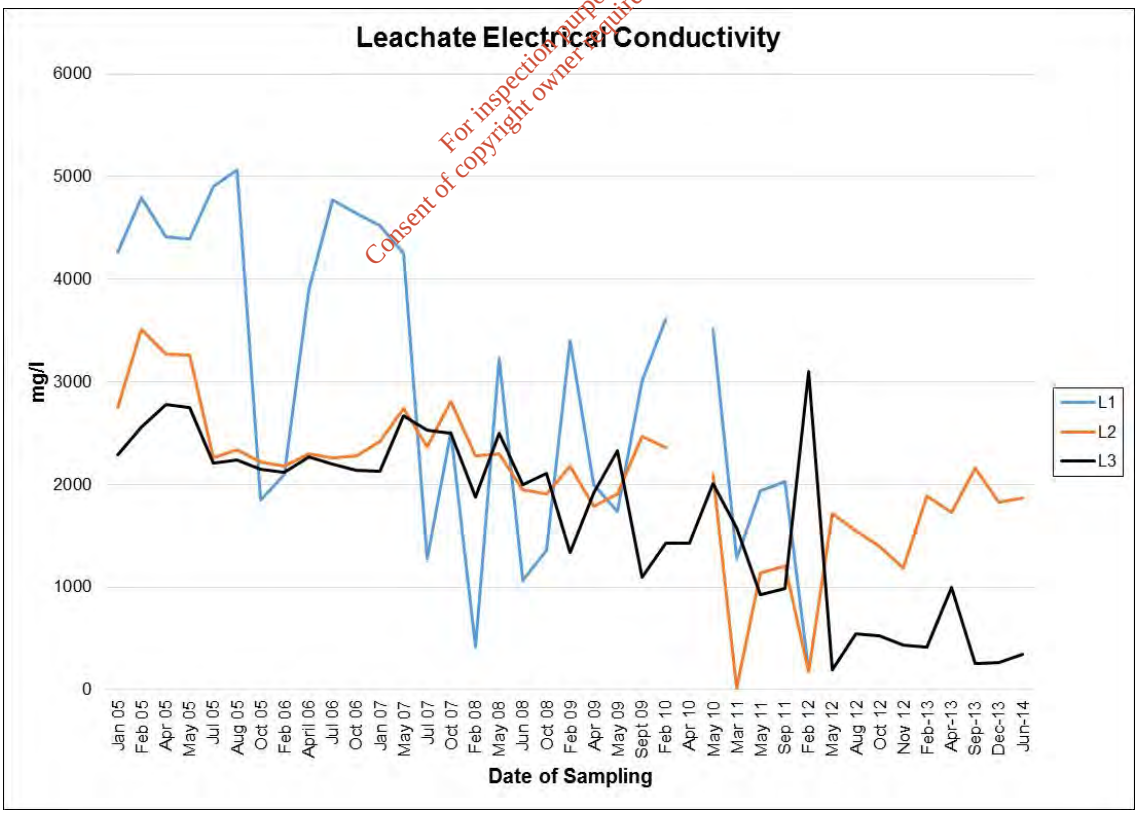


Figure 8.2 Electrical Conductivity Levels - Leachate

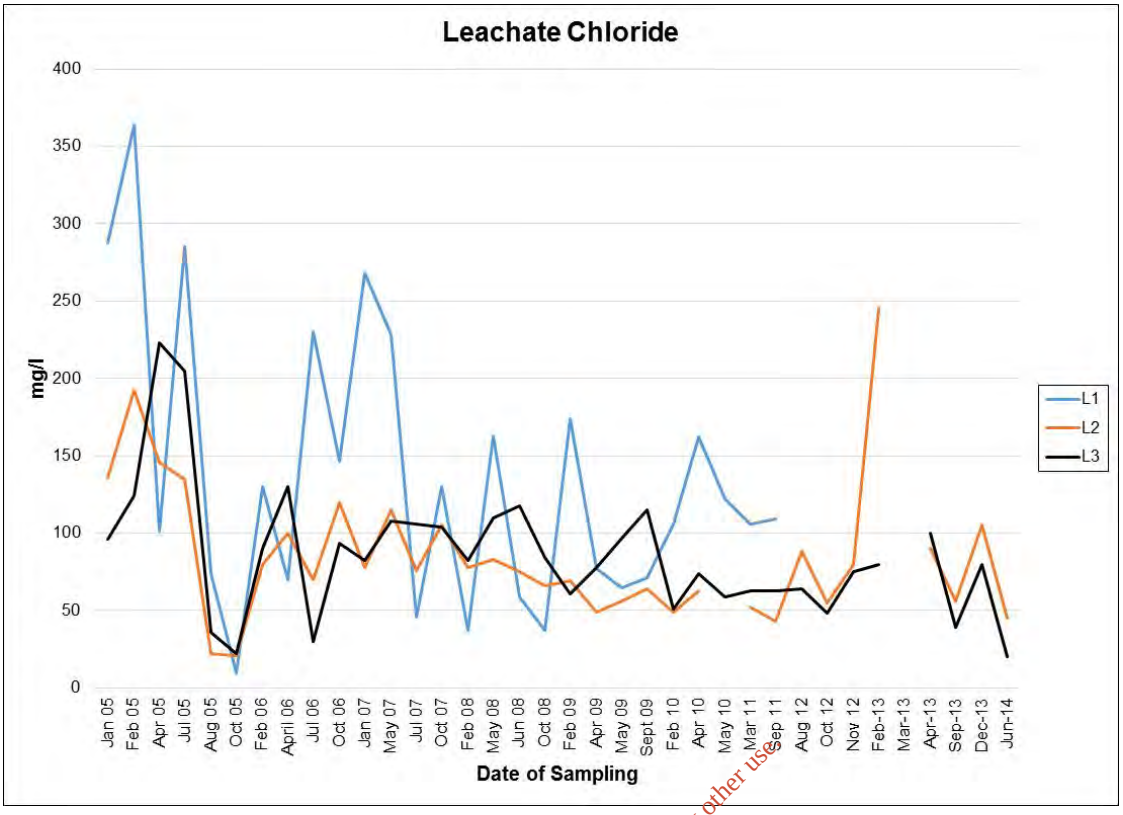


Figure 8.3 Chloride Levels - Leachate

8.4 Groundwater Quality

Groundwater monitoring is undertaken within three monitoring boreholes as detailed in **Section 8.1.** BH4 ceased monitoring in 2007 due to inaccessibility issues and was recently re-drilled in December 2014. The following parameters are discussed in detail in relation to Churchtown landfill:

8.4.1 Ammoniacal Nitrogen

Ammoniacal Nitrogen levels within upgradient monitoring well **BH3** recorded levels ranging between 0.02 and 0.25 mg/l (see **Figure 8.4**). The levels are predominantly below the 2010 GTV with the exception no. 3 no. minor exceedances over time that are attributed to natural variations.

Ammoniacal Nitrogen levels in **BH1**, which is considered to be partially downgradient of the waste body, are also typically recorded below the 2010 GTV since May 2009 with one minor exceedance recorded in September 2013 (*i.e.* 0.3 mg/l). Since 2010 the levels detected in BH1 are consistently lower than those detected in upgradient well BH3 which suggests a low level of impact by the landfill on groundwater. It is however noted that BH1 is not truly downgradient of the waste body and may not accurately reflect the level of contaminant groundwater flux towards the River Finn.

Prior to 2007, similarly low levels of Ammoniacal Nitrogen were recorded within **BH4** with a single minor exceedance in July 2006. No samples were collected from BH4 between May 2007 and March 2015.

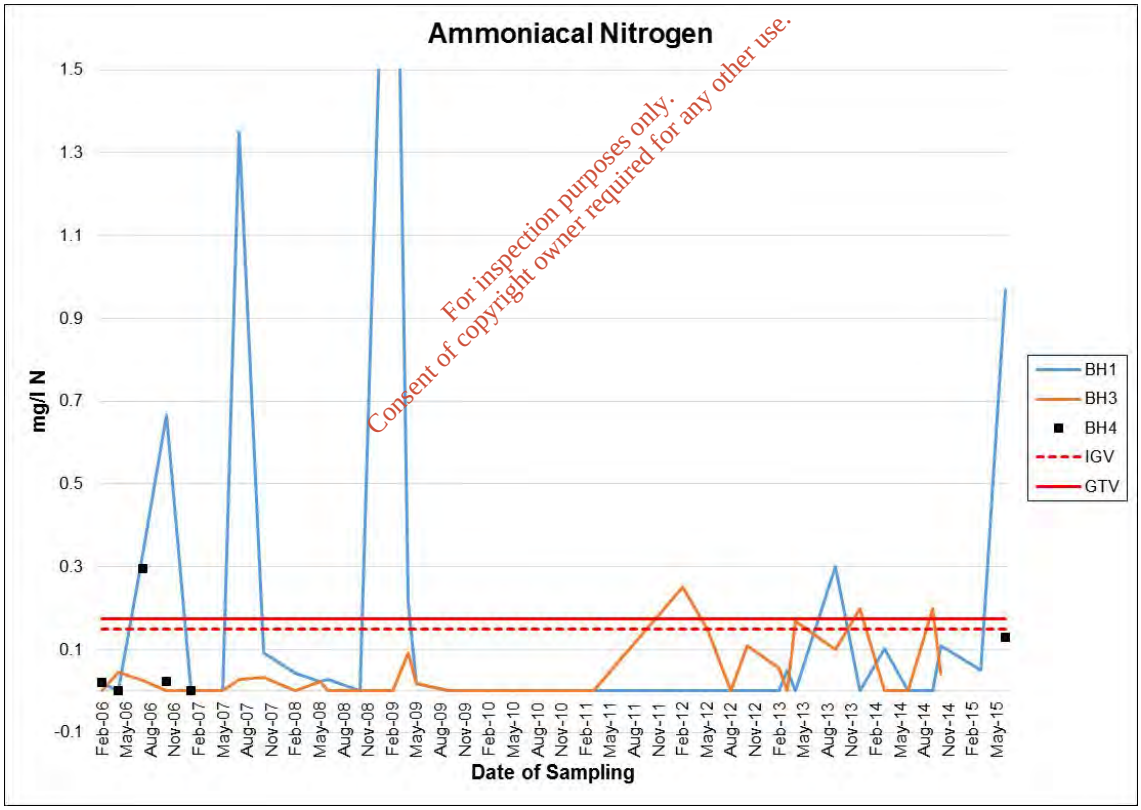


Figure 8.4 Ammoniacal Nitrogen Levels - Groundwater

8.4.2 Electrical Conductivity (EC)

EC levels within upgradient monitoring well **BH3** ranged between 155 and 529 µS/cm representing background conditions. Generally reduced EC levels were recorded within **BH1** ranging between 86 and 482 µS/cm. EC levels in **BH4** pre 2007 were recorded consistently between 335 and 385 µS/cm and between 347 and 403 µS/cm in 2015.

EC levels in BH1 are consistently lower than those recorded in upgradient well BH3 and do not indicate an impact to groundwater by the waste body. A notable decrease in EC in BH1 was recorded between October 2008 and March 2011 which may be attributed to surface water or river water ingress during flooding events. As highlighted in Section 8.4.1, BH1 is not truly downgradient of the waste body and may not accurately reflect the level of contaminant groundwater flux towards the River Finn.

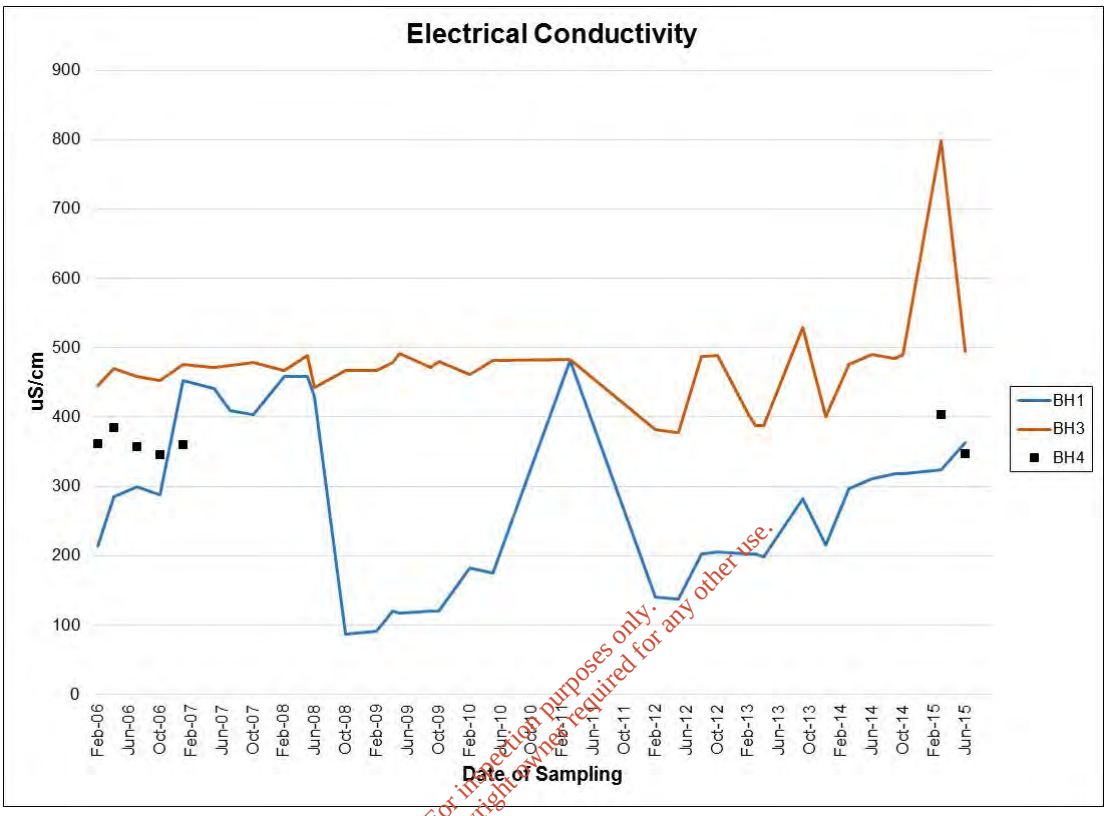


Figure 8.5 Electrical Conductivity Levels - Groundwater

8.4.3 Chloride

Chloride levels are recorded consistently below the 2010 GTV ranging between 16 and 60 mg/l within upgradient well **BH3** and between 13 and 41 mg/l in partially downgradient well **BH1**. Levels within **BH4** pre 2007 were recorded between 25 and 30 mg/l.

8.4.4 Total Organic Carbon (TOC)

TOC levels were generally recorded at background levels across the site with the exception of one isolated spike in **BH3** (81.17mg/l). This level subsequently returned to background levels of <4 mg/l during the following sampling event. A notable increase in TOC levels were noted between June 2008 and February 2009 in downgradient well BH1 (*i.e.* 13.1, 16.0 and 11.9 mg/l respectively). This extended increase in TOC is unclear but may be resulting from surface water ingress to the well during this period.

8.4.5 Total Oxidised Nitrogen (TON)

Elevated and variable levels of TON were occasionally recorded in both the upgradient and downgradient monitoring wells (see **Figure 8.6**). High levels of TON in a water body can contribute to excessive algal growth in waterways as TON is a measure of both nitrate and nitrite in soluble compound form, readily usable by plants and algae.

There appears to be a broad decreasing trend in downgradient monitoring well BH1 and no apparent trend in the upgradient BH3. The levels recorded within BH1 are generally higher than those recorded in upgradient well BH3 which suggests an impact of the landfill on groundwater immediately upgradient of BH1.

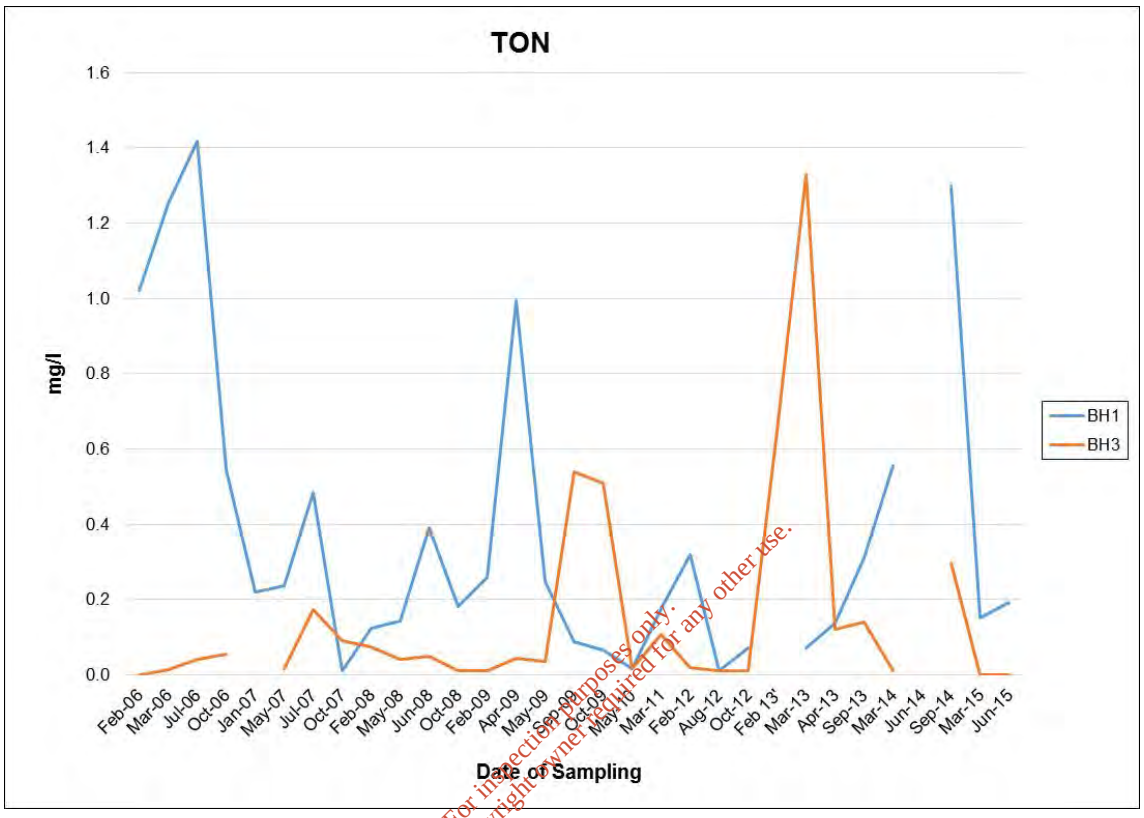


Figure 8.6 TON Levels

8.4.6 Other Parameters

- Sodium

All levels of Sodium were recorded well below the 2010 GTV of 150 mg/l. All levels were generally recorded below 20mg/l with the exception of two isolated occasions where more elevated levels were recorded in both BH1 and BH3 (*i.e.* 86 mg/l, September 2009 and 56.5 mg/l, June 2014 respectively).

- Nitrate & Nitrite

No detection of Nitrate or Nitrite above the 2010 GTVs were recorded in groundwater across the site.

- Sulphate

No detections of Sulphate above the GTV were recorded in groundwater across the monitoring period to 2015.

- Iron

Significant uncertainties persist regarding the true results provided by the Donegal County Council laboratory in relation to units and limits of detection. Therefore no accurate assessment has been undertaken as part of the completion of this report.

- ORP

Levels of ORP were recorded in **BH3** ranging between 0.001 and 0.185 mg/l. The IGV for ORP is 0.03 mg/l. Notable more elevated levels were recorded in **BH1** ranging between 0.001 and 0.258 mg/l over the monitoring period to date. The levels recorded within **BH4** are broadly similar to those recorded in BH3 ranging between <0.01 and 0.082 mg/l. The downgradient levels in BH1 suggest the waste body was historically impacting on groundwater quality between upgradient and downgradient monitoring wells. However a downward trend is noted in BH3 since June 2008 and within Bh1 since February 2009. No detections of elevated ORP have been recorded in BH1 since May 2010.

- Heavy Metals

Heavy metals were not recorded above their respective IGV or GTV in groundwater samples during the monitoring period to-date.

- Semi Volatile & Volatile Organic Compounds

No detection of VOCs or sVOCs above the laboratory limits of detection or any threshold guideline value was recorded in either upgradient or downgradient monitoring wells between 2006 and 2015.

- BTEX Hydrocarbons

No recording of BTEX (Benzene, Toluene, Ethyl-Benzene & Xylene) hydrocarbons were recorded above the limit of detection (LOD) for this suite of testing.

- Phenols

Phenol analysis was occasionally undertaken in monitoring wells BH1 and BH3. The results recorded were consistently below the laboratory limit of detection.

- Trihalomethanes (THMs)

Total-Trihalomethanes (THM) is the sum of Dichloromethane, Chloroform, Bromodichloromethane and Bromoform. Chemical analysis was occasionally undertaken in groundwater for these parameters and the results were consistently below the laboratory limit of detection.

8.5 Surface Water Quality

The primary receptor for the Churchtown landfill catchment has been identified as the River Finn (River Code; IE_XB_01_1_3). The river is located along the southeastern site boundary, flows in a northeast direction and forms the border between Donegal and Northern Ireland.

The overall status of River Finn has been described as 'Poor' by the EPA; with a General physio-chemical status (PC) status of 'High', a Macroinvertebrate status (Q) of 'Poor' and an overall ecological status (ES) of 'Poor'. It has been given an overall risk status of 1a (at risk). The Q-rating for the river is current rated as Q3 – poor quality status. Surface water sampling for monitoring purposes is undertaken at 7 locations on and around Churchtown landfill (See **Table 8.4** below and **Figure 3**).

It should be noted that uncertainties surround the accuracy of the laboratory results in addition to the sampling locations within the river during sampling events.

Monitoring Point	Easting	Northing	Location
SW1	230,934	396,164	Upgradient within drain along northeastern site boundary
SW2	231,177	395,895	Downgradient within drain along northeastern site boundary
SW3	231,180	395,840	River Finn (at landfill site)
SW4	231,026	395,734	Southwestern site drain upgradient of treated leachate discharge location
SW5	231,038	395,711	Southwestern site drain downgradient of treated leachate discharge location[3]
SW6	230.983	295,705	Upstream (River Finn)
SW7	231,248	395,949	Downstream (River Finn)

Table 8.4 Surface water sampling locations

8.5.1 Ammoniacal Nitrogen

Surface Water Drains

Upgradient surface water quality within the northeastern boundary landfill drain (*i.e.* **SW1**) flowing from an upgradient location before discharging into the River Finn is recorded as generally good quality with relatively low levels of Ammoniacal Nitrogen detected. The levels of Ammoniacal Nitrogen at this location range between 0.01 and 0.3 mg/l. The flow within this drain is currently unknown.

The drain discharges to the River Finn in the southeastern corner of the landfill. **SW2** is located within the drain immediately prior to its discharge to the River Finn. Water quality monitoring at SW2 over time recorded significantly elevated levels of Ammoniacal Nitrogen ranging between 0.02 and 128.2 mg/l (see **Figure 8.8**). The levels recorded indicate an impact from landfill leachate during a time when leachate was allowed to be dispersed to this drain from the flanks of uncapped landfill. The drain is currently visually impacted with heavy iron ochre, in particular towards the River Finn end of the drain (see **Figure 8.9**).

[3] It is noted that SW5 is currently sampled from an adjacent site drain at the site. However, it is considered more beneficial if the sample location was collected from the River Finn within the mixing zone of the SW4 drain and the river.

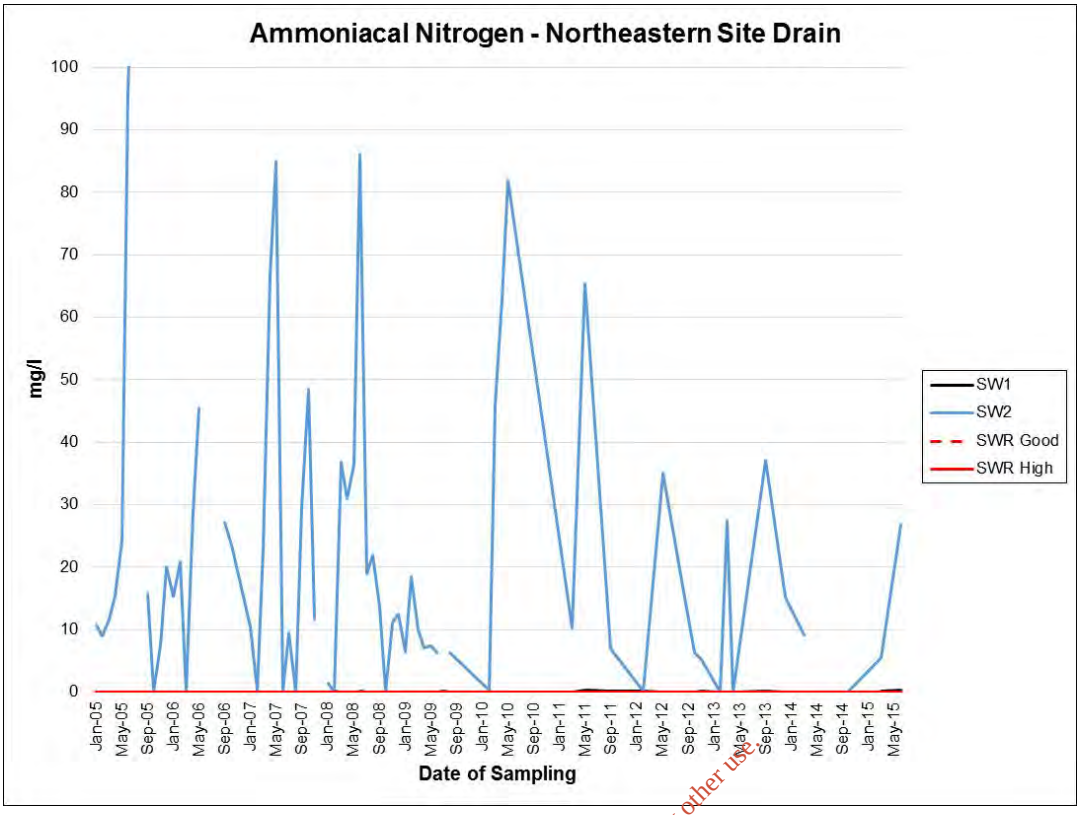


Figure 8.8 **Northeastern Drain - Ammoniacal Nitrogen Levels**

Figure 8.9 **Leachate Impact within Northeastern Boundary Drain pre-restoration**

Elevated levels of Ammoniacal Nitrogen have been recorded within the southwestern boundary drain (see **Figure 8.10**) within samples **SW4** and further downgradient at **SW5**. The levels within SW4 range between 0.01 and 65.3 mg/l and within SW5 ranging between 0.01 and 151 mg/l. The levels recorded vary over time with broadly reducing levels noted between 2010 and 2014. However, increased levels have been noted in both locations since mid-2014.

The high levels of Ammoniacal Nitrogen in this drain are, similar to the northeastern drain, resultant from landfill leachate during a time when leachate was allowed to be dispersed to this drain from the flanks of uncapped landfill. These levels are expected to decrease significantly following completion of all remedial works at the site.

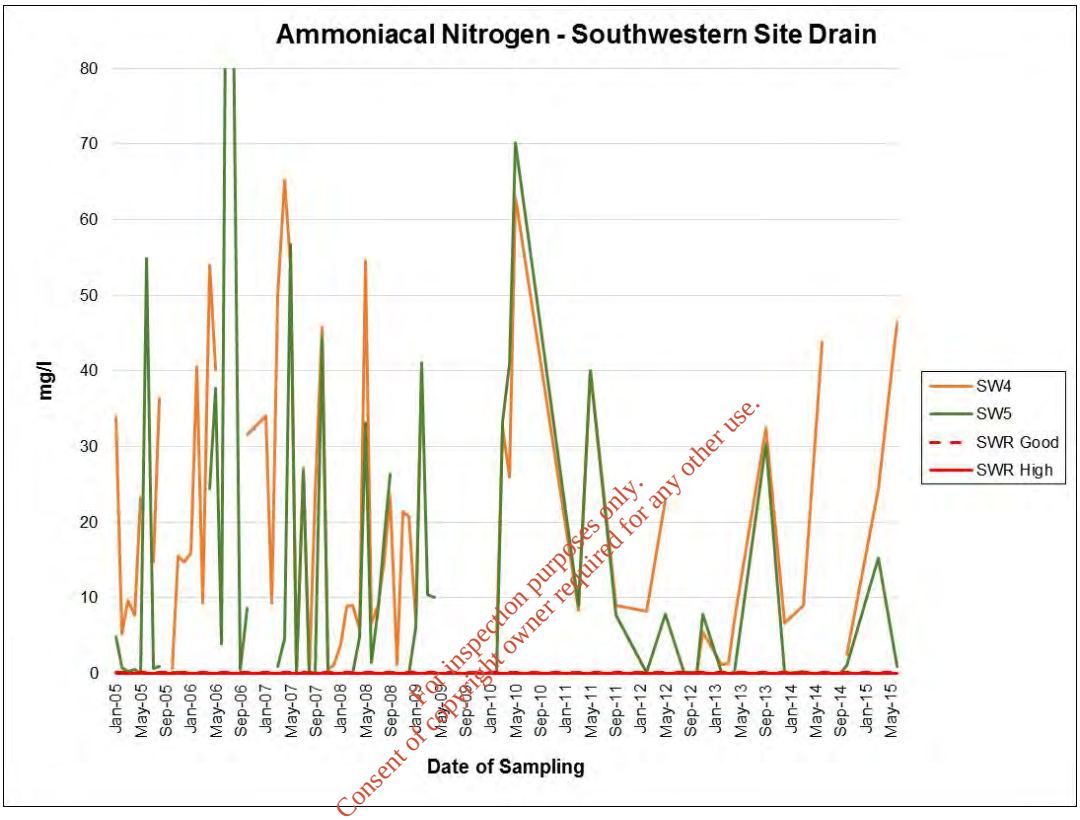


Figure 8.10 Southwestern Drain - Ammoniacal Nitrogen Levels

River Finn

Ammoniacal Nitrogen levels upgradient of the site within the River Finn at **SW6** range between 0.01 and 26.0 mg/l. The levels are generally below the 2009 Surface Water Regulations (SWR) threshold for Good Status River Water of 0.065 mg/l with elevated 'spiked' levels noted on occasion. These spiked readings were recorded on three occasions only – *i.e.* 2005, 2010 and 2014 ranging between 1.69 and 26.0 mg/l/.

Mid-gradient monitoring at **SW3,** in the immediate vicinity of the landfill, recorded slightly more elevated levels ranging between 0.01 and 1.8 mg/l. Historically the levels were recorded within or slightly above the SWR; however, increasing levels have been noted since November 2012. These increasing levels are attributed to the current uncontrolled discharge of leachate contaminated surface water drains from the landfill. Notable reductions in levels are expected at SW3 following completion of proposed leachate treatment works at the site.

Downgradient monitoring at **SW7** within the River Finn ranged between 0.01 and 1.44 mg/l. The levels are broadly similar to mid-gradient sample SW3 with levels recorded both higher and lower than levels at SW3 on various occasions. On occasions when SW7 levels are recorded above SW3, the source of this increase may be attributed to a potential downgradient agricultural source of contamination or potentially due to sampling locations/techniques within the river (*i.e.* sample collected from the river bank and/or from the centre of the river).

A comparison of levels recorded with rainfall was undertaken. A number of notable increases in downstream Ammoniacal Nitrogen levels were recorded within SW7 following periods of high rainfall.

The data suggests that the landfill is having a limited impact on the quality of the River Finn in the immediate vicinity of the landfill in its current setup. The impact at SW3 is predominantly attributed to the discharges from the site drains at the landfill site. As is evident from the site data, notable reductions are typically recorded in downstream sample SW7. In addition the assimilative capacity calculation in **Section 8.9** confirms the low impact that is occurring.

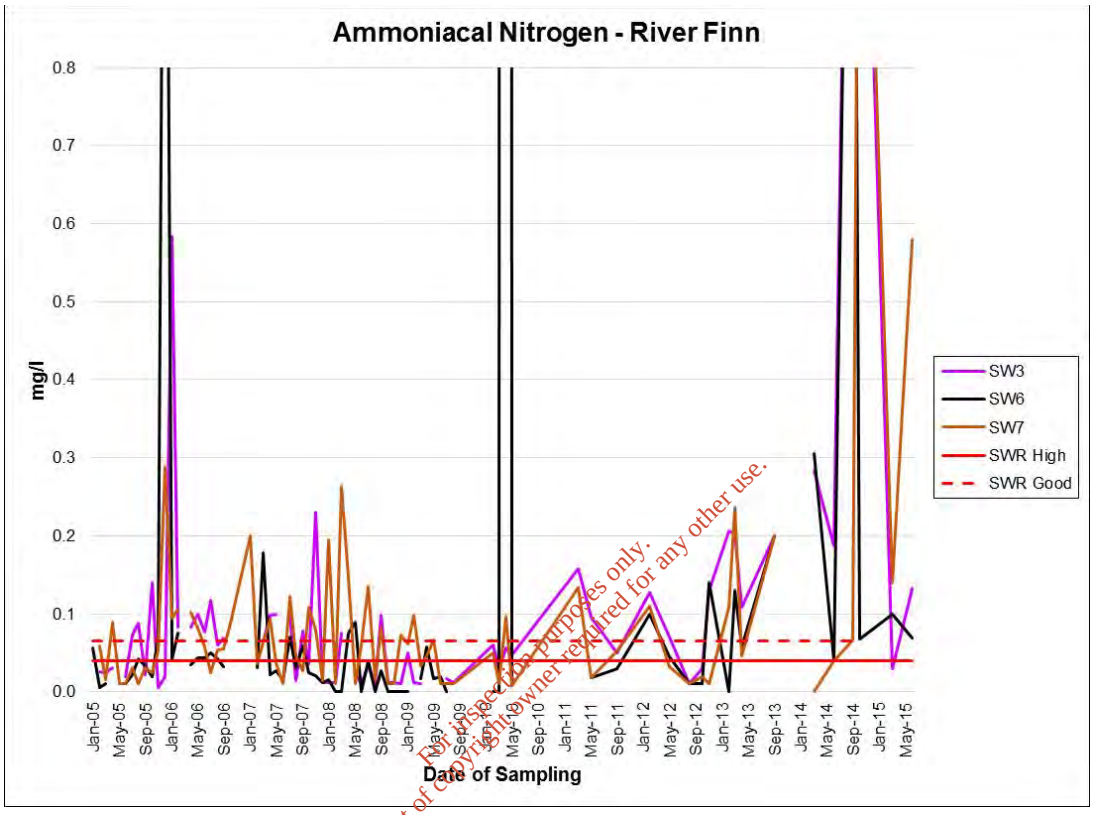


Figure 8.11 River Finn - Ammoniacal Nitrogen Levels

8.5.2 Electrical Conductivity (EC)

Surface Water Drains

Upgradient EC levels within the northeastern boundary drain *i.e.* **SW1**, are consistently recorded between 200 and 300 µS/cm whereas EC levels in downgradient sample location, **SW2**, typically recorded a notable increase in EC levels (see **Figure 8.11)** ranging between 50 and 5050 µS/cm.

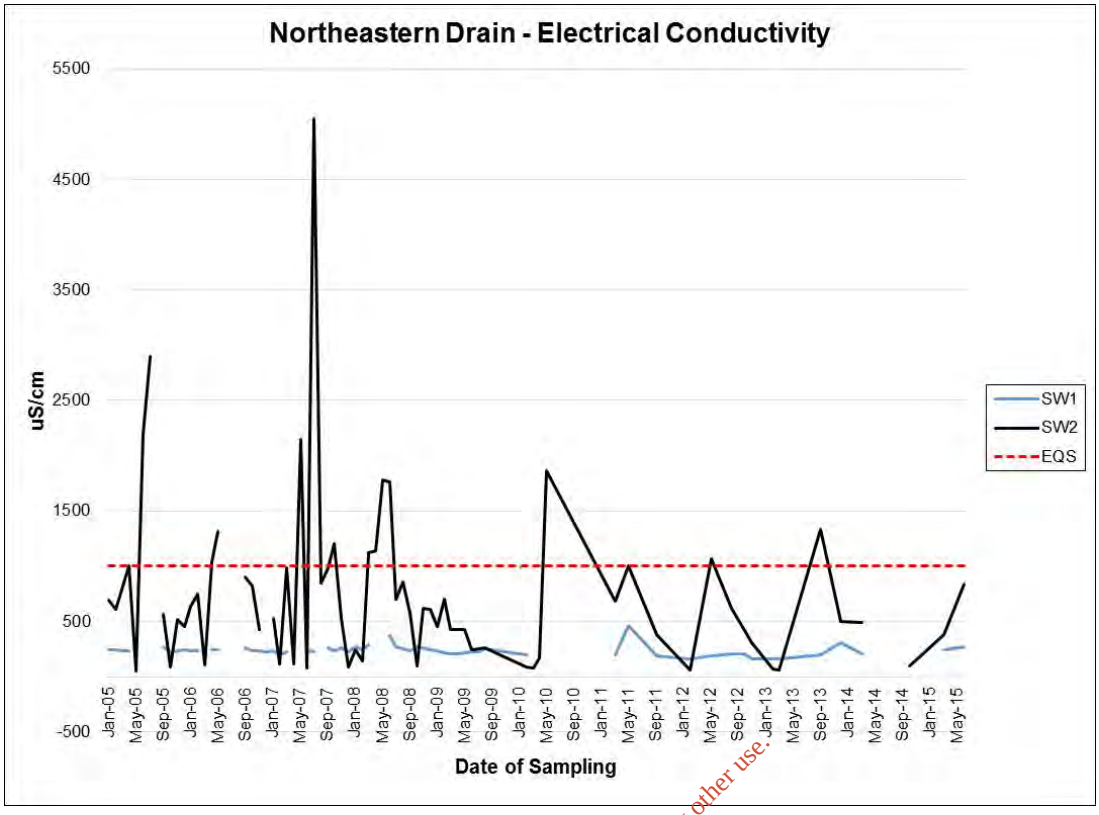


Figure 8.12 Northeastern Drain – Electrical Conductivity

Elevated EC levels were recorded in both **SW4** and **SW5** in the southwestern site drain ranging between 50 and 3350 µS/cm. The levels recorded in both drains are broadly similar during each sampling event and confirm an impact from landfill leachate.

River Finn

EC levels within the River Finn are typical of background unpolluted surface waters ranging between 40 and 232 µS/cm. Isolated 'spiked' reading were recorded at each sample location separately ranging between 561 and 1119 µS/cm. The levels recorded upgradient and downgradient of the site do not record any noticeable difference as the river flows by the landfill site.

8.5.3 Chloride

Surface Water Drains

Upgradient Chloride levels within the northeastern boundary drain *i.e.* **SW1**, are consistently recorded between 14 and 39 mg/l whereas Chloride levels in downgradient sample location, **SW2**, typically recorded a notable increase in levels ranging between 13 and 155 µS/cm.

Elevated Chloride levels were recorded in both SW4 and SW5 in the southwestern site drain ranging between 13 and 242 µS/cm. The levels recorded at both locations are broadly similar during each sampling event and confirm an impact from landfill leachate.

River Finn

Chloride levels within the River Finn are broadly similar between upgradient and downgradient sampling locations. Levels range between 8.3 and 36 mg/l. A single isolated high level of 172 mg/l was recorded at SW3 in September 2014.

8.5.4 Orthophosphate (ORP)

River Finn

ORP levels within the River Finn are broadly similar between upgradient and downgradient sampling locations general below the Good Status SWR. Notable isolated 'spiked' levels are recorded at mid-gradient sample point, SW3 ranging between 0.076 and 1.08 mg/l above the mean SWR of 0.035 mg/l. A single isolated high level of 172 mg/l was recorded at SW3 in September 2014.

Surface Water Drains

Upgradient ORP levels within the northeastern boundary drain *i.e.* **SW1**, are consistently recorded between 0.003 and 0.07 mg/l with an isolated high level of 3.3 mg/l recorded in February 2009. ORP levels in downgradient sample location, **SW2**, typically recorded a notable increase in ORP levels ranging between 0.002 and 0.28 mg/l.

Elevated ORP levels were recorded in both SW4 and SW5 in the southwestern site drain ranging between 0.002 and 0.35 mg/l. The levels recorded at both locations are broadly similar during each sampling event.

8.5.5 Biochemical Oxygen Demand (BOD)

River Finn

BOD levels within the River Finn are broadly similar between upgradient and downgradient sampling locations. Levels range between 0.04 and 7.8 mg/l. A single isolated high level of 20 mg/l was recorded at SW7 in February 2010.

Surface Water Drains

Upgradient BOD within the northeastern boundary drain *i.e.* **SW1**, are relatively variable ranging between 0.03 and 6.12 mg/l. BOD levels in downgradient sample location, **SW2**, typically recorded between 0.04 and 12.2 mg/l. A single high BOD level of 46.2 in May 2011 was recorded in SW2. The BOD level at SW1 are occasional more elevated than levels detected at SW2 and vice versa.

Occasionally elevated BOD levels were recorded in both SW4 and SW5 in the southwestern site drain ranging between 0.04 and 9.0 mg/l with the levels at both locations broadly similar.

8.5.6 VOCs/sVOCs/Hydrocarbons/Heavy Metals

The remaining parameters analysed, as per **Table 8.1** were recorded below laboratory limits of detection or within EQS threshold levels and are not considered further in this report.

8.6 Surface Water Quality Summary

In summary, water quality data within the northeastern and southwestern boundary drains demonstrates an impact from landfill leachate over time with elevated levels of contaminants indicative of an impact from landfill leachate. The source of the impact is from landfill leachate during a time when leachate was allowed to be dispersed to these drains from the flanks of uncapped landfill. As the remediation of the site is not completed to-date, these surface waters will continue to record an impact from leachate in the short term. However, on completion of the works, the water quality in both drains are expected to noticeable increase over time.

The quality of the River Finn, with the current discharges from the landfill drains (and to a significantly lesser extent from groundwater baseflow), does not indicate a significant impact over time as the river flows by the landfill. A slight deterioration in quality is noted within the discharge zones of the surface water drains into the River Finn, however the scale of the impact is considered to be low. On occasion where downstream contaminant levels are recorded above mid-stream levels at the landfill site, the source of this increase may be attributed to a downgradient agricultural source of contamination or

potentially due to sampling locations within the river (*i.e.* sample collected from the river bank and/or from the centre of the river).

8.7 Groundwater Contaminant Fluxes / Assimilative Capacity

An estimate of the assimilative capacity of the River Finn was made by comparing the Ammoniacal Nitrogen load discharging from the landfill site via **groundwater flux** and the actual concentrations measured in the river.

Leachate discharge from the site can be described by Darcy's Law equation:

$$Q = KiA$$

where: Q_{river} = annual mean flow of the River Finn (m^3/sec) – 0.4 m^3/s (95^{th} %ile) or 34,560 m^3/day (see **Section 5.1**).

K = the hydraulic conductivity of the conducting units – in this case the average of site specific readings from BH1 and BH3 (*i.e.* 3.7 x 10^{-6} m/sec) – see **Section 6.9**.

i = the hydraulic gradient utilising highest recorded gradients as a conservative measure (*i.e.* 0.019).

A = the area over which contaminant flow is occurring *i.e.* 100 metre length (*i.e.* and 6 metre deep vertical plane across approximately 100% of the section.

Based on the above data a daily groundwater throughput (*i.e.* Q_{gw}) of 3.6 m^3/day or **3,644 litres/day** was calculated which equates to 3.5 g/day.

Therefore given the flow within the River Finn, the dilution effect in the river is estimated at approximately **9,483** times the landfill groundwater flux. Using the highest Ammoniacal Nitrogen concentration recently recorded in BH1 (*i.e.* 0.97 mg/l in September 2015), the dilution capacity within the river would reduce this level to 0.1 µg/l approximately which represents an approximate increase of <0.01% of Ammoniacal Nitrogen levels within the river.

An assimilative capacity assessment for two monitoring periods (*i.e.* June 2013 and September 2015) was undertaken to represent most recent conditions and prior to completion of the current remediation works. This assessment is detailed in **Appendix E** and indicates the following:

- The predicted Ammoniacal Nitrogen concentration downstream of the landfill at SW7 in **September 2015** was recorded to be higher than the actually recorded downstream level in the river. This would imply that other factors are reducing the contaminant loading to the river *e.g.* the flow in the river at this time was greater than the $95\%^{th}$ile flow or lower contaminant fluxes to the river are actually occurring rather than what is being recorded in BH1. These results also suggest that the surface water discharges from the landfill are also having a low level impact on the river quality.
- The predicted Ammoniacal Nitrogen concentration downstream of the landfill at SW7 in June 2013 were similar to the chemical data recorded in the river for this monitoring event with no notable increase in downstream levels predicted or recorded.

Based on the above, it is evident that the current conservatively calculated groundwater contaminant flux to the river from the landfill body is having a negligible effect on the quality of the River Finn. It is also noted that the calculations ignore the further reducing effects of the peat/silty overburden and the reducing trends occurring over time which are likely to reduce impacts to the river even further. Finally, although the contributions from the surface water landfill drains are likely to have a significantly greater impact on the river in comparison to the groundwater flux, these impacts are considered to be low to negligible.

9 UPDATED HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

The preliminary source-pathway-receptor approach is now revisited to facilitate a hydrogeological conceptual model of the site. A cross-sectional profile of the site is presented in **Figure 5.**

9.1 Source Areas

- The raw leachate results from the landfill are within the maximum and minimum concentrations of typical landfill leachate in Ireland and are considered to represent a landfill in the methanogenic stage of decomposition of organic compounds. The leachate is considered to be relatively low strength and is broadly reducing in strength over time.
- No Hazardous substances as per the EPA Classification of Hazardous and Non-Hazardous substances in groundwater (2010) were detected in the leachate and groundwater at the site;

  Non-Hazardous Substances detected include:

  ✓ Ammoniacal Nitrogen.

The entire landfill waste body has been capped with an engineered cap and wetland system as agreed with the EPA. Toe drains are lined with an engineered liner. Therefore the generation of leachate is primarily from the degradation of the waste body itself and the ingress of groundwater rather than the effect of rainfall ingress.

9.2 Pathways

- The hydrogeological regime across Churchtown Landfill comprises a leachate within the waste body and a groundwater body within the overburden/shallow bedrock. Both appear to be hydraulically connected. A separate groundwater body within the deeper bedrock and flowing under pressurised artesian conditions may also be present based on the conditions encountered within monitoring well BH4. Shallow groundwater interacts with the waste mass and facilitates the generation of leachate. The migration of the leachate is likely to flow within the overburden towards the River Finn. The head of leachate is dependant on the surrounding groundwater levels and the ability of the leachate to continue to migrate from the landfill depends on the permeability and thickness of the overburden and the head of leachate within the waste body. No clear reduction in leachate levels within the waste body is evident since completion of the landfill cap. This would suggest that leachate levels are highly dependent on groundwater level variations over time.
- The relatively low permeability overburden is anticipated to encourage the horizontal migration of shallow groundwater towards the River Finn
- Groundwater levels vary between 7.3 mOD (BH3) and -0.2 mOD (BH1) metres across the site with a groundwater gradient ranging between 0.002 and 0.019 which is considered to be low.
- Historical dispersal of leachate from the waste body to the surface water drains alongside of the waste body historically occurred at the site prior to remediation works. As the remediation of the site is not completed to-date, these surface waters will continue to record an impact from leachate in the short term. This pathway is expected to be removed on completion of the site remediation works.

9.3 Receptors

The key potential environmental receptor that could be impacted by the presence of the contaminant source on the site is the River Finn. The River is an SAC and a salmonid river. Given the observed depth and size of the river, it is considered to be a hydraulic boundary for the landfill *i.e.* all groundwater discharges to it rather than under it.

There are no source protection areas mapped in the vicinity of the Landfill and no private groundwater wells are present in the vicinity of the site.

9.4 Updated S-P-R – Risk Screening

The impact assessment is guided by the source-pathway-receptor (S-P-R) model. The S-P-R model is used to identify the sources of water and potential contaminants, the environmental assets affected by such, and the pathways by which water and contaminants reach those receptors. **Table 9.1** summarises an update to the preliminary SPR linkages identified in **Table 7.1** for the landfill.

Sources	Pathways	Receptors	Risk
Leachate	Horizontal Migration of Groundwater	River Finn	Low to Moderate
	Vertical migration to groundwater		Low to Moderate
		Groundwater	Low
	Horizontal migration to surface water	River Finn	Moderate[1]

Note 1: This linkage is based on leachate migration for an unremediated site. This linkage is not expected to be present following completion of the current remediation programme and is not considered further in this assessment.

Table 9.1 Updated S-P-R

9.5 Assessment of Current Groundwater Impacts & Extent of Plumes

Based on average values of Ammoniacal Nitrogen levels between 2009 and 2014 the rule of thumb of 100xGTV was not exceeded in any groundwater monitoring well. The highest level recorded was 2.63 mg/l in BH1 which is approximately 15 times the GTV. It is noted that no immediate downgradient monitoring wells currently exists between the landfill body and the River Finn. It is also unclear if BH1 is truly downgradient of the waste body or being impacted due to its proximity to the waste.

In accordance with the Water Framework Directive (WFD), the groundwater contaminant levels are unlikely to affect the status of the Raphoe GWB or likely to pose a risk to the objectives of the Water Framework Directive. The prevention of hazardous of substances entering the groundwater system is being maintained. Limiting the ingress of non-hazardous substances is being met by the mitigation measures that have been installed to date at the site and will be limited even further on completion of the reed bed/constructed wetland treatment system currently being installed at the site which will provide treatment of the leachate for the first time. It is anticipated that the new leachate treatment system will be fully operational in 2016.

The following points are noted:

- No groundwater users are located downgradient of the landfill site.
- The area of impact from the landfill leachate is considered to be minor relative to the groundwater body catchment area of the Raphoe GWB *i.e.* < 0.01%;
- Given the proximity to the landfill to the river, no significant plume, if any, is envisaged.
- The strength of the leachate is considered to be relatively low. Clear evidence exists that demonstrates the strength of leachate within the waste body is reducing over time.
- No groundwater monitoring well between the waste body and the River Finn exists and therefore the true contaminant groundwater flux to the river is unclear.
- The site in its present condition appears to be having a low impact on the quality of the River Finn with surface water discharges from the landfill site drains the dominant pathways for contaminant flux. No impact to the current WFD status of the river is anticipated. Additional monitoring is recommended to ascertain the impact occurring – in particular on completion of the current site restoration/remediation works.

10 REMEDIAL STRATEGY

Based on this hydrogeological assessment and the identified potential risk posed to the River Finn, the following actions are recommended to support the existing data set for the site, to confirm the level of risk posed and to identify possible mitigation solutions, if deemed necessary.

- **It is noted that Churchtown Landfill is currently in the process of a new pilot remediation solution involving constructed wetlands and willow plantations. This programme of works is expected to significantly improve the current contaminant conditions presence at the site. Therefore the assessment undertaken within this report is based on previous and recent contaminant conditions and a reassessment of site conditions will be required following a period of 12 months post-completion of the works.**

- Given the uncertainty surrounding the installation and location of monitoring well BH1, two wells are recommended along the southern boundary (*i.e.* between the waste body and the River Finn). In addition, a separate bedrock well is recommended in the vicinity of BH1 to ascertain impacts to deeper groundwater from the waste body. These additional wells will provide a more accurate understanding of true shallow groundwater contaminant fluxes from the waste body. Given the soft ground conditions present between the waste body and the river it is proposed to drill shallow boreholes/piezometers by hand-held window sampling techniques. Very soft ground conditions and access restrictions in this area will not facilitate the drilling of bedrock boreholes between the waste body and the River Finn.

- Hydraulic conductivity testing should be undertaken in all monitoring wells across the site to provide accurate understanding of contaminant fluxes to the river.

- Flow monitoring within both boundary drains should be undertaken to facilitate assimilative capacity assessments of discharges to the River Finn post remediation works.

- All iron ochre staining in all surface water drains should be appropriately remediated by excavation following completion of all current remediation works for the site to minimise the remobilisation of contaminated sediments in the drains post remediation.

- The current water monitoring programme as per the current EPA licence requirements and limited additional monitoring as detailed in **Table 11.1** are recommended.

- Laboratory Limits of Detection for Total Phenols should be reduced to <0.05 µg/l.

- Sampling protocol should be as per present and should include the filtration of samples for metal analysis.

- Due to uncertainty relating to quality of the laboratory results provided, in particular surrounding reported units of Iron, clarification from Donegal County Council laboratory is recommended going forward in relation to required detection and reporting limits and quality control.

- It is noted that SW5 is currently sampled from an adjacent site drain at the site. However, it is considered more beneficial if the sample location was collected from the River Finn within the mixing zone of the SW4 drain and the river.

- Appropriate surface water sampling locations and methodologies within the River Finn should be determined to ensure consistent monitoring results over time and to more accurately assess the impact of the landfill on the river.

11 COMPLIANCE MONITORING

Discharge activities subject to Tier 2 or Tier 3 assessments must undertake compliance monitoring to verify predicted impact and check compliance with terms of the authorisation. Compliance monitoring dictates that receptor-based water quality standards (or threshold values) should not be exceeded at receptor locations. For this reason sampling is conducted to monitor water quality at receptors, as appropriate.

11.1 Compliance Monitoring Locations

A compliance point is the point (location, depth) at which a compliance value should be met. Generally it is represented by a borehole or monitoring well from which representative groundwater samples can be obtained. In this case, the aim is to monitor groundwater before it enters the River Finn, downgradient of the site.

It is proposed that the existing groundwater monitoring programme be continued at the site until completion of the current remediation works at the site and the recording of at least 12 months of monitoring data post works completion. A reassessment of the proposed monitoring wells in **Section 10.0** can be reassessed on completion of an updated CSM at this stage. The existing downgradient monitoring wells are considered to be partially suitably to provide appropriate downgradient compliance monitoring locations.

11.2 Compliance Values

A compliance value is the concentration of a substance and associated compliance regime that, when not exceeded at the compliance point, will prevent pollution and/or achieve water quality objectives at the receptor. In this case, the aim is to protect surface water quality in the area.

The general chemical assessment test identifies groundwater bodies where widespread deterioration in quality has, or will, compromise strategic use of groundwater for existing or planned, human consumption and/or other potential purposes. Schedule 5 of the Groundwater Regulations (SI 9 of 2010) lists Threshold Values for selected parameters that are indicative of potential pollution events when exceeded**.** Where significant and sustained upward trends are identified, correcting action must be taken.

Based on the recorded groundwater quality data to-date at Churchtown Landfill, there are **no sustained upward trends in groundwater contaminant export from the site**. In addition, all parameters when detected above the GTV are significantly below the 100xGTV rule of thumb and confirm that the landfill is not affecting the WFD status of the groundwater body.

Given the existing relatively good groundwater quality both upgradient and downgradient of the landfill, it is proposed to assign compliance values based on a combination of the existing 2010 GTVs, EPA IGVs and 2 x standard deviation levels of the mean values since 2010. Exceedance of these compliance levels (see **Table 11.1**) warrants further assessment. Any exceedances should also be considered in conjunction with a trend analysis of the data to ascertain increasing levels over time. Levels below these compliance values in addition to downward or stable trends confirm that the impact or risk of the landfill on groundwater and surface waters is acceptable.

It is noted that there are on-going remediation works at the site. These works will further reduce the groundwater and surface water fluxes from the site and will further reduce the risk posed to the River Finn.

Sample ID	Current Monitoring Parameter	Current Monitoring Frequency	Proposed Monitoring Parameter	Proposed Monitoring Frequency
Groundwater Monitoring BH1, BH3 & BH4 and 3 no. proposed additional monitoring wells	Groundwater levels, Ammoniacal Nitrogen, Chloride, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, Potassium, Sodium, TON, TOC, Nitrate, Nitrite, Phenols. Visual Inspection/Odour.	Quarterly	EC, pH, DO & Temp (field parameters) Groundwater levels, Ammoniacal Nitrogen, Chloride, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, Potassium, Sodium, TON, TOC, Nitrate, Nitrite, Phenols. Visual Inspection/Odour.	Annually and then review post remediation and CSM review
	Boron, Cadmium, Calcium, Chromium, Copper, Cyanide, Fluoride, Iron, Lead, List I & II organic substances, Manganese, Magnesium, Mercury, Sulphate, Total Alkalinity, Total Phosphorous, Residue on evaporation, Zinc, Faecal Coliforms, Total Coliforms	Annually	Heavy Metals (*i.e.* Bo, Cd, Ca, Cr, Cu, Cn, F, Pb, Mg, Mn, Hg, Zn) Residue on Evaporation ORP, Sulphate, Manganese	Annually and then review post remediation and CSM review
	TPH VOCs/sVOCs	Once-off	No change	Review post remediation and CSM review
Leachate Wells (L1, L2 & L3)	Groundwater levels, Ammoniacal Nitrogen, Chloride, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, Potassium, Sodium, TON, TOC, Nitrate, Nitrite, Phenols. Visual Inspection/Odour.	Quarterly	Groundwater levels, Ammoniacal Nitrogen, Chloride, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, Potassium, Sodium, TON, TOC, Nitrate, Nitrite, Phenols. Visual Inspection/Odour.	Quarterly continued and reducing to biannual post remediation and CSM review
	Boron, Cadmium, Calcium, Chromium, Copper, Cyanide, Fluoride, Iron, Lead, List I & II organic substances, Manganese, Magnesium, Mercury, Sulphate, Total Alkalinity, Total Phosphorous, Residue on evaporation, Zinc, Faecal Coliforms, Total Coliforms	Annually	Boron, Cadmium, Calcium, Chromium, Copper, Cyanide, Fluoride, Iron, Lead, List I & II organic substances, Manganese, Magnesium, Mercury, Sulphate, Total Alkalinity, Total Phosphorous, Residue on evaporation, Zinc, Faecal Coliforms, Total Coliforms	Annually
	TPH VOCs/sVOCs	Once-off	No change	Once-off post CSM review
Surface Water River Finn SW6, SW3 & SW7, Drains SW1, SW2, SW4 & SW5	Ammoniacal Nitrogen, BOD, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, TSS, Chlorine, Copper, Nitrate, Nitrite, Phenols, Zinc	Quarterly	Ammoniacal Nitrogen, BOD, Dissolved Oxygen, Electrical Conductivity, pH, Temperature, TSS, Chlorine, Copper, Nitrate, Nitrite, Phenols, Zinc, Iron, Lead, ORP	Quarterly continued and reducing to biannual post remediation and

Sample ID	Current Monitoring Parameter	Current Monitoring Frequency	Proposed Monitoring Parameter	Proposed Monitoring Frequency
				CSM review
	COD, Chloride	Quarterly	No change	Quarterly continued and reducing to biannual post remediation and CSM review
	Cadmium, Calcium, Chromium, Iron, Lead, List I & II organics, Magnesium, Manganese, Mercury, Potassium, Sulphate, Sodium, Total Alkalinity, Total Phosphorous, TON.	Annually	No change	Annually

Table 11.1 Proposed Monitoring

Monitoring Well	Parameter	Compliance Value	Source
All groundwater monitoring wells	Lead	18.5 µg/l	2010 GTV
	Ammoniacal Nitrogen	BH3 (0.175 mg/l) BH4 (0.175 mg/l) BH1 (2.08 mg/l)	2010 GTV 2010 GTV 2 times Standard Deviation of the mean from 2009
	Electrical Conductivity	1000 µS/cm	EPA IGV
	Sulphate	187.5 mg/l	2010 GTV
	Iron	200 µg/l	2007 Drinking Water Regulations
	Manganese	50 µg/l	EPA IGV
	Chloride	BH3 (46.8 mg/l) BH4 (36.5 mg/l) BH1 (50.35 mg/l)	2 times Standard Deviation of the mean
	Dissolved Oxygen, pH, Temperature, Fluoride, Total Alkalinity, Orthophosphate, Total Oxidised Nitrogen, Total Organic Carbon	-	EPA IGVs, 2010 GTVs & 2007 Drinking Water Regulations
	Metals/Non-Metals (*i.e.* B, Cd, Ca, Cr, Cu, Hg, Pb, Mg, Ni, K, Na and Zn)		EPA IGVs, 2010 GTVs & 2007 Drinking Water Regulations
	Hazardous Substances (*i.e.* VOCs & SVOCs, Total Hydrocarbons)	-	EPA IGVs, 2010 GTVs & 2007 Drinking Water Regulations
All Surface Water Monitoring Locations	As per existing licence requirements	-	2009 Surface Water Regulations & 2007 Drinking Water Regulations

Table 11.2 Proposed Monitoring Parameter Thresholds

12 SUMMARY & CONCLUSIONS & RECOMMENDATIONS

- A hydrogeological risk assessment of Churchtown Landfill Site was undertaken by BREL based on previous investigation reports and monitoring data between 2006 and 2015.

- Churchtown Landfill is a former solid waste facility where historically waste was landfilled into bunded cells which were excavated from the in-situ cohesive alluvial subsoils. The excavated soils were then used in bund construction. When landfilling ceased at Churchtown the final area of the waste body was approximately 5 hectares and waste body forms a plateau shape compared to the adjacent lands.

- The site is an unlined site historically operated on a dilute and disperses principal, whereby solid waste was tipped directly onto the underlying excavated surface with leachate allowed to percolate directly through the soils with no engineered liner installed. Landfilling began in 1987 and the site ceased operations on the 31st August 2000

- On the 19th May 2000 the Environmental Protection Agency granted the Council a Waste Licence (registration number WL62-1) for the orderly closure, capping and restoration of the landfill facility, in accordance with the Third Schedule of the Waste Management Act, 1996.

- The hydrogeological regime across the landfill comprises two groundwater bodies (*i.e.* one within the waste body and a separate groundwater body within the overburden/shallow bedrock) that are likely to be hydraulically connected. A third groundwater body within the bedrock and flowing under pressurised artesian conditions may also be present based on the conditions encountered within monitoring well BH4. Shallow groundwater interacts with the waste mass and facilitates the generation of leachate.

- Groundwater level variability in the area significantly impacts on leachate levels within the waste body. The correlating increases and reductions in groundwater and leachate levels confirm this scenario with groundwater appearing to intersect the waste body. Groundwater level variations and levels upgradient of the site have a differing signature to groundwater levels closer to the River Finn. This suggests that the river is partially impacting on groundwater downgradient of the landfill.

- Following a review of the preliminary Conceptual Site Model for the site and all available water monitoring data, a revised Conceptual Site Model (CSM) was developed based on available information and monitoring data and identified a number of SPR linkages ranging from Low to Moderate risk to identified sensitive receptors *i.e.* the River Finn and the Raphoe GWB.

- The SPR linkage of concern relates to:

  ✓ The vertical migration of leachate from the unlined waste cells to the underlying shallow groundwater aquifer which subsequently flows to the River Finn.

- The raw leachate results from the landfill are considered to represent a landfill in the methanogenic stage of decomposition of organic compounds. The leachate is considered to be relatively low strength and the levels, which are reducing over time, are expected to reduce further.

- Groundwater quality data does not indicate any upwards trends over time. This is expected to continue following completion of the current remedial measures. The only upward trend was recorded within BH1 with a single elevated level of Ammoniacal Nitrogen recorded in September 2013. On-going monitoring of this detected level in conjunction with a trend analysis on receipt of sufficient monitoring data over time is recommended.

- Both groundwater and surface water contaminant fluxes from the landfill have the potential to impact on the quality of the River Finn. However, available data suggests that groundwater contaminant fluxes to the river are having a negligible effect on the river downstream of the landfill. It is noted that a more representative downgradient monitoring well is required between the landfill and the river to provide a more accurate determination of this flux.

However, it also noted that site access to a suitably located downgradient monitoring may be restricted due to the proximity to the river and soft ground conditions. In relation to surface water discharges, available data suggests that surface water discharges to the river representative the predominant contaminant load to the river. The effects of this loading on the river are considered to be low with significant dilution capacity available within the river itself.

- Based on the water quality data, the landfill does not affect the current status of the River Finn and is in accordance with the WFD objectives.

- The rule of thumb of 100xGTV has not been exceeded in any groundwater monitoring well at the site. The highest Ammoniacal Nitrogen level recorded was 2.63 mg/l in BH1 (February 2009) which is approximately 15 times the GTV. In accordance with the Water Framework Directive (WFD), these levels are not likely to affect the status of the Raphoe GWB nor potentially pose a risk to the objectives of the Water Framework Directive. No groundwater contaminant plume has been identified to-date from the existing groundwater monitoring network.

  The following points are noted:

  - ✓ No groundwater users are located downgradient of the landfill site.
  - ✓ The area of impact from the landfill leachate is considered to be minor relative to the groundwater body catchment area of the Raphoe GWB *i.e.* < 0.01%;
  - ✓ Given the proximity to the landfill to the river, no significant plume, if any, is envisaged.
  - ✓ The strength of the leachate is considered to be relatively low. Clear evidence exists that demonstrates the strength of leachate within the waste body is reducing over time.
  - ✓ No groundwater monitoring well between the waste body and the River Finn exists and therefore the true contaminant groundwater flux to the river is unclear.
  - ✓ The site in its present condition appears to be having a low impact on the quality of the River Finn with surface water discharges from the landfill site drains the dominant pathways for contaminant flux. No impact to the current WFD status of the river is anticipated. Additional monitoring is recommended to ascertain the impact occurring – in particular on completion of the current site restoration/remediation works.

- The site is compliant with the "prevent" or "limit" objective of the WFD and GWD. The prevention of hazardous of substances entering the groundwater system is being met based on available chemical analysis. Limiting the ingress of non-hazardous substances is also being met by the mitigation measures that have been installed to date at the site *i.e.* landfill capping and lining of surface water drains and mitigations currently being installed *i.e.* active leachate treatment by willow plantations and constructed wetlands.

- Corrective actions undertaken to-date at the site includes:
  - ✓ A permanent landfill capping across the entire waste body;
  - ✓ The development of a willow bed plantation and constructed wetlands over the waste body to treat all leachate generated on site and disposal to the River Finn. This system is currently being developed at the site, and,
  - ✓ On-going groundwater and surface water monitoring as per the licence requirements.

- In summary, based on available site data, the risk posed by Churchtown Landfill on the River Finn is considered to be low in the immediate vicinity of the e landfill. The predominant contamination linkage to the river is via surface water drain discharges from the landfill site to the river. Monitoring data indicates that these discharges are having a low impact on the quality of the River Finn. In addition, it is anticipated that on completion of the current remedial measures being implemented at the site, this impact will reduce further over time.

- A series of additional recommendations to provide a more representative understanding of the contaminant fluxes to the River Finn have been provided in Section 10.0. It is noted that as the site is actively undergoing remediation works, it is proposed that these recommendations are considered after at least 12 months of groundwater level and water quality monitoring post full

completion of the works. A revised CSM will be undertaken at this stage and the proposed recommendations reassessed. In the meantime, the current monitoring programme is considered sufficient as an interim measure until completion of the remediation works.

ooOOoo

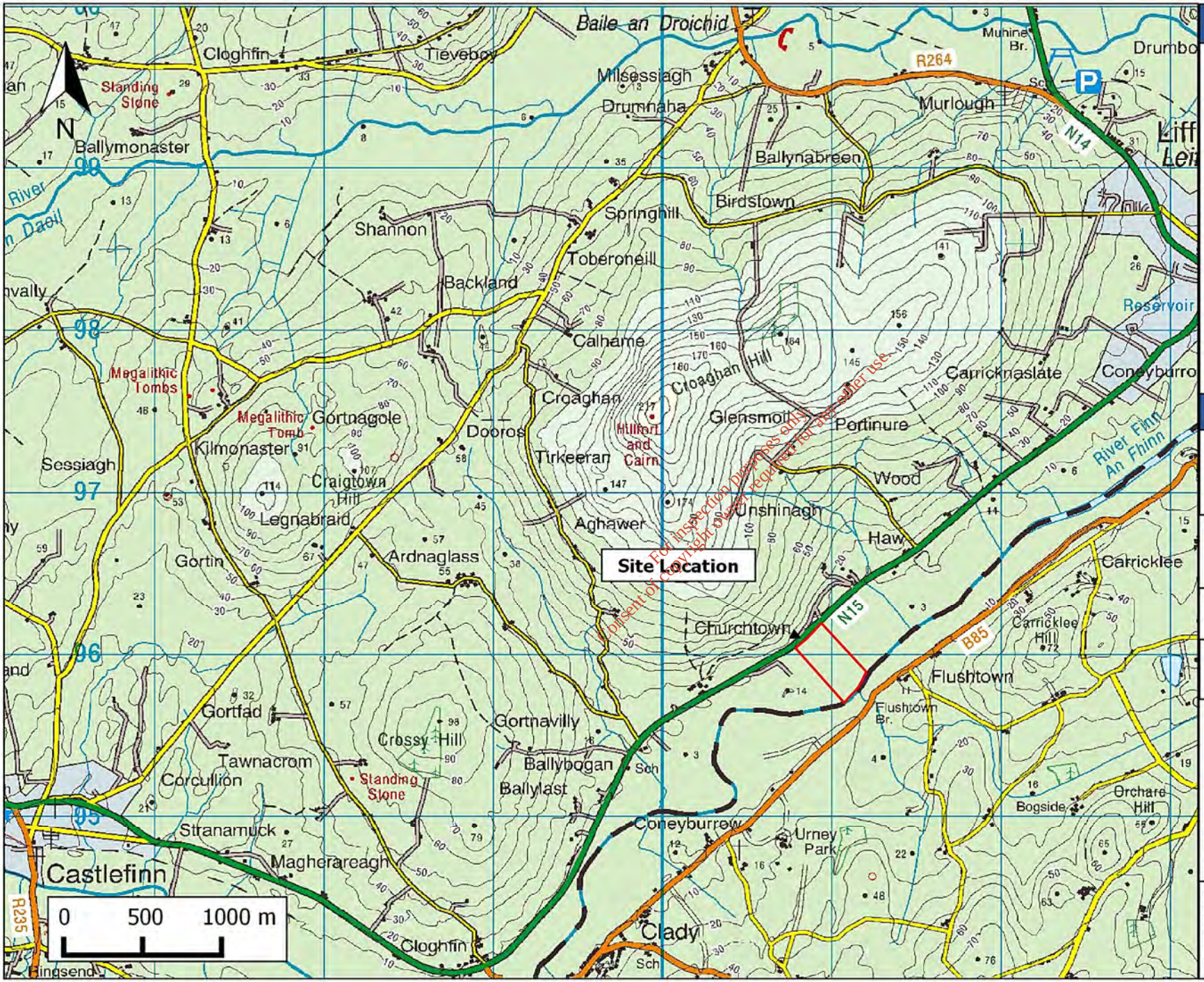
Respectfully submitted by

Niall Mitchell

Hydrogeologist / Chartered Engineer

On behalf of Donegal County Council (Waste Licence No. WL62-1)

FIGURES



Legend

Landfill Location

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure 1**

Title: **Site Location**

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File Ref :	BRE14023
Drawing Ref :	BRE14023DG01
Revision :	V01
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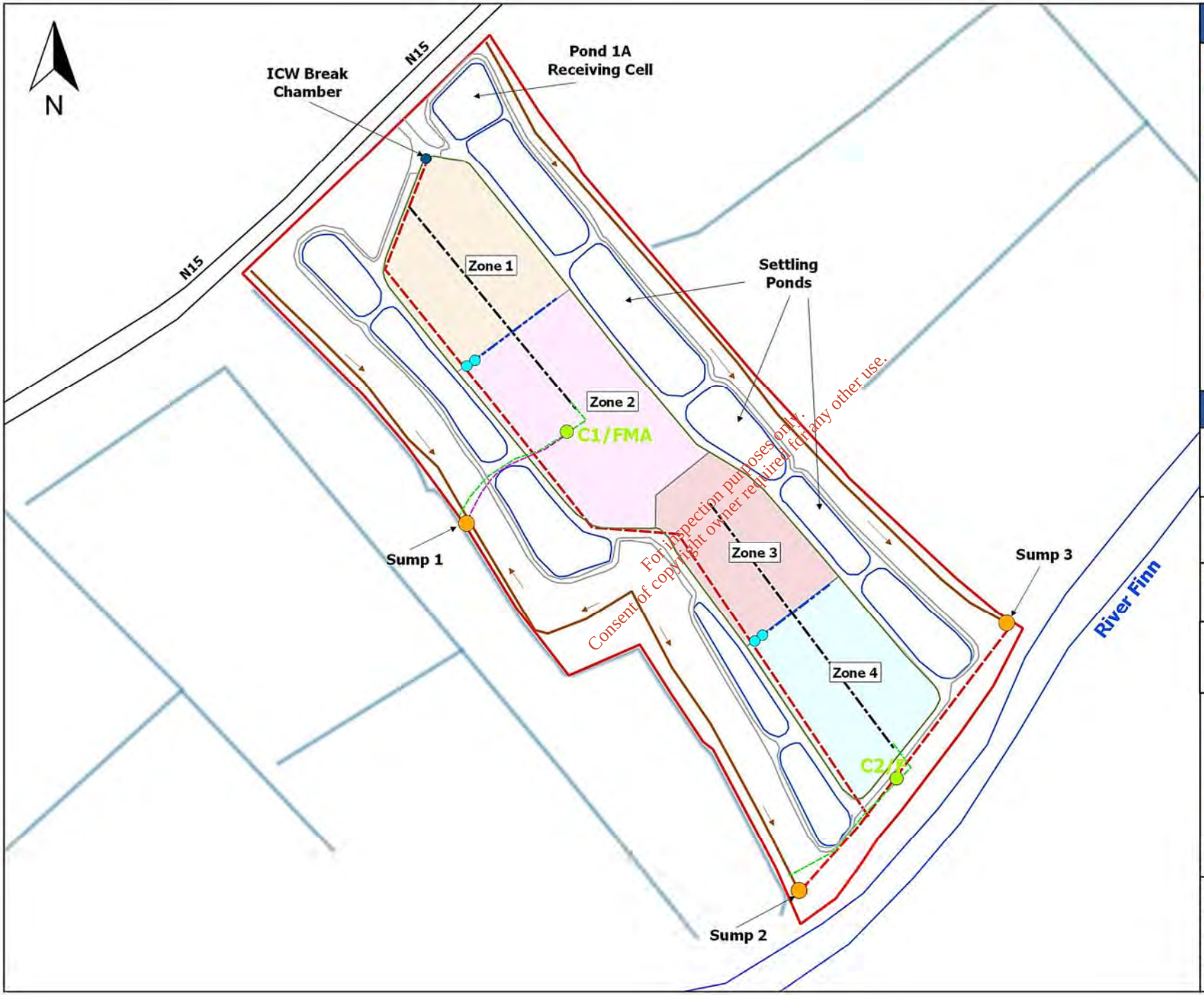

Legend

- Site Boundary
- Leachate Distribution
- Distribution Pipes
- Outfall Pipe (Collection Sump)
- Outfall Pipe
- French Drain
- Leachate Toe Drain
- 90mm HDPE Pumping Main

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure 2**

Title: **Site Layout**

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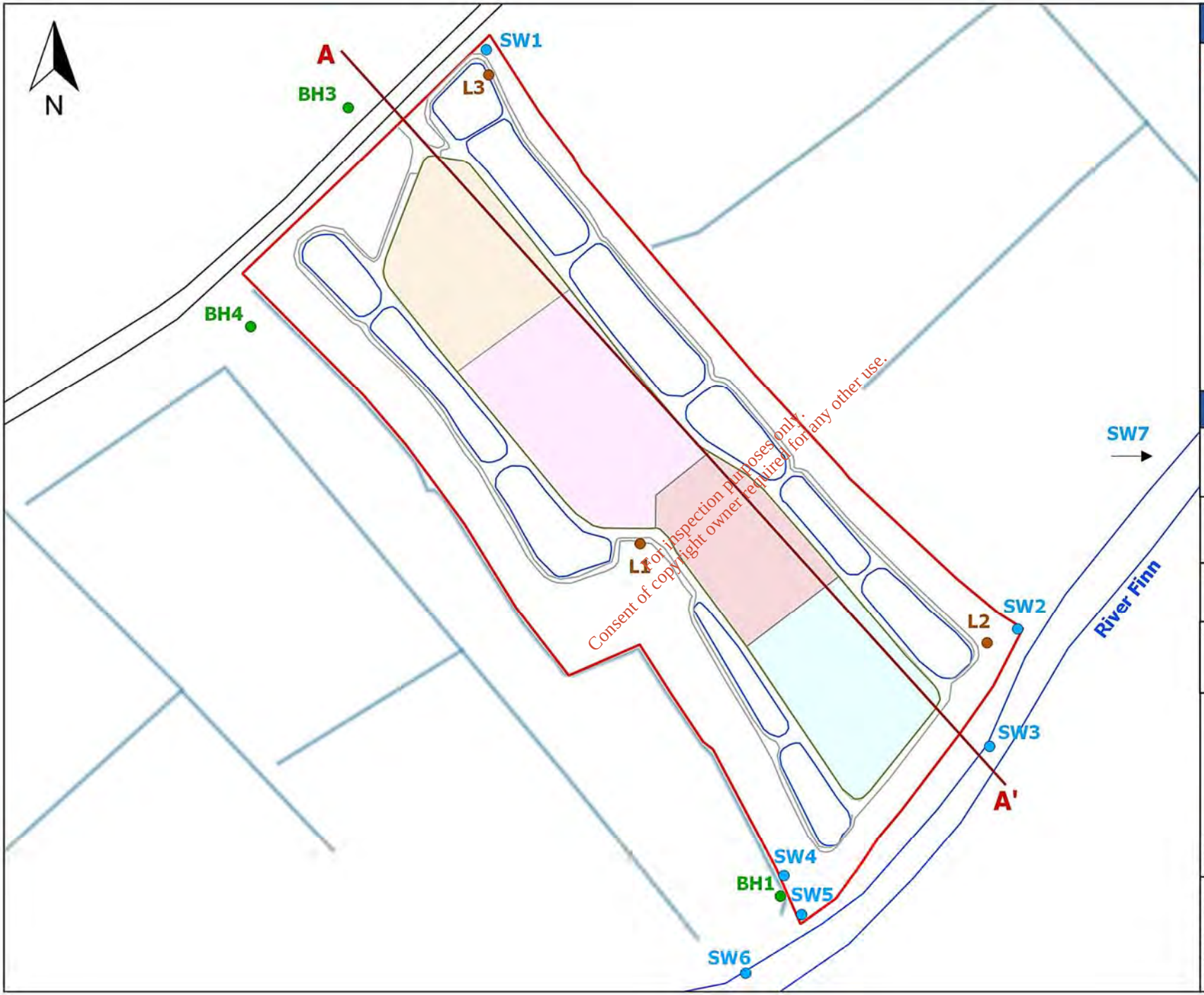

Legend

- Site Boundary
- Groundwater Monitoring Boreholes
- Leachate Monitoring
- Surface Water Monitoring
- River Finn
- Local Drains
- Cross Section

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure 3**

Title: **Monitoring Locations**

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Drawing Ref : BRE14023DG03
Revision : V01
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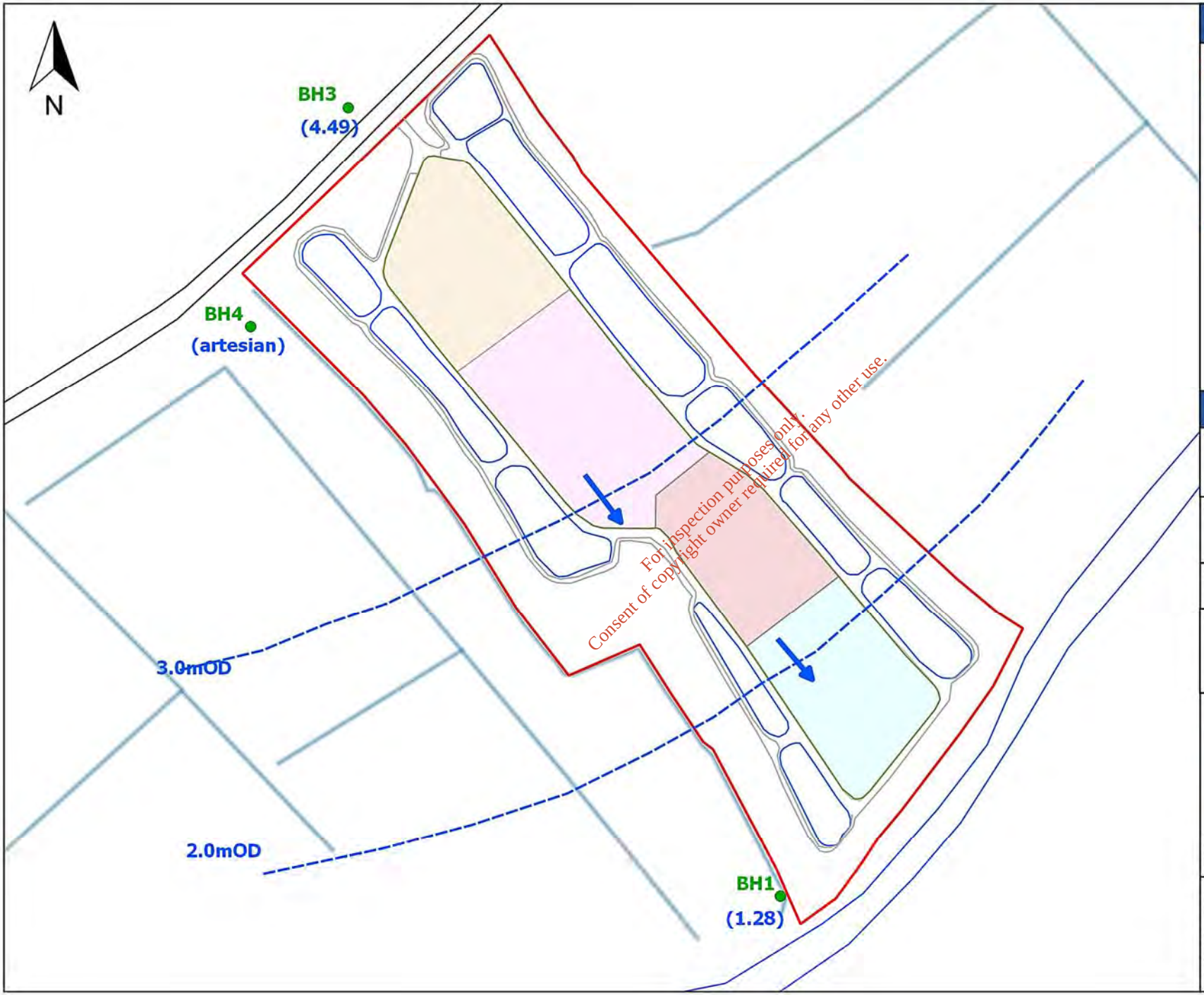

Legend

- Site Boundary
- February 2015 Contours
- Groundwater Monitoring Boreholes
- (1.28) Groundwater Level (metres ordance datum)
- Groundwater Flow Direction

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure 4**

Title: **Groundwater Contours February 2015**

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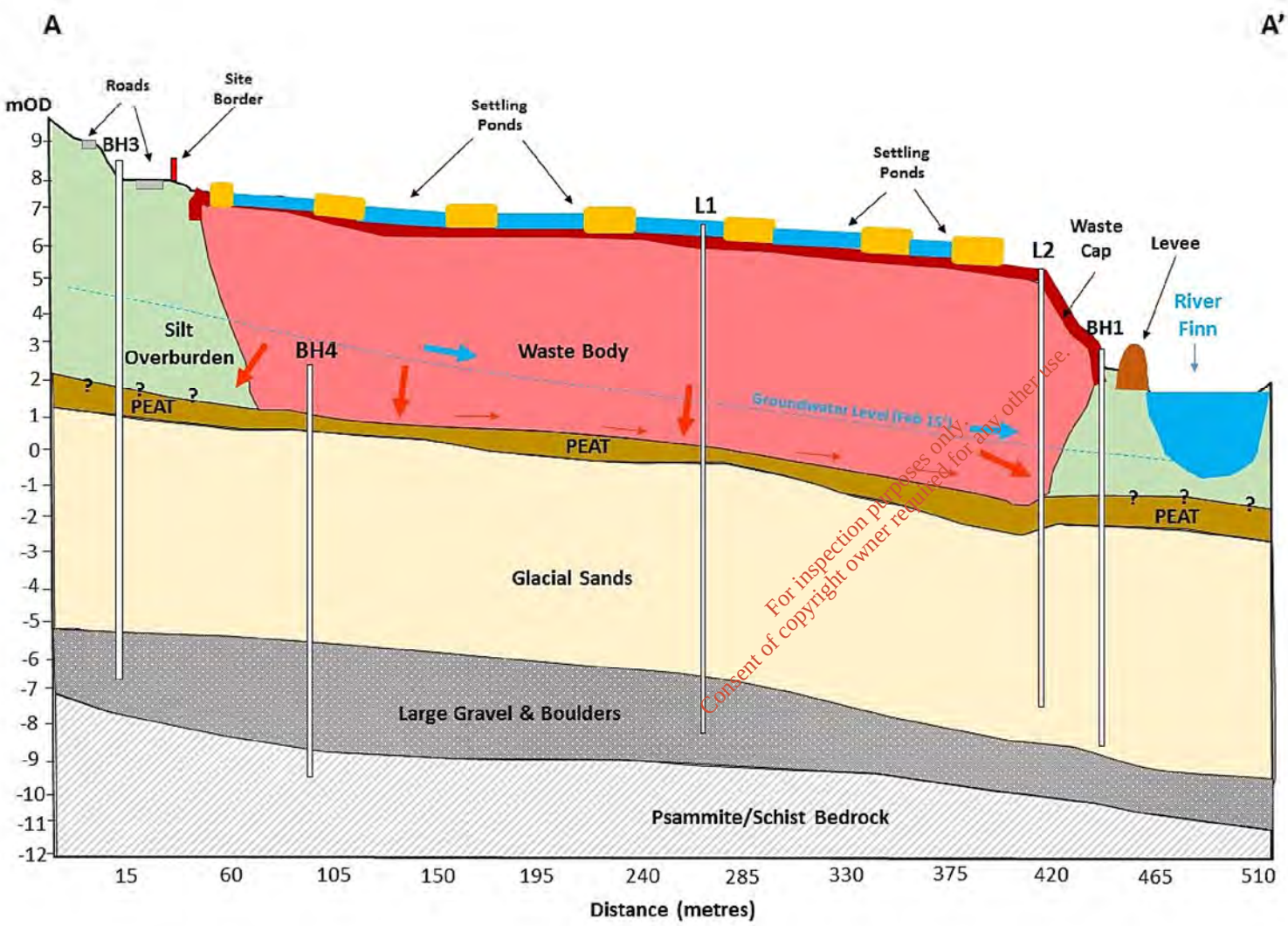

Legend

- Leachate Flow Direction
- Groundwater Flow Direction

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure 5**

Title: **Conceptual Site Model**

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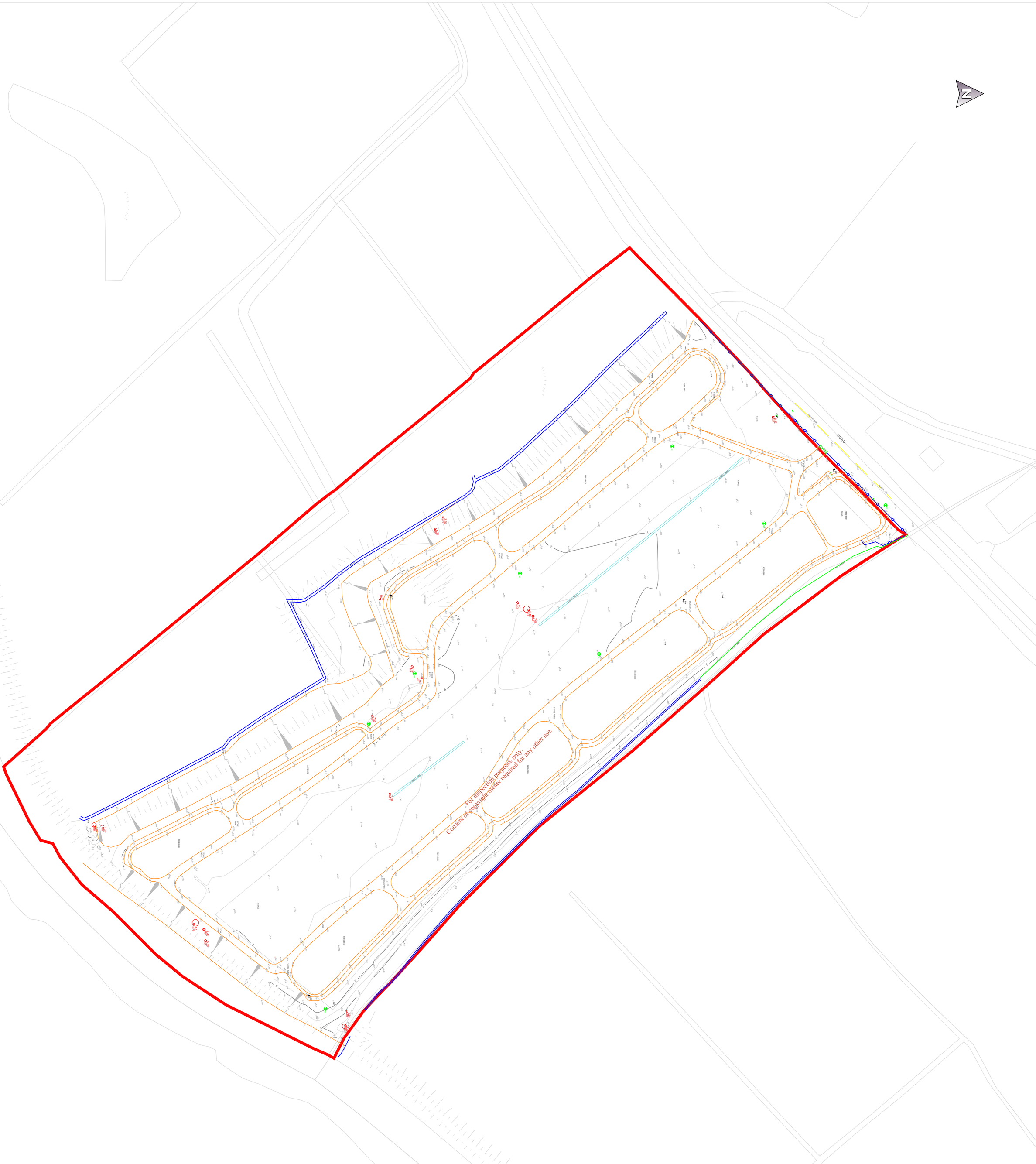
Drawing Ref:	BRE14023DG01
Revision:	V01
Date:	21/04/2015
Drawn by:	SH
Copyright:	OSI EN0075112

APPENDIX A



NOTES

1. Verifying Dimensions.
   The contractor shall verify dimensions against such other drawings or site conditions as pertain to this part of the work.
2. Existing Services.
   Any information concerning the location of existing services indicated on this drawing is intended for general guidance only. It shall be the responsibility of the contractor to determine and verify the exact horizontal and vertical alignment of all cables, pipes, etc. (both underground and overhead) before work commences.
3. Issue of Drawings.
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4. Date Surveyed 05 December 2014 by LSS Survey Services
5. Datum: Malin Head Ordnance Datum
6. Keys

Site Boundary
Reed Bed Pond
Contour Major
Contour Minor
Ditch
Trees
New Fence
Old Fence
Yellow Line
Gate
Duct Chambers
Manholes
Existing Boreholes
Spot Heights

rev	amendments	drawn	date

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Client
Donegal County Council

Project
Churchtown Landfill Site -
Provision of M&E Services

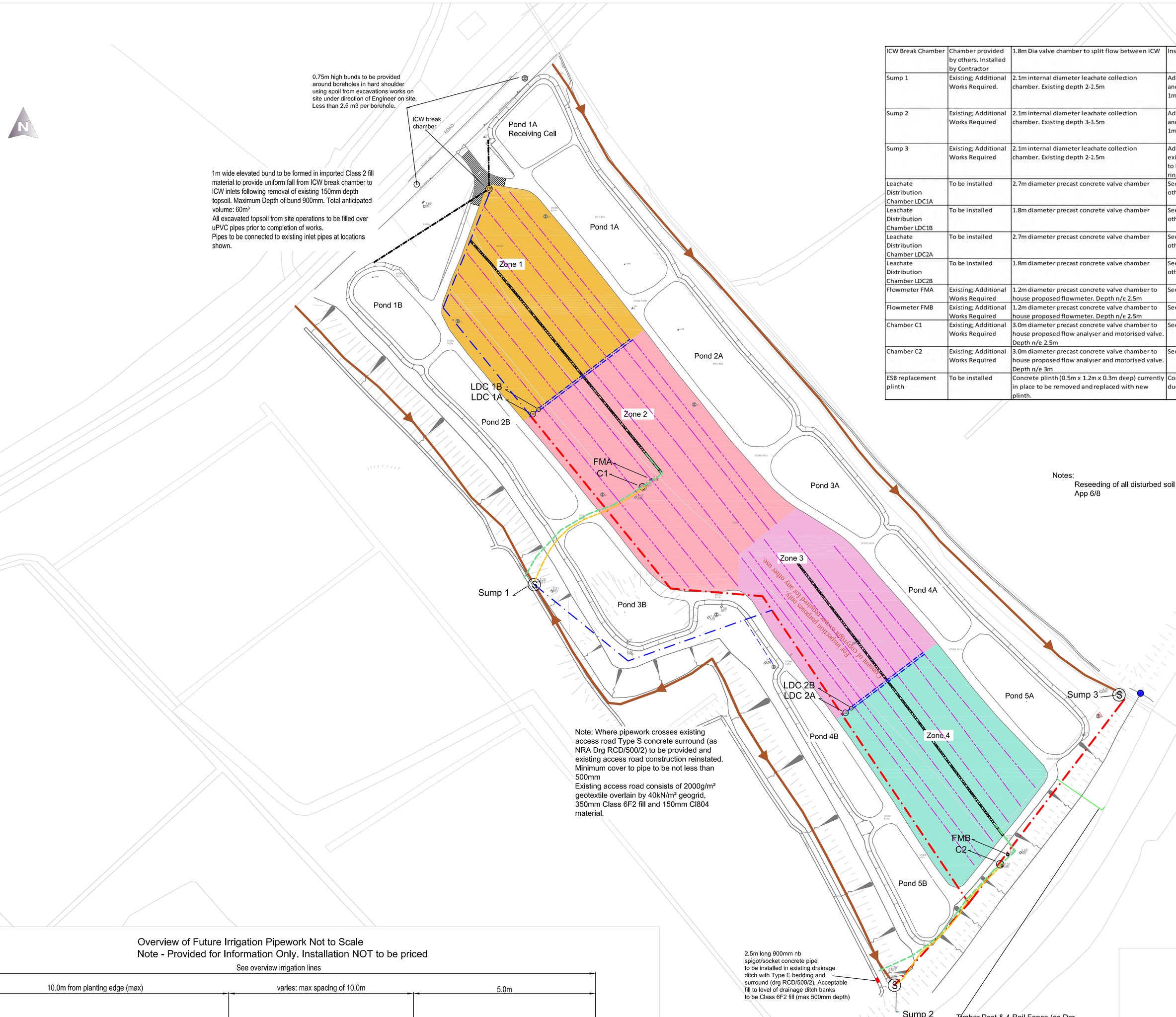
Title
Existing Site Layout

Drawing Status	Sheet Size	Drawing Scale
Tender	A1	1:1000

Drawing Number
IBR0514 /ME101

Rev
0

Project Leader	Drawn By	Date	Initial Review
JB	AMB	Dec '14	JD



ICW Break Chamber	Chamber provided by others. Installed by Contractor	1.8m Dia valve chamber to split flow between ICW	Installation only as per Drg IBR0514/ME103A
Sump 1	Existing; Additional Works Required.	2.1m internal diameter leachate collection chamber. Existing depth 2-2.5m	Additional 1m depth ring to be installed. Cover slab and cover to be replaced. See Drg IBR0514/ME103A. 1m ring and cover slab provided by others
Sump 2	Existing; Additional Works Required	2.1m internal diameter leachate collection chamber. Existing depth 3-3.5m	Additional 1m depth ring to be installed. Cover slab and cover to be replaced. See Drg IBR0514/ME103A. 1m ring and cover slab provided by others
Sump 3	Existing; Additional Works Required	2.1m internal diameter leachate collection chamber. Existing depth 2-2.5m	Additional 1m depth ring and replacement of existing top 0.5m depth ring. Cover slab and cover to be replaced. See Drg IBR0514/ME103A. 1m + 0.5m ring and cover slab provided by others
Leachate Distribution Chamber LDC1A	To be installed	2.7m diameter precast concrete valve chamber	See Drg IBR0514/ME103A. Chamber provided by others
Leachate Distribution Chamber LDC1B	To be installed	1.8m diameter precast concrete valve chamber	See Drg IBR0514/ME103A. Chamber provided by others
Leachate Distribution Chamber LDC2A	To be installed	2.7m diameter precast concrete valve chamber	See Drg IBR0514/ME103A. Chamber provided by others
Leachate Distribution Chamber LDC2B	To be installed	1.8m diameter precast concrete valve chamber	See Drg IBR0514/ME103A. Chamber provided by others
Flowmeter FMA	Existing; Additional Works Required	1.2m diameter precast concrete valve chamber to house proposed flowmeter. Depth n/e 2.5m	See Drg IBR0514/ME103A
Flowmeter FMB	Existing; Additional Works Required	1.2m diameter precast concrete valve chamber to house proposed flowmeter. Depth n/e 2.5m	See Drg IBR0514/ME103A
Chamber C1	Existing; Additional Works Required	3.0m diameter precast concrete valve chamber to house proposed flow analyser and motorised valve. Depth n/e 2.5m	See Drg IBR0514/ME103A
Chamber C2	Existing; Additional Works Required	3.0m diameter precast concrete valve chamber to house proposed flow analyser and motorised valve. Depth n/e 3m	See Drg IBR0514/ME103A
ESB replacement plinth	To be installed	Concrete plinth (0.5m x 1.2m x 0.3m deep) currently in place to be removed and replaced with new plinth.	Construction of ESB concrete plinth and associated ducting and path as per Drg IBR0514/ME105

Notes:
Reseeding of all disturbed soil surface as Spec App 6/8

NOTES

1. Verifying Dimensions.
   The contractor shall verify dimensions against such other drawings or site conditions as pertain to this part of the work.
2. Existing Services.
   Any information concerning the location of existing services indicated on this drawing is intended for general guidance only. It shall be the responsibility of the contractor to determine and verify the exact horizontal and vertical alignment of all cables, pipes, etc. (both underground and overhead) before work commences.
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4. Datum: Malin Head Ordnance Datum
5. Key:

Required Works to be priced and Completeed

- 50mm Ø MDPE Header (Supply) Pipes
- 50mm Ø MDPE Header (Supply) Pipes [between 90mm HDPE main and LDC1B/2B and LDC1A/2A]
- 150mm Ø nb uPVC pipe [between ICW Break chamber and connected to inlets to ICWs]
- 90mm Ø HDPE PE100 Pumping Main
- Proposed 4 Rail Timber Fence to RCD/300/1
- Proposed Wicket Gate to RCD/300/12
- Proposed Ditch Crossing

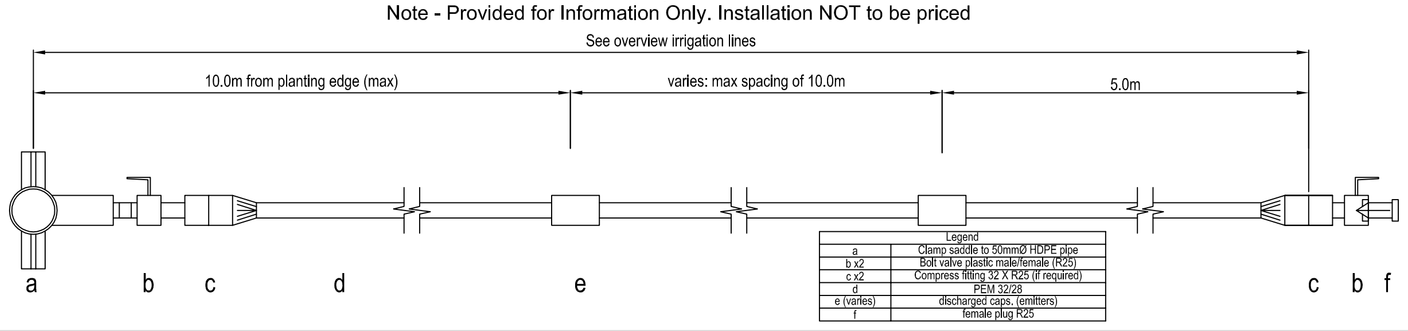
Potential Additional Works. For Information Purposes

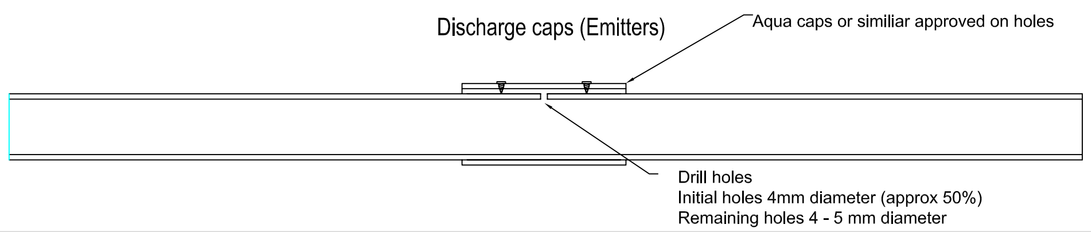
- 32mm Ø PEM Lateral Irrigation Pipes

Existing Infrastructure

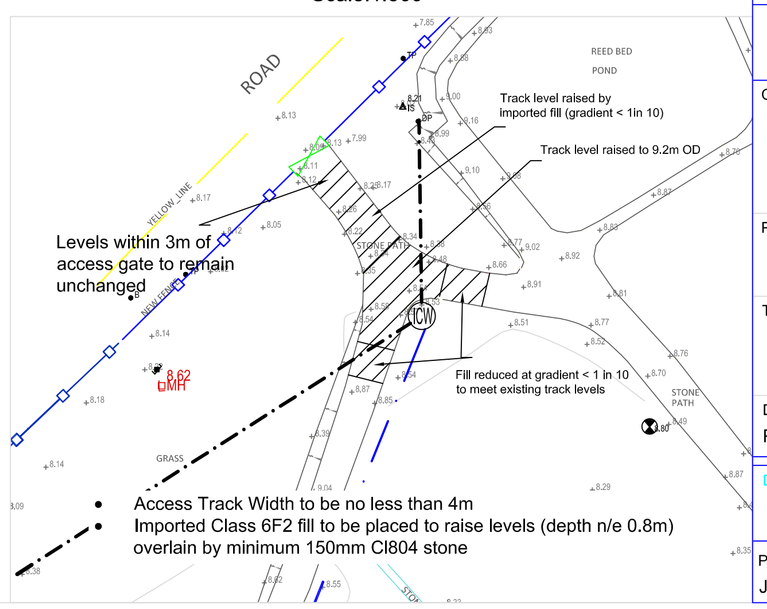
- Existing 150mm Ø HDPE Outfall Pipe [To Drainage Ditch] with 100mm bedding and surround
- Existing 63mm Ø HDPE Outfall Pipe [To Collection Sump]
- Existing Lined French Drain (Runoff Drainage)
- Existing Leachate Toe Drain - Collecting Leachate from beneath landfill cap and discharging to Collection Sump
- Existing Access Track to be raised in level
- +8.54 Existing Ground Levels (mOD)

Overview of Future Irrigation Pipework Not to Scale
Note - Provided for Information Only. Installation NOT to be priced





Access Track Raising
Scale:1:500



- Access Track Width to be no less than 4m
- Imported Class 6F2 fill to be placed to raise levels (depth n/e 0.8m) overlain by minimum 150mm Cl804 stone

rev	amendments	drawn	date
A	Change to work requirements	DR	March 15

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Client
Donegal County Council

Project
Churchtown Landfill Site - Provision of M&E Services

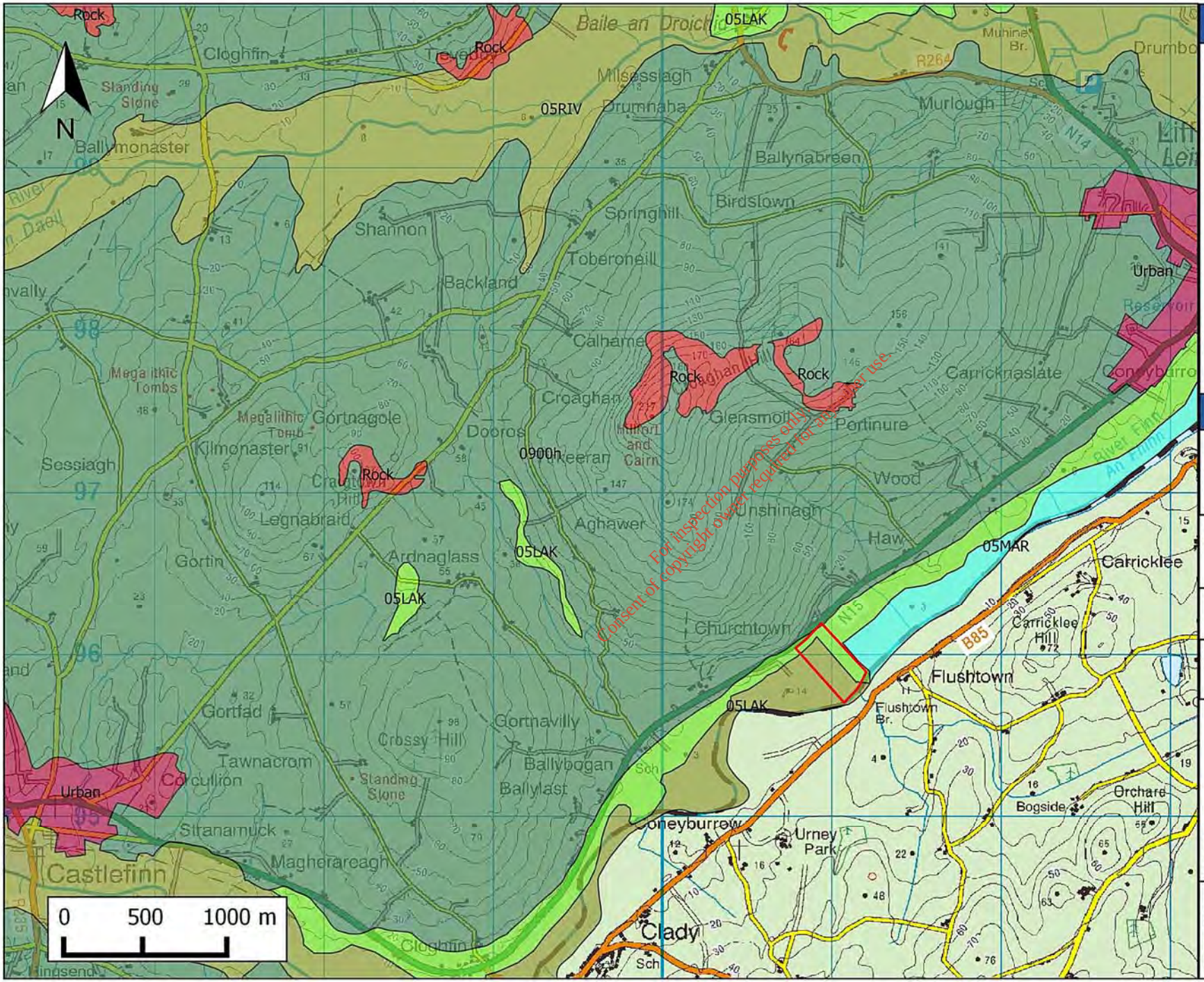
Title
Leachate Management Layout

Drawing Status	Sheet Size	Drawing Scale
Preliminary	A1	1:1000

Drawing Number	Rev
IBR0514 /ME102	A

Project Leader	Drawn By	Date	Initial Review
JB	AMB/DR	Mar' 15	JD

APPENDIX B



Legend

- Churchtown Site Location

Soils Classification

- 05LAK
- 05MAR
- 05RIV
- 0900h
- Rock
- Urban

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure A**

Title: **Soil Classification**

BlueRock Environmental
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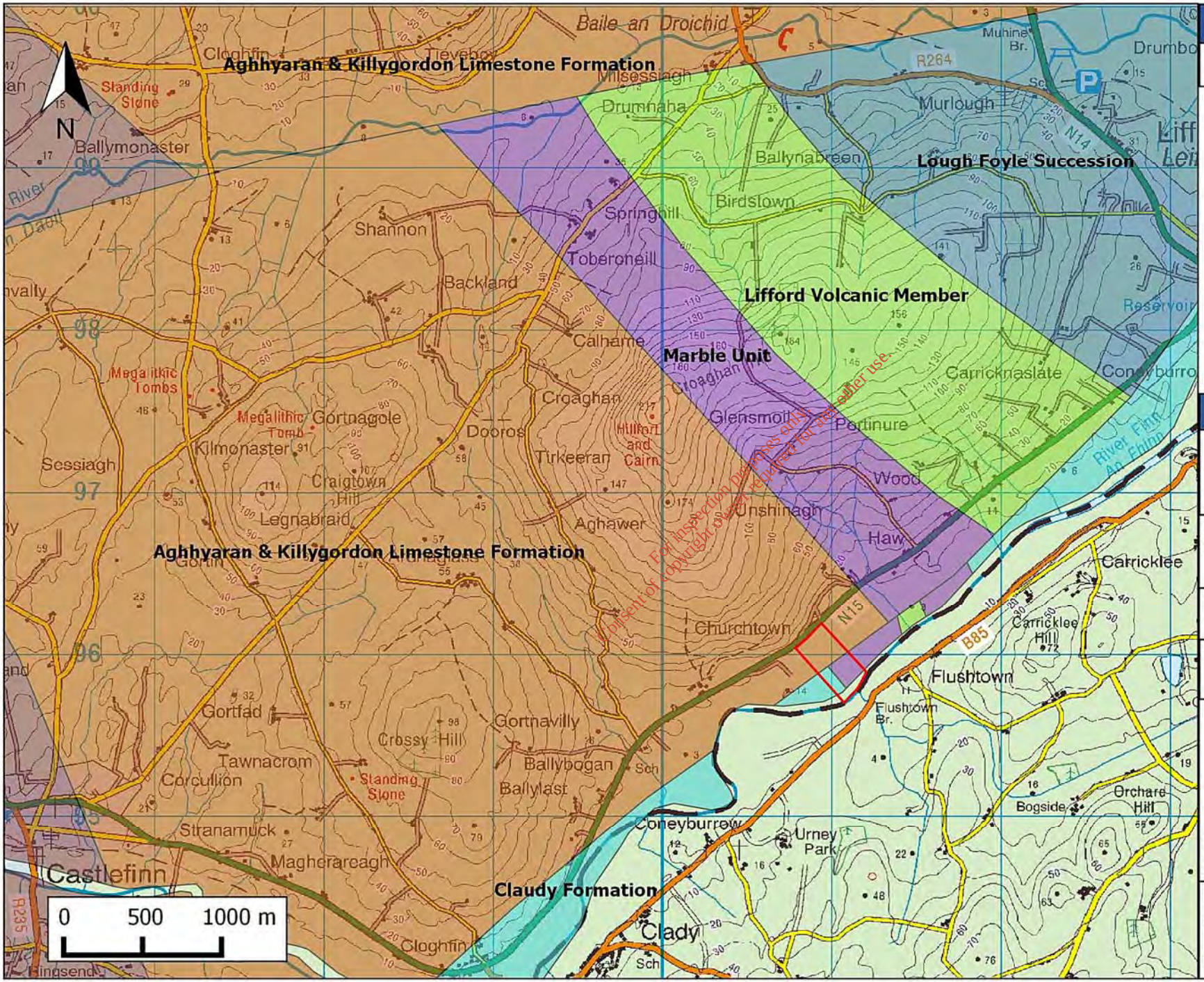
File Ref :	BRE14023
Drawing Ref :	BRE14023DG04
Revision :	V01
Date :	21/04/2015
Drawn by:	SH
Copyright:	OSI EN0075112



Legend

Landfill Location

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure B**

Title: **Bedrock Classification**

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File Ref :	BRE14023
Drawing Ref :	BRE14023DG05
Revision :	V01
Date :	21/04/2015
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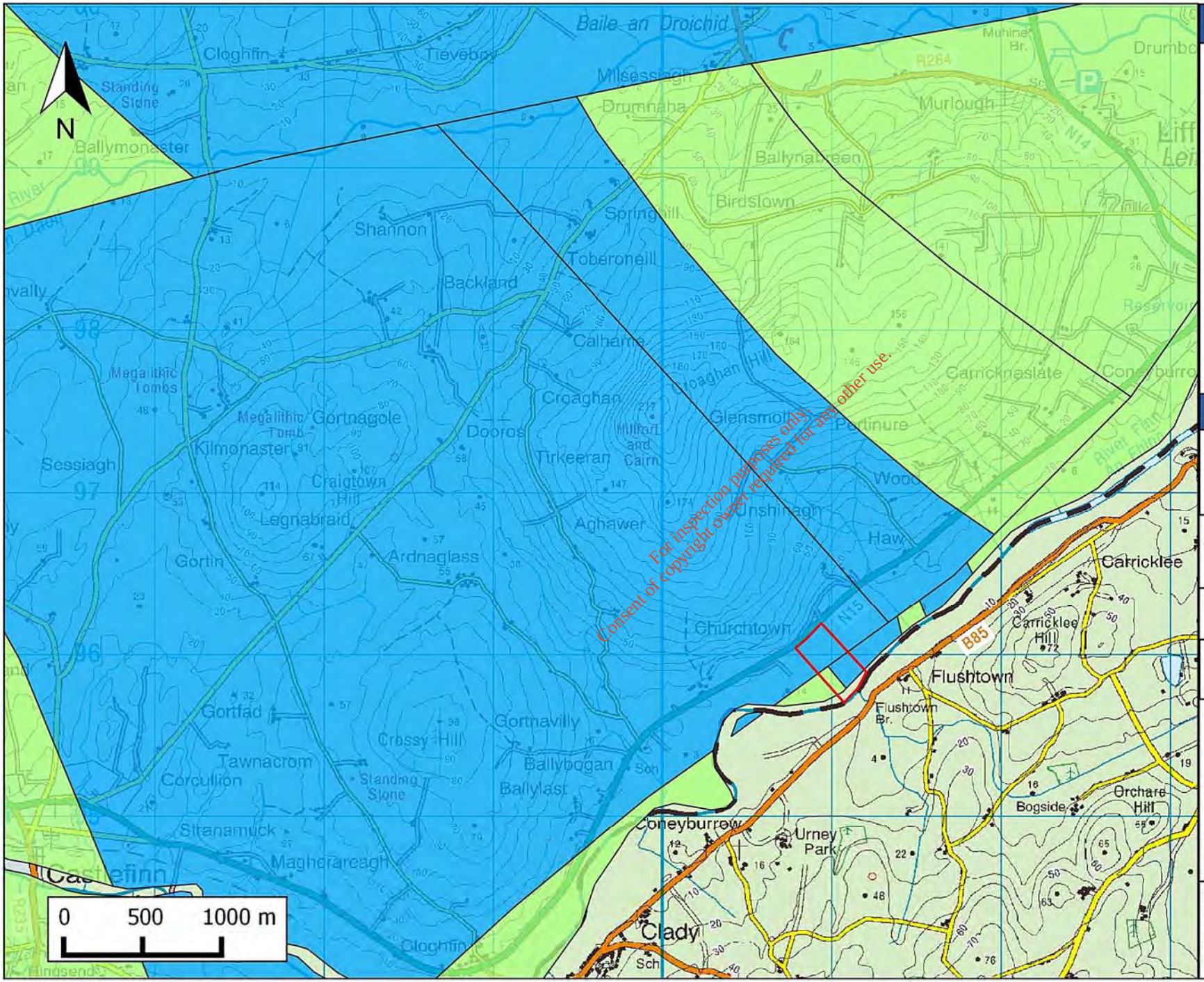

Legend

Landfill Location

Aquifer Classification

- Bedrock which is Moderately Productive only in Local Zones (Ll)
- Bedrock which is Generally Unproductive except for Local Zones (Pl)

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure C**

Title: **Aquifer Classification**

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Drawing Ref :	BRE14023DG06
Revision :	V01
Date :	21/04/2015
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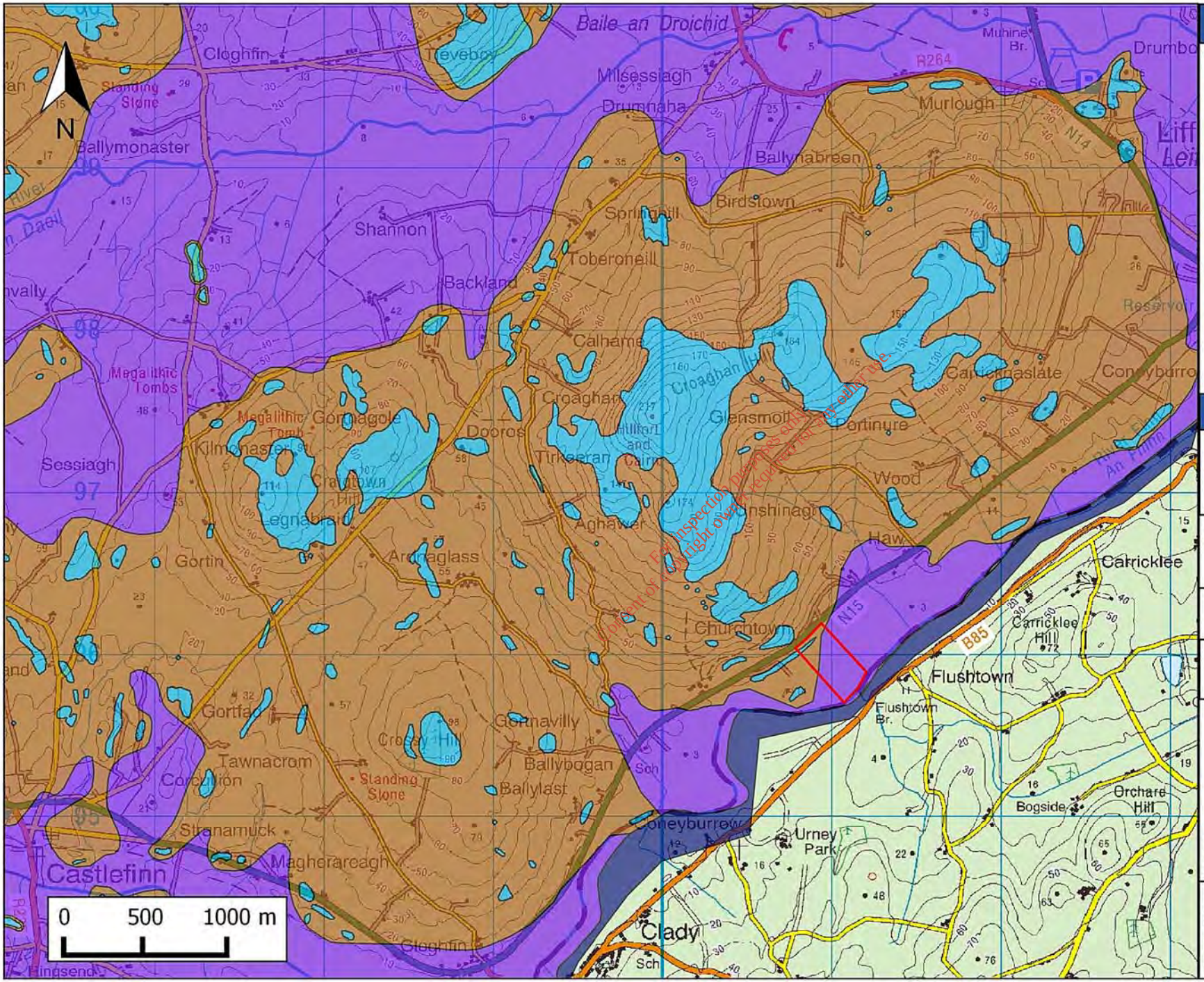

Legend

- Landfill Location

Vulnerability Classification

- Extreme
- Extreme (Rock near Surface or Karst)
- High
- High to Low
- Low
- Medium
- No data

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure D**

Title: **Aquifer Vulnerability**

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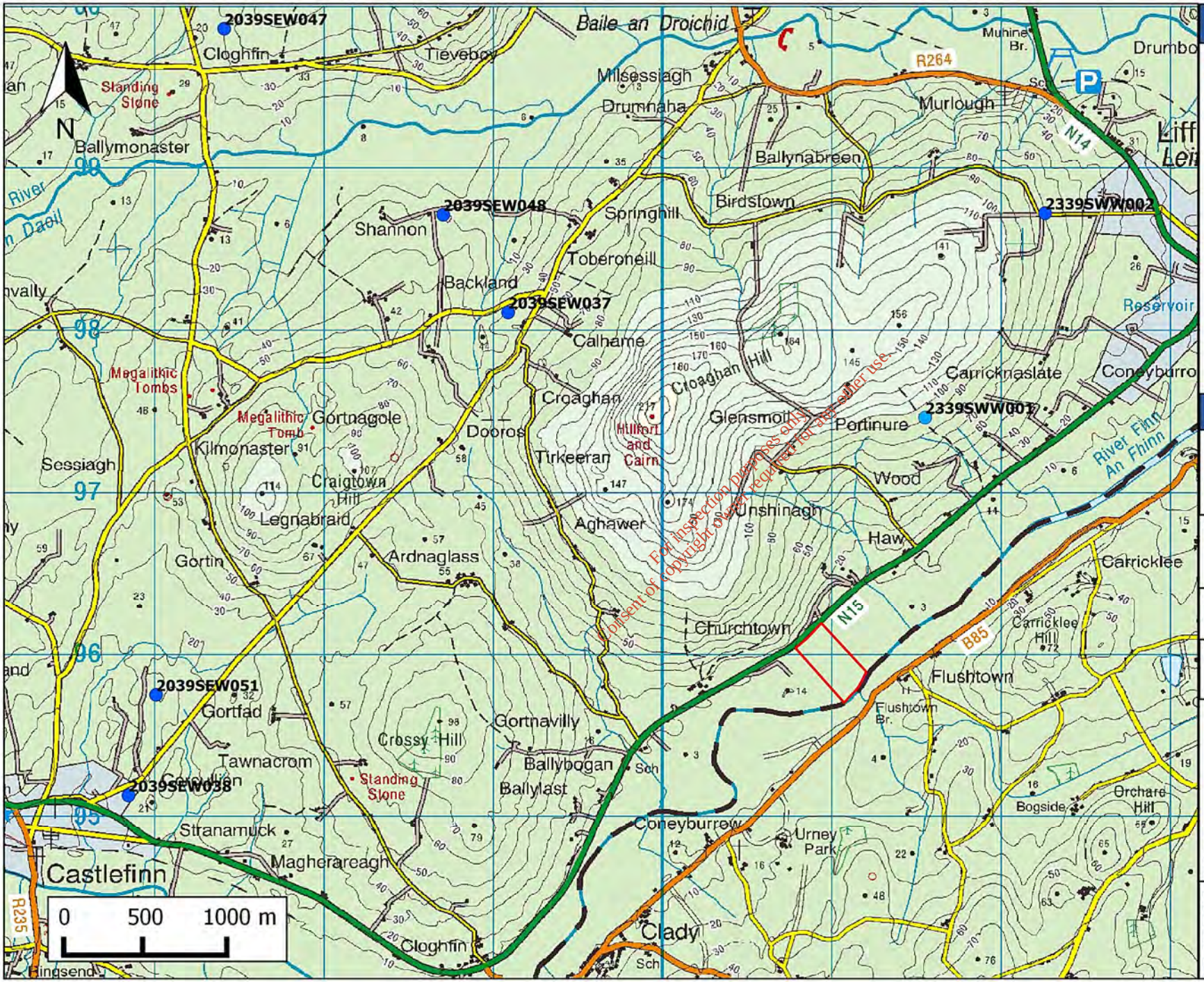
File Ref :	BRE14023
Drawing Ref :	BRE14023DG07
Revision :	V01
Date :	21/04/2015
Drawn by:	SH
Copyright:	OSI EN0075112



Legend

- Churchtown Site Location
- Wells (10-50m accuracy)
- Wells (1km accuracy)

Project

Churchtown Landfill Hydrogeological Risk Assessment

Client: **Donegal County Council**

Drawing: **Figure E**

Title: **GSI Well Locations**

BlueRock Environmental
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File Ref :	BRE14023
Drawing Ref :	BRE14023DG08
Revision :	V01
Date :	21/04/2015
Drawn by:	SH
Copyright:	OSI EN0075112

APPENDIX C

REPLACEMENT WELLS

Drumaboden & Churchtown Landfill Sites County Donegal

Report No: 05-135

Client: Donegal County Council

Engineer: RPS Kirk McClure Morton

May 2005

Drumaboden & Churchtown Landfill Sites
County Donegal
Replacement Wells

CONTENTS Page No.

Methods of describing soils and rocks

Soil descriptions are based on the guidance in Section 6 of BS 5930: 1999, *The Code of Practice for Site Investigation*, with the following exceptions:

1. Where the strength of clay is based on field assessment without the availability of laboratory or in-situ test results the following terms are used, where applicable:

   soft to firm: clay with undrained shear strength close to the BS5930 boundary (40kPa) between soft and firm soil.

   firm to stiff : clay with undrained shear strength close to the BS5930 boundary (75kPa) between firm and stiff soil.

2. The relative density of coarse-grained soils, described in trial pit logs, is based on field observations including stability of pit sides and the ease/difficulty of excavation. The description is for indicative purposes only: as required by BS 5930, the relative density should only be determined by use of insitu tests, including standard penetration tests.

Drumaboden & Churchtown Landfill Sites
County Donegal
Replacement Wells

1 AUTHORITY

On the instructions of the Engineer RPS Kirk McClure Morton, Glover Site Investigations Ltd were instructed to install four replacement gas monitor wells at Drumabodan and Churchtown Landfill Sites in County Donegal on behalf of the Client Donegal County Council.

2 DESCRIPTION OF FIELDWORK

Four boreholes were drilled by means of a Competitor 130 light percussion drilling rig on the 28th and 29th of April 2005. These boreholes were LG6 and LG8 in Drumaboden and LG8 and LG9 in Churchtown. In addition, a new gas valve and flush cover were installed in LG7 at Drumaboden.

Gas monitoring standpipes were installed in each well slotted from the bottom to 1.0 metre below ground level with a gravel pack.

The top metre was backfilled with a bentonite seal and a flush lockable cover was fitted.

A stainless steel plate was installed on the flush cover to aide in identification.

The other headworks were stripped back and the installation pipe-work checked prior to new gas valves and headworks being installed in LG7 at Drumboden.

The original wells which were removed showed no visible signs of damage but were replaced as it was reported that there were no inflows of gas into the well.

The new wells were replaced to best practice standards to maximise inflows of gas into the wells, but if the gas is not present in the strata then there will be no inflows into the replacement wells.

Appendix 1

Borehole Logs

GLOVER SITE INVESTIGATIONS LIMITED

Glover Site Investigations Ltd

Site Drumaboden Landfill Site, County Donegal			**Borehole Number** LG6
Boring Method Competitor 130	**Casing Diameter** 150mm cased to 6.00m	**Ground Level (mOD)**	**Client** Donegal County Council	**Job Number** 05-135
	Location As Plan	**Dates** 28/04/05	**Engineer** RPS KMM	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	TOPSOIL		
						(1.20)	MADE GROUND: Soft to firm light grey brown gravelly sandy CLAY (FILL)		
						1.30	Spongy dark brown pseudofibrous PEAT		
				Water strike(1) at 3.80m.		(3.50)			▽1
						4.80	Uncompact grey organic fine sandy SILT		
				28/04/05		(1.20)			
						6.00	Complete at 6.00m		

Remarks
Installed 38mm standpipe to 6.00m. Gravel pack 6.00m - 1.00m, bentonite 1.00m - 0.00m. Flush lockable cover fitted

Scale (approx)	Logged By
1:50	DC/CM

Figure No. 05-135.LG6

Glover Site Investigations Ltd

Site	Borehole Number
Drumaboden Landfill Site, County Donegal	LG8

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Competitor 130	150mm cased to 6.00m		Donegal County Council	05-135
	Location	**Dates**	**Engineer**	**Sheet**
	As Plan	28/04/05	RPS KMM	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	TOPSOIL		
						(0.70)	MADE GROUND: Soft grey brown gravelly sandy CLAY (FILL)		
						0.80	Spongy dark brown pseudofibrous PEAT		
				Water strike(1) at 3.00m.		(3.40)			▽1
						4.20	Uncompact grey organic fine sandy SILT		
				28/04/05		(1.80)			
						6.00	Complete at 6.00m		

Remarks
Installed 38mm standpipe to 6.00m. Slotted from 6.00m - 1.00m with gravel pack, bentonite seal 1.00m - 0.00m. Flush lockable cover fitted

Scale (approx)	Logged By
1:50	DC/CM

Figure No. 05-135.LG8

Glover Site Investigations Ltd

Site Churchtown Landfill Site, Lifford, County Donegal			**Borehole Number** LG8
Boring Method Competitor 130	**Casing Diameter** 150mm cased to 6.00m	**Ground Level (mOD)**	**Client** Donegal County Council	**Job Number** 05-135a
	Location As Plan	**Dates** 29/04/05	**Engineer** RPS KMM	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	TOPSOIL		
						(0.30)	Firm brown slightly gravelly sandy CLAY		
						0.40	Medium dense light brown gravelly fine to coarse SAND		
						(2.10)			
						2.50	Soft grey (damp) sandy gravelly CLAY		▽1
				Water strike(1) at 2.70m.					
						(3.50)			
				29/04/05		6.00	Complete at 6.00m		

Remarks
Installed 38mm standpipe to 6.00m. Gravel pack 6.00m - 1.00m, bentonite seal 1.00m - 0.00m. Flush lockable cover fitted

Scale (approx)	Logged By
1:50	DC/CM

Figure No. 05-135a.LG8

Glover Site Investigations Ltd

Site Churchtown Landfill Site, Lifford, County Donegal			**Borehole Number** LG9
Boring Method Competitor 130	**Casing Diameter** 150mm cased to 6.00m	**Ground Level (mOD)**	**Client** Donegal County Council	**Job Number** 05-135a
	Location As Plan	**Dates** 29/04/05	**Engineer** RPS KMM	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						0.10	TOPSOIL		
						(2.60)	Medium dense light brown gravelly fine to coarse SAND		
				Water strike(1) at 2.70m.		2.70	Soft grey (damp) sandy gravelly CLAY		▽1
						(3.30)			
				29/04/05		6.00	Complete at 6.00m		

Remarks
Installed 38mm standpipe to 6.00m. Gravel pack 6.00m - 1.00m, bentonite seal 1.00m - 0.00m with flush cover

Scale (approx)	Logged By
1:50	DC/CM

Figure No. 05-135a.LG9

Appendix 2

References

REFERENCES

DRUMABODEN

1. The Code of Practice for Site Investigation Fieldwork BS : 5930 : 1999

2. The Code of Practice for Site Investigation Laboratory Testing BS 1377 Parts 1 to 9 : 1990

3. Ordnance Survey of Ireland Discovery Series
   Sheet No. 6

4. Geological Map of the Site
   Sheet No. 1 & 2

REFERENCES

CHURCHTOWN

1. The Code of Practice for Site Investigation Fieldwork BS : 5930 : 1999

2. The Code of Practice for Site Investigation Laboratory Testing BS 1377 Parts 1 to 9 : 1990

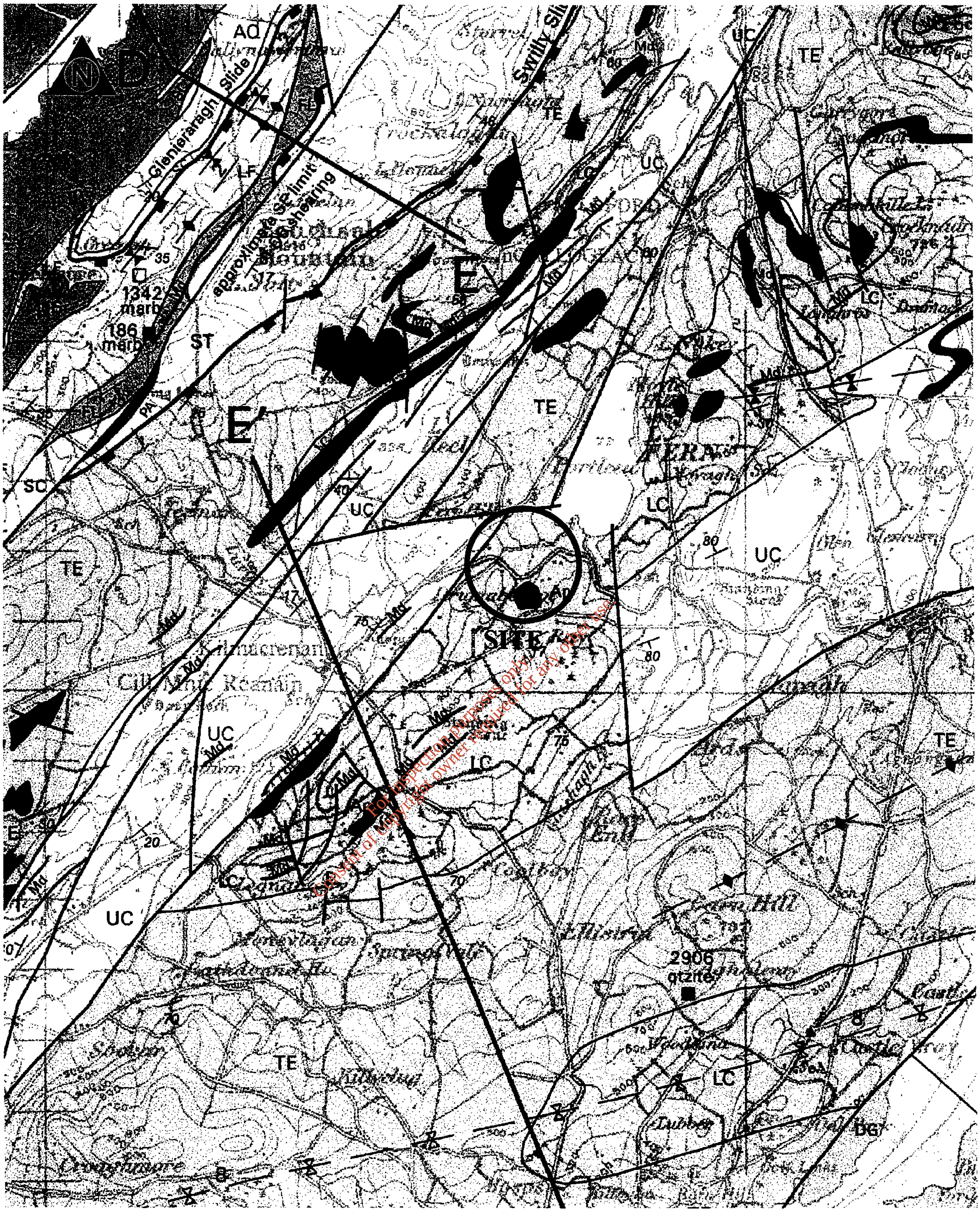
3. Ordnance Survey of Ireland Discovery Series
   Sheet No. 12

4. Geological Map of the Site
   Sheet No. 3&4

Appendix 3

Geological Map of the Sites

GLOVER SITE INVESTIGATIONS LIMITED



PROJECT: Drumnabodan Landfill Site, Co Donegal	TITLE: Geology Location Plan
CLIENT: Donegal County Council	KEY:
ENGINEER: RPS Kirk McClure Morton	

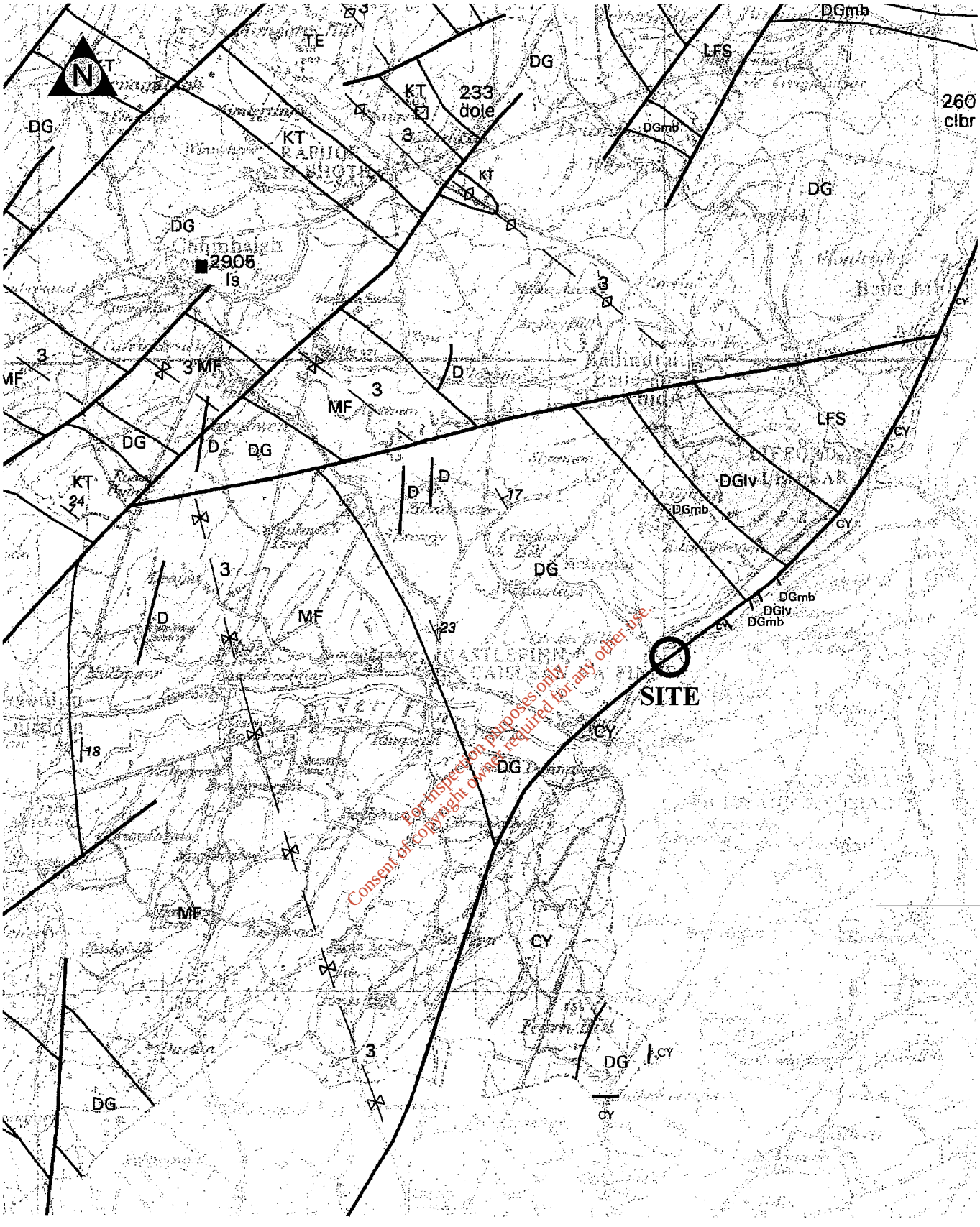
SCALE:	SERIES:	DATE:	DRWN:	CHCK:
N.T.S.	2 of 2	May 05	O.C.	D.C.

GLOVER SITE INVESTIGATIONS LIMITED

REV:	DATE:	DETAILS:	DRW:	CHK:

DWG No: 05-135-SLoc-002

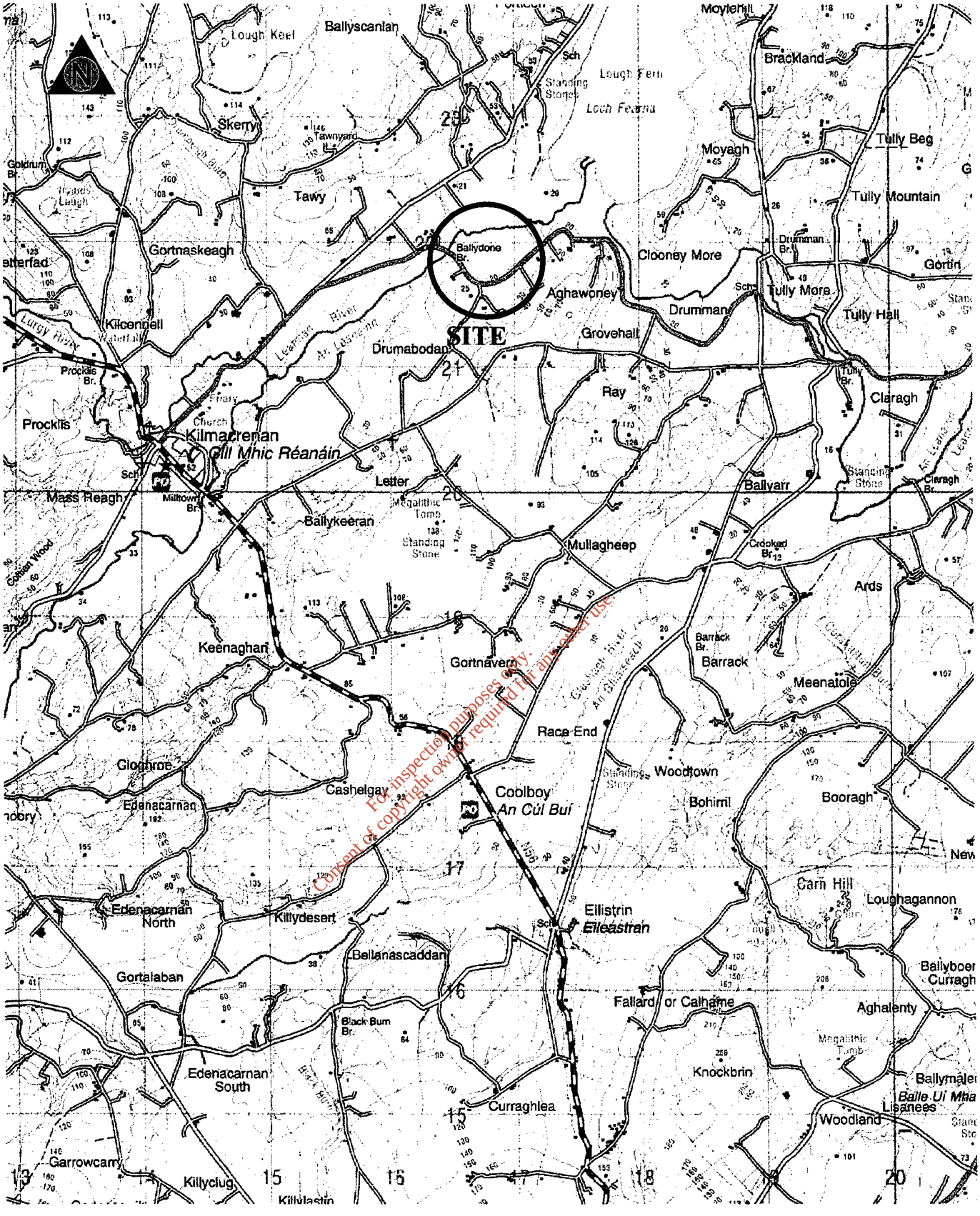
REV:



PROJECT: Churchtown Landfill Site, Co Donegal					TITLE: Geology Location Plan					
CLIENT: Donegal County Council					GLOVER SITE INVESTIGATIONS LIMITED	KEY:				
ENGINEER: RPS Kirk McClure Morton										
SCALE: N.T.S.	SERIES: 2 of 2	DATE: May 05	DRWN: O.C.	CHCK: D.C.			REV:	DATE:	DETAILS:	DRW: CHK:
						DWG No: 05-135-SLoc-004				REV:

Appendix 4

Site Location Plans



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TITLE:	Site Location Plan
CLIENT:	Donegal County Council
ENGINEER:	RPS Kirk McClure Morton
KEY:	

GLOVER SITE INVESTIGATIONS LIMITED

SCALE:	SERIES:	DATE:	DRWN:	CHCK:
N.T.S.	1 of 2	May 05	O.C.	D.C.

REV:	DATE:	DETAILS:	DRW:	CHK:

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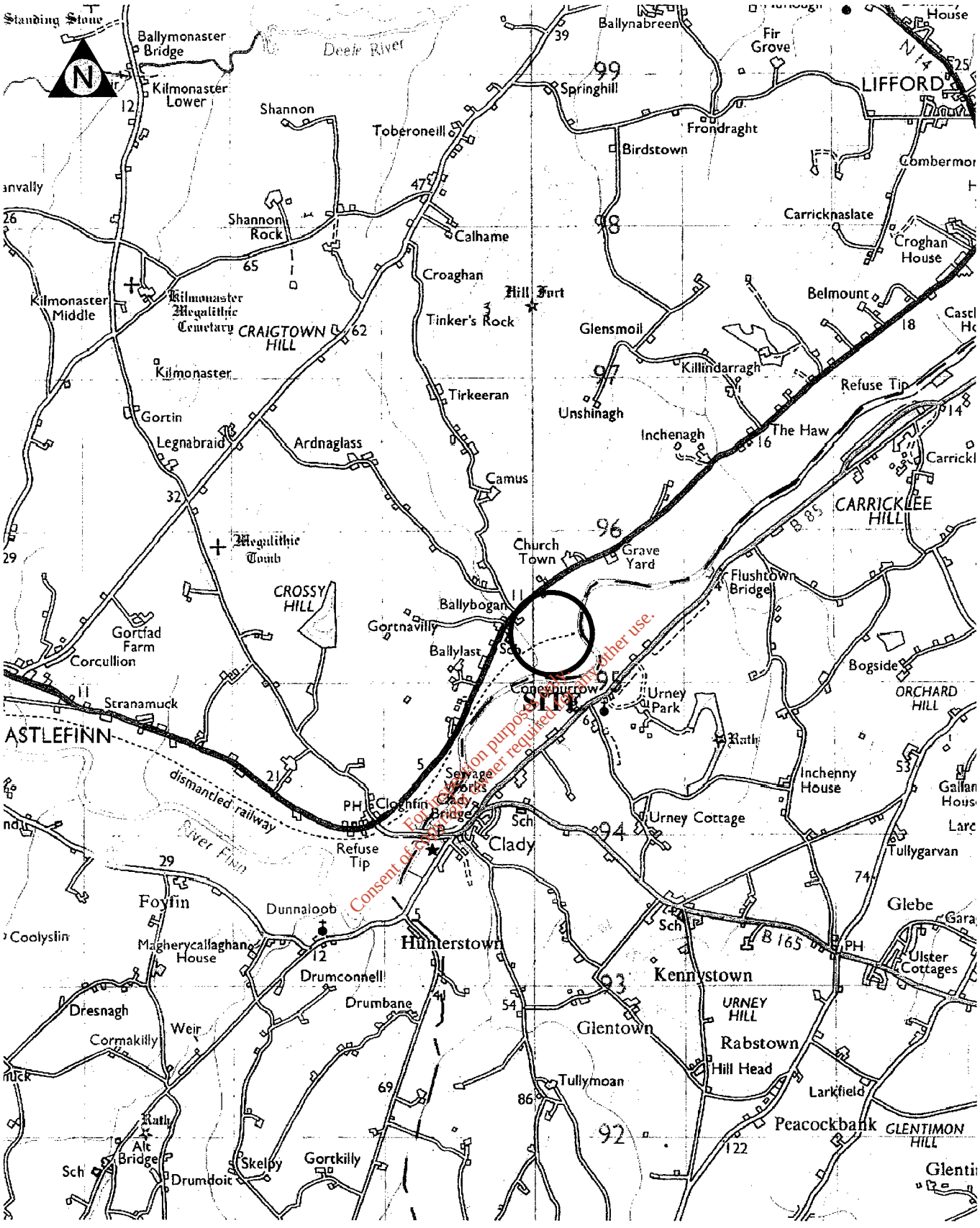


PROJECT: Churchtown Landfill Site, Co Donegal					TITLE: Site Location Plan				
CLIENT: Donegal County Council					GLOVER SITE INVESTIGATIONS LIMITED	KEY:			
ENGINEER: RPS Kirk McClure Morton									
SCALE: N.T.S.	SERIES: 1 of 2	DATE: May 05	DRWN: O.C.	CHCK: D.C.		REV:	DATE:	DETAILS:	DRW: CHK:
						DWG NO: 05-135-SLoc-003			REV:

Ground Check Ltd
SITE INVESTIGATION SPECIALISTS

SITE RESTORATION CONTRACT
CHURCHTOWN LANDFILL
LIFFORD
COUNTY DONEGAL

GROUND INVESTIGATION REPORT

Client: Donegal County Council

Engineer: TAL Civil Engineering Ltd

Job Ref: 14-1170

Issued: February 2015

CONTENTS

1.0 INTRODUCTION

1.1 Terms of Reference

Ground Check Ltd was commissioned by TAL Civil Engineering Ltd, acting on behalf of Donegal County Council, to undertake a ground investigation for a site restoration contract at Churchtown Landfill, Lifford, County Donegal. The location of the site is shown by Figure 1.

1.2 Method

The ground investigation was undertaken in accordance with the guidelines set-out in BS5930:1999 + A2 2010, Code of practice for site investigations and UK Specification for Ground Investigation, 2nd edition (2011), BS EN 1997-2 (2007) and BS EN ISO 22475-1 (2006) and related standards and the scope of works comprised of the following elements.

- **Exploratory Holes**

The locations of exploratory holes are shown by Figure 2 and logs are included in Appendix A.

- **Shell and Auger Boreholes:** Eleven boreholes were sunk using a Dando 2000 shell and auger drilling rig and were advanced using 200mm diameter casing and tools.
- **Rotary Percussive Drilling:** One borehole (BH4) was sunk using a Commachio MC305 rig equipped with Symmetrix casing and tools and air flush.
- **Rotary Core Drilling:** Intact core specimens of rock were recovered in one borehole (BH4) using a T2 86 core barrel with double liner.

- **Sampling & In-situ Testing**

- **Disturbed samples:** comprising sealed plastic bags of soil were recovered at intervals shown on the borehole logs, generally being taken at one metre depth increments and from each stratum.
- **Bulk samples:** comprising soil sealed in heavy gauge plastic sacks were recovered at intervals shown on the logs.
- **Groundwater Samples:** were recovered where possible during drilling or from borehole standpipes after purging and were contained in one litre plastic bottles.
- **Standard Penetration Tests (SPT):** were undertaken at intervals shown on the borehole logs and were conducted in accordance with BS1377:1990 Code of Practice: Methods of Test for Soils for Engineering Purposes - Part 9 In-Situ Tests.
- **Variable Head Permeability Test:** was scheduled to be undertaken in the completed standpipe installation of BH04. Due to the strong artesian flow recorded in BH04 a rising head test could not be performed.

- **Instrumentation & Monitoring**
  - **Standpipe Installations:** selected boreholes were installed with a 50mm HDPE slotted standpipe and gravel pack on completion of drilling and the depth and length of the response zone were scheduled by the Engineer. Construction details of the standpipe installations and headworks are given on the relevant borehole logs which are presented in Appendix A.
  - **Gas and Groundwater Monitoring:** One monitoring visits were undertaken by a geotechnician and were performed in accordance with CIRIA C665 guidance using a GFM-430 gas meter fitted with an internal flow pod. Water levels were measured using an electronic dip-meter. Monitoring results are presented in Appendix C.

- **Geotechnical Laboratory Testing**

  Selected soil, groundwater and rock core samples were scheduled for the following laboratory tests which were conducted in accordance with procedures outlined in BS1377. Results are included in Appendix D.
  - Particle Size Distribution

2.0 SITE DESCRIPTION

The site is situated on the southern side of the N15 road about 4kms south west of Lifford, County Donegal. The ground surface is generally flat but is elevated above the adjacent ground near its western and southern boundaries. The River Finn is located directly to the south of the landfill site. The existing layout of the site is shown by Figure 2 and Plate 1 provides an aerial overview.

Plate 1: Overview of Site

3.0 GROUND CONDITIONS

3.1 Geology

The geological maps of the area indicate that the site is underlain by the following strata.

- **Recent Deposits**
- **Glacial Deposits**
- **Bedrock [DALRADIAN]**

3.2 Ground Conditions

The findings of the ground investigation are listed in Table 1 and are summarised below.

- **Made Ground:** The site is mantled by made ground at all locations investigated except for Borehole 4. The made ground is composed generally of soft and soft to firm, brown and grey, gravelly, sandy, silty clay with low cobble and boulder content, containing domestic refuse, glass, textile, rubber and wire.
- **Recent:** Occurs immediately beneath the made ground at Boreholes LG8 and LG9 from respective depths of 2.30 and 2.40m and from ground level at Borehole 4. It is described generally as Loose, brown, very silty, fine to coarse sand, very soft, dark brown, slightly sandy, clayey peat, and soft, becoming soft to firm, grey, sandy, silty clay.
- **Glacial Deposits:** Were encountered only in Borehole 4 beneath the geologically recent deposits at 6.20m depth and are composed generally of loose, brownish grey, silty, sandy, fine to coarse gravel with low cobble content.
- **Bedrock:** Grey, highly fractured, weathered SCHIST was encountered at 7.90m depth in Borehole 4 and continued to its terminal depth..

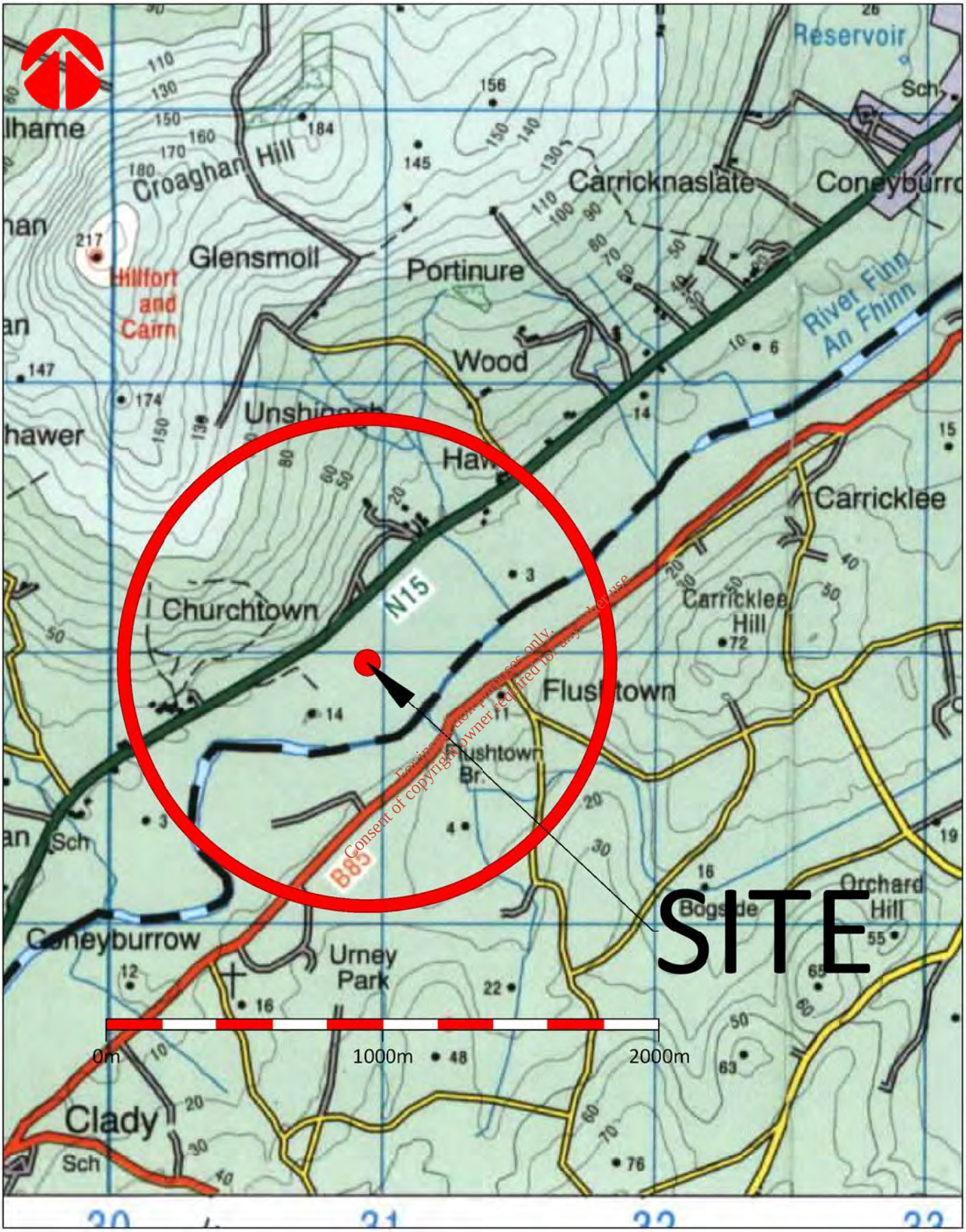
3.3 Groundwater

Slight flows of groundwater entered Boreholes LA1, LG2AR, LG3A, LG7A and 4 at depths ranging between 3.80 and 7.00m below ground level. A strong sub-artesian flow entered Borehole 4 at 9.00m depth, rising to 0.50m after twenty minutes. Groundwater was not observed in the other boreholes. It should be noted, however, that such short term observations may not represent the presence or absence of a water table and that groundwater conditions can vary.

Table 1: Ground Conditions Summary

Exploratory Hole Reference	Completion Depth (m)	Stratum Base Depth (m)			Bedrock Top (m)
		Made Ground	Recent	Glacial	
L1A	6.50	>6.50	-	-	-
LG1A	5.30	>5.30	-	-	-
L2	6.50	>6.50	-	-	-
LG2A	2.80	>2.80	-	-	-
LG2AR	5.00	.5.00	-	-	-
LG3A	4.50	>4.50	-	-	-
LG5A	4.30	>4.30	-	-	-
LG6A	4.20	>4.20	-	-	-
LG7A	4.50	>4.50	-	-	-
LG8	7.20	2.30	>7.20	-	-
LG9	7.00	4.00	>7.00	-	-
4	12.00	-	6.20	7.90	7.90

FIGURES



Project: CHURCHTOWN LANDFILL, LIFFORD, COUNTY DONEGAL			Title: FIGURE 1 SITE LOCATION MAP		
Client: DONEGAL COUNTY COUNCIL			Engineer: TAL CIVIL ENGINEERING LTD		
Job Reference: 14-1170	Figure Ref: F14-1170/01	Revision: 0	Date: 20.12.14	Produced by: LK	Scale: AS SHOWN

Ground Check Ltd
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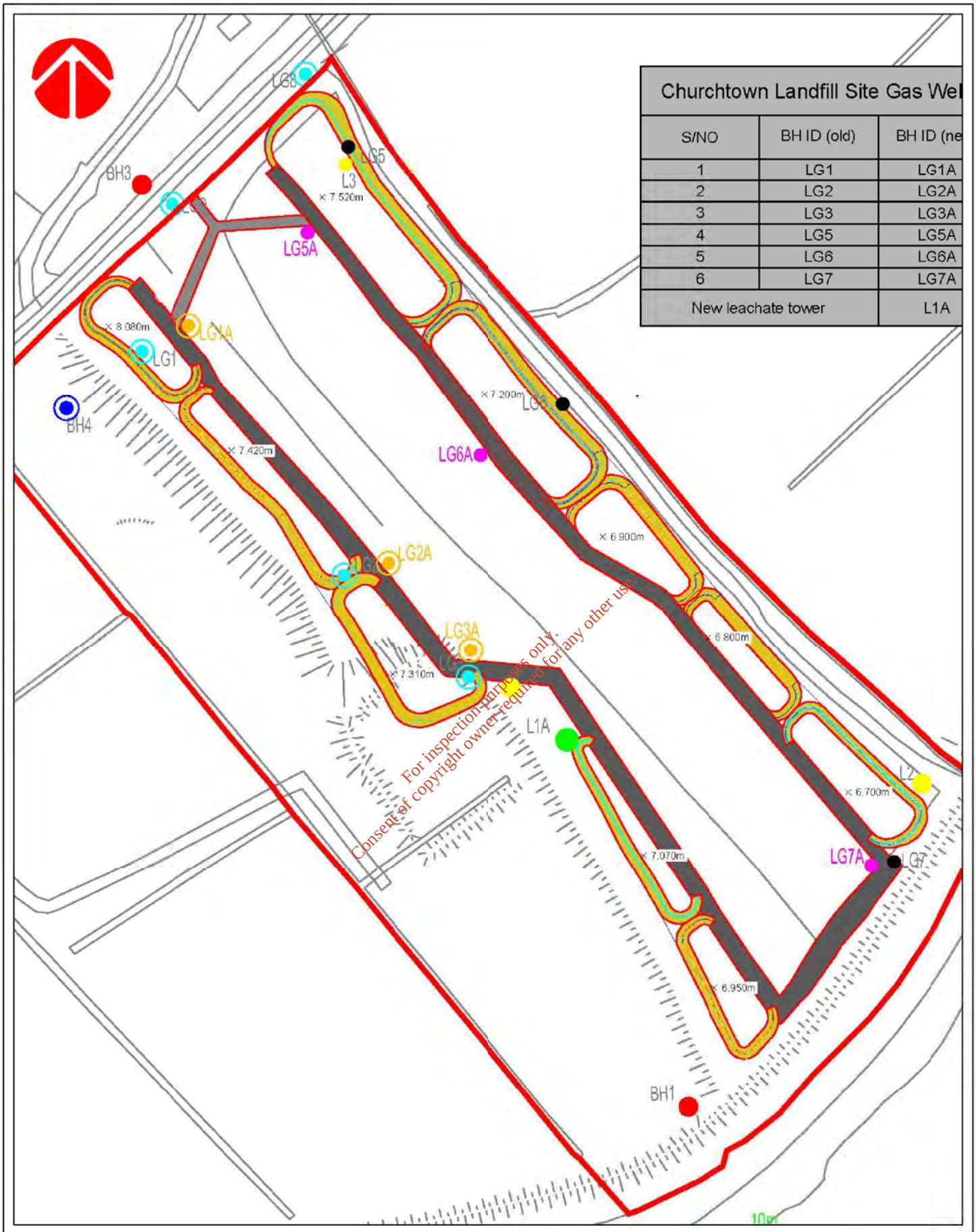

Churchtown Landfill Site Gas Wel		
S/NO	BH ID (old)	BH ID (ne
1	LG1	LG1A
2	LG2	LG2A
3	LG3	LG3A
4	LG5	LG5A
5	LG6	LG6A
6	LG7	LG7A
New leachate tower		L1A

Project: CHURCHTOWN LANDFILL, LIFFORD, COUNTY DONEGAL			Title: FIGURE 2 EXPLORATORY HOLE LOCATION MAP		
Client: DONEGAL COUNTY COUNCIL			Engineer: TAL CIVIL ENGINEERING LTD		
Job Reference: 14-1170	Figure Ref: F14-11707/02	Revision: 0	Date: 20.12.14	Produced by: LK	Scale: AS SHOWN

Ground Check Ltd
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APPENDIX A: BOREHOLE LOGS AND INSTRUMENTATION DETAILS

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	4

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Rotary Percussive	200mm cased to 12.00m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
		09/12/2014-10/12/2014	TAL Civil Engineering Ltd	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
							Soft, brownish grey, sandy, silty CLAY. Sand is fine to medium. [RECENT]		▼2	
1.00-1.45 1.00	SPT N=2 D1			1,0/1,0,0,1		(2.40)				
2.00-2.45 2.00	SPT N=3 D2			1,0/1,0,1,1		2.40	Soft, becoming soft to firm, grey, sandy, silty CLAY. Sand is fine to coarse. [RECENT]			
3.00-3.45 3.00	SPT N=3 D3			1,1/1,0,1,1						
4.00-4.45 4.00	SPT N=4 D4			1,1/1,1,1,1		(3.80)				
5.00-5.45 5.00	SPT N=5 D5			1,1/2,1,1,1						
6.00	D6					6.20				
6.50-6.95	SPT N=7			1,1/2,2,1,2			Loose, brownish grey, silty, sandy, fine to coarse, subrounded GRAVEL with low cobble content. [GLACIAL]		▼1	
7.00	D7			Slight flow(1) at 7.00m, no rise after 20 mins.		(1.70)				
8.00	D8					7.90	Grey, highly fractured, weathered SCHIST. [DALRADIAN]			
9.00	D9			Strong Flow(2) at 9.00m, rose to 0.50m in 20 mins.		(4.10)			▽2	

Remarks

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.BH4

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	4

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Rotary Percussive	200mm cased to 12.00m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
		09/12/2014-10/12/2014	TAL Civil Engineering Ltd	2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
10.00	D10									
11.00	D11					(4.10)				
12.00	D12					12.00	Complete at 12.00m			

Remarks
Terminated at required depth. Standpipe installed to 11.50m.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.BH4

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	L1A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 6.5m.	200mm cased to 6.50m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	231020.6 E 395902.6 N	07/11/2014-10/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(1.20)	Soft to firm, light brownish grey, slightly gravelly, slightly sandy, clayey SILT. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
1.00	B1									
1.00	D1					1.20				
1.20-1.65	SPT N=8			2,2/1,2,2,3		(0.20)	Soft, dark brown, gravelly, slightly sandy, silty CLAY. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse. [MADE GROUND]			
						1.40	Soft to firm, dark brown, slightly sandy, clayey SILT with plastic bags, plastic and glass bottles. Sand is fine to coarse. [MADE GROUND]			
2.00-2.45	SPT N=16			1,6/3,4,2,7						
				07/11/2014:DRY						
				10/11/2014:						
3.00-3.45	SPT N=28			2,1/10,12,2,4						
						(5.10)				
4.00-4.45	SPT N=13			2,3/7,2,3,1					▽1	
				slight (1) at 4.80m.						
5.00-5.45	SPT N=15			3,6/8,3,2,2						
6.00-6.45	SPT N=50			3,2/2,6,42						
				10/11/2014:4.80m		6.50				
							Complete at 6.50m			

Remarks
Terminated at required depth. Standpipe installed to 6.5m.
Chiselling from 3.10m to 3.20m for 1.5 hours. Chiselling from 3.20m to 3.40m for 1.0 hour.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.L1A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	L2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 6.5m.	200mm cased to 6.50m		Donegal County Council	14-1170
	Location	**Dates** 10/11/2014	**Engineer** TAL Civil Engineering Ltd	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.50)	TOPSOIL. [MADE GROUND]			
						0.50				
						(0.50)	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse. [MADE GROUND]			
						1.00				
1.00	B1						Soft to firm, dark brown, slightly sandy SILT with plastic and food packaging. Sand is fine to coarse. [MADE GROUND]			
1.00	D1									
1.20-1.65	SPT N=10			2,3/2,2,3,3						
2.00-2.45	SPT N=7			3,3/2,3,1,1						
3.00-3.45	SPT N=20			3,4/6,7,4,3						
						(5.50)				
4.00-4.45	SPT N=21			4,5/7,3,4,7						
5.00-5.45	SPT N=23			5,6/6,7,5,5						
				05/11/2014:DRY		6.50	Complete at 6.50m			

Remarks
Terminated at required depth. Standpipe installed to 6.5m.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.R1

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG1A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 5.3m.	200mm cased to 5.30m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230864.3 E 396073.7 N	05/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.50)	TOPSOIL. [MADE GROUND]			
0.50	D1					0.50	Soft to firm, brown, slightly gravelly, slightly sandy, silty CLAY with low cobble and boulder content. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse. [MADE GROUND]			
1.00	B1					(0.90)				
1.00	D2									
1.20-1.65	SPT N=10			2,3/2,2,3,3		1.40				
						(0.40)	Soft, greyish brown, slightly gravelly, slightly sandy, silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
						1.80				
						(0.30)				
2.00-2.45	SPT N=7			3,3/2,3,1,1		2.10				
2.00	D4					(0.30)	Soft, brown, slightly gravelly, slightly sandy, silty CLAY with plastic. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
2.10	D5					2.40				
2.60	D3						Soft, dark brown, peaty silty CLAY with glass and plastic. Sand is fine to coarse. [MADE GROUND]			
3.00-3.45	SPT N=20			3,4/6,7,4,3			Soft to firm, dark brown, slightly sandy, clayey SILT with plastic and wire. Sand is fine to coarse. [MADE GROUND]			
						(2.90)				
4.00-4.45	SPT N=21			4,5/7,3,4,7						
5.00-5.45	SPT N=23			5,6/6,7,5,5						
				05/11/2014:DRY		5.30				
							Complete at 5.30m			

Remarks
Terminated at required depth. Standpipe installed to 5.3m.
Chiselling from 0.50m to 0.80m for 1.5 hours. Chiselling from 4.00m to 5.30m for 1.5 hours.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG1A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG2A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 2.8m.	200mm cased to 2.80m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230946.7 E 395975.7 N	06/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(1.40)	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble and boulder content. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]		
1.00-1.45 1.00 1.00	SPT N=8 B1 D1			2,2/1,2,2,3		1.40			
						(1.40)	Soft, dark brown, slightly sandy, SILT with plastic and paper bags, food packaging and other domestic waste. [MADE GROUND]		
2.00-2.45	SPT N=5			1,2/1,1,2,1					
				06/11/2014:DRY		2.80	Terminated at 2.80m		

Remarks
Terminated upon virtual refusal. Backfilled with bentonite. Re-setup and re-bored as LG2AR
Chiselling from 2.75m to 2.80m for 2.0 hours.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG2A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG2AR

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percusive to 5.0m.	200mm cased to 5.00m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230946.7 E 395975.7 N	06/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(1.40)	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
1.00-1.45 1.00 1.00	SPT N=10 B1 D1			2,3/3,2,2,3						
						1.40	Soft, dark brown, slightly sandy SILT with plastic, cloth, textiles, and rubber. Sand is fine to coarse. [MADE GROUND]			
2.00-2.45	SPT N=7			2,1/2,2,1,2						
3.00-3.45	SPT N=4			1,0/0,1,2,1		(3.60)				
4.00-4.45	SPT N=18			1,2/7,3,6,2					▽1	
				slight(1) at 4.50m.						
				06/11/2014:4.50m		5.00				
5.00-5.45	SPT N=14			1,0/2,8,1,3			Complete at 5.00m			

Remarks
Terminated at required depth. Standpipe installed to 5.0m.
Chiselling from 3.50m to 4.00m for 1.0 hour.

Scale (approx)	Logged By
1:50	LK

Figure No.
14-1170.LG2AR

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG3A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 4.5m.	200mm cased to 4.50m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230980.4 E 395939.7 N	07/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.50) 0.50	Dark brown TOPSOIL. [MADE GROUND]			
1.00-1.45 1.00 1.00	SPT N=10 B1 D1			2,2/3,2,3,2		(1.80)	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
2.00-2.45 2.00 2.00	SPT N=8 B2 D2			2,3/1,3,2,2		2.30	Soft, dark brown, slightly sandy, SILT with plastic, cloth, concrete blocks and wire. Sand is fine to coarse. [MADE GROUND]			
3.00-3.45	SPT N=13			1,0/3,7,2,1		(2.20)			∇1	
4.00-4.45	SPT N=15			slight(1) at 4.00m. 6,1/4,5,2,4 06/11/2014:4.00m		4.50	Complete at 4.50m			

Remarks
Terminated at required depth. Standpipe installed to 4.5m.
Chiselling from 2.90m to 4.00m for 1.5 hours.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG3A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG5A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 4.3m.	200mm cased to		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230913.4 E 396112 N	11/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.40) 0.40	TOPSOIL. [MADE GROUND]			
1.00-1.45 1.00 1.00	SPT N=13 B1 D1			2,2/3,3,4,3		(1.50) 1.90	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble and boulder content. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
2.00-2.45	SPT N=3			2,2/1,1,1,0			Soft, dark brown, slightly sandy, clayey SILT with plastic bags, food packaging and other domestic waste. [MADE GROUND]			
3.00-3.45	SPT N=8			0,0/1,2,3,2		(2.40)				
4.00-4.45	SPT N=6			1,1/1,2,1,2						
				11/11/2014:DRY		4.30	Terminated at 4.30m			

Remarks
Terminated at required depth. Stanpipe installed to 4.0m.
Chiselling from 3.00m to 4.20m for 1.0 hour.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG5A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG6A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 4.3m.	200mm cased to 4.30m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230984.3 E 396020.2 N	11/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.40) 0.40	Dark brown TOPSOIL. [MADE GROUND]			
1.00-1.45 1.00 1.00	SPT N=11 B1 D1			2,2/3,3,2,3		(1.40) 1.80	Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
2.00-2.45	SPT N=9			2,3/3,2,3,1			Soft, dark brown, slightly sandy, SILT with plastic and waste packaging. Sand is fine to coarse. [MADE GROUND]			
3.00-3.45	SPT N=7			1,2/2,2,1,2		(2.40)				
4.00-4.45	SPT N=7			1,1/2,2,2,1		4.20				
				06/11/2014:			Complete at 4.30m			

Remarks
Terminated at required depth. Standpipe installed to 4.2m.
Chiselling from 3.00m to 3.80m for 1.0 hour.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG6A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG7A

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 4.5m.	200mm cased to 4.50m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	231146 E 395850.8 N	10/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(0.50) 0.50	TOPSOIL. [MADE GROUND]			
1.00	B1						Soft to firm, light brown, slightly gravelly, slightly sandy, silty CLAY with low cobble content. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse. [MADE GROUND]			
1.00	D1					(1.30)				
1.20-1.65	SPT N=10			2,2/3,2,2,3						
						1.80				
2.00-2.45	SPT N=15			6,3/4,1,7,3			Soft, dark brown, slightly sandy, SILT with plastic and food packaging. Sand is fine to coarse. [MADE GROUND]			
3.00-3.45	SPT N=6			2,3/1,1,3,1		(2.70)				
				slight(1) at 3.80m.					▽1	
4.00-4.45	SPT N=28			3,7/8,6,5,9						
				11/11/2014:3.80m		4.50	Complete at 4.50m			

Remarks
Terminated at required depth. Standpipe installed to 4.5m.
Chiselling from 3.00m to 4.20m for 1.5 hours.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG7A

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG8

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 7.2m.	200mm cased to 7.20m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230912.4 E 396177.3 N	12/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(1.70)	Soft to firm, light brownish grey, slightly gravelly, slightly sandy, silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
1.00-1.45 1.00 1.00	SPT N=11 B1 D1			2,2/3,3,3,2						
						1.70				
						(0.60)	Soft to firm, light brown, slightly sandy, silty CLAY. Sand is fine to coarse. [MADE GROUND]			
2.00-2.45 2.00 2.00	SPT N=11 B2 D2			2,3/3,2,3,3		2.30				
						(0.80)	Loose, orange brown, very silty, fine to coarse SAND. [RECENT]			
3.00-3.45	SPT N=7			1,2/2,2,1,2		3.10				
							Soft, light greyish brown, sandy, clayey SILT. Sand is fine to coarse. [RECENT]			
4.00-4.45	SPT N=5			1,2/2,1,1,1						
5.00-5.45	SPT N=4			1,1/1,1,1,1		(4.10)				
6.50-6.95	SPT N=3			1,1/0,1,1,1						
				12/11/2014:DRY		7.20				
							Complete at 7.20m			

Remarks
Terminated at required depth. Standpipe installed to 7.0m.
Chiselling from 1.20m to 2.30m for 1.0 hour.

Scale (approx)	Logged By
1:50	LK

Figure No. 14-1170.LG8

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG9

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable percussive to 7.0m.	200mm cased to 7.00m		Donegal County Council	14-1170
	Location	**Dates**	**Engineer**	**Sheet**
	230857.5 E 396123.7 N	12/11/2014	TAL Civil Engineering Ltd	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
							Loose, brownish grey, silty, very gravelly, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse. [MADE GROUND]			
0.50	D1									
1.00	D2									
1.20-1.65	SPT N=10			2,2/3,2,2,3						
1.50	B1									
						(4.00)				
2.00-2.45	SPT N=15			6,3/4,1,7,3						
2.00	D3									
3.00-3.45	SPT N=6			2,3/1,1,3,1						
3.00	B2									
3.00	D4									
4.00-4.45	SPT N=28			3,7/8,6,5,9		4.00				
4.00	D5						Very soft, dark brown, slightly sandy, clayey PEAT. [RECENT]			
						(0.60)				
4.50	B3					4.60				
5.00	D6						Loose, light brown, very silty, fine to coarse SAND. [RECENT]			
						(2.40)				
6.00	B4									
6.00	D7									
7.00	D8			12/11/2014:0.00m		7.00				
							Complete at 7.00m			

Remarks
Terminated at required depth. Standpipe installed to 4.5m.

Scale (approx)	Logged By
1:50	LK

Figure No.
14-1170.LG9

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	4

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 150 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
	▼2			0.25	Concrete
					Bentonite Seal
	▼1				
	▽2			9.50	
					Slotted Standpipe
				11.50	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		7.00 9.00		Slight flow Strong Flow				7.00 0.50	

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

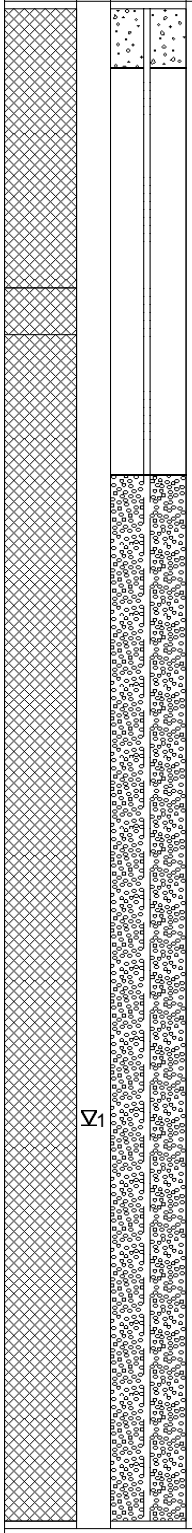
Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	L1A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
231020.6 E 395902.6 N		TAL Civil Engineering Ltd	1/1



Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		4.80		slight					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
07/11/14						pm	3.00		dry	
10/11/14						pm	6.50		4.80	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	L2

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
231020.6 E 395902.6 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete Concrete
				0.25	
					Bentonite Seal
				1.00	
					Slotted Standpipe
				6.50	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
05/11/14						pm	6.50		dry	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG1A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230864.3 E 396073.7 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete Concrete
				0.25	
					Bentonite Seal
				1.00	
					Slotted Standpipe
				5.30	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
05/11/14						pm	5.30		dry	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG2AR

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230946.7 E 395975.7 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete Concrete
				0.25	
					Bentonite Seal
				1.00	
					Slotted Standpipe
	▽1			5.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	
		4.50		slight					

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
06/11/14						pm	5.00		4.50	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

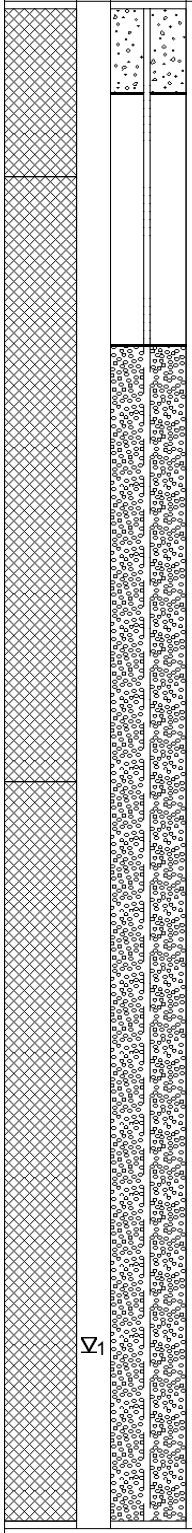
Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG3A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230980.4 E 395939.7 N		TAL Civil Engineering Ltd	1/1



Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		4.00		slight					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
06/11/14						pm	4.50		4.00	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG5A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230913.4 E 396112 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.70	Concrete Concrete
				0.25	
					Bentonite Seal
				0.80	
					Slotted Standpipe
				4.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
11/11/14						pm	4.30		dry	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG6A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230984.3 E 396020.2 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete Concrete
				0.25	
					Bentonite Seal
				1.00	
					Slotted Standpipe
				4.20	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
06/11/14						pm	4.30			

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

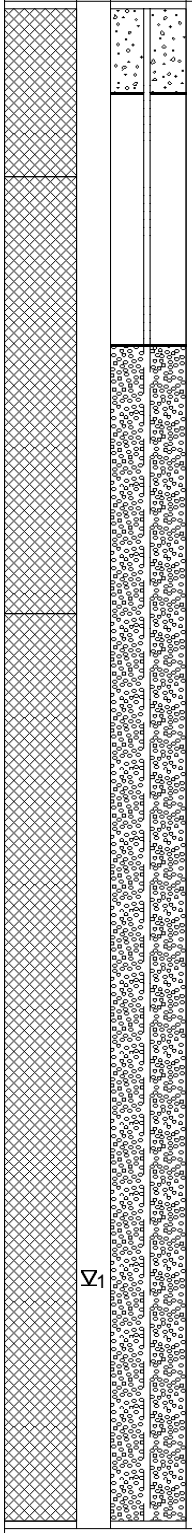
Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG7A

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
231146 E 395850.8 N		TAL Civil Engineering Ltd	1/1



Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	Readings 10 min	Readings 15 min	Readings 20 min	Depth Sealed (m)
		3.80		slight					

Groundwater Observations During Drilling

Date	Start of Shift Time	Start of Shift Depth Hole (m)	Start of Shift Casing Depth (m)	Start of Shift Water Depth (m)	Start of Shift Water Level (mOD)	End of Shift Time	End of Shift Depth Hole (m)	End of Shift Casing Depth (m)	End of Shift Water Depth (m)	End of Shift Water Level (mOD)
11/11/14						pm	4.50		3.80	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A] Time	Instrument [A] Depth (m)	Instrument [A] Level (mOD)	Remarks

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG8

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230912.4 E 396177.3 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete
				0.25	Concrete
					Bentonite Seal
				1.00	
				7.00	Slotted Standpipe

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
12/11/14						pm	7.20		dry	

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

Remarks

Ground Check Ltd

Site	Borehole Number
Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal	LG9

Installation Type	Dimensions	Client	Job Number
Standpipe	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 200 mm	Donegal County Council	14-1170

Location	Ground Level (mOD)	Engineer	Sheet
230857.5 E 396123.7 N		TAL Civil Engineering Ltd	1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				-0.50	Concrete
				0.25	Concrete
					Bentonite Seal
				1.00	
					Slotted Standpipe
				7.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings				Depth Sealed (m)
					5 min	10 min	15 min	20 min	

Groundwater Observations During Drilling

Date	Start of Shift					End of Shift				
	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
12/11/14						pm	7.00			

Instrument Groundwater Observations

Inst. [A] Type : Standpipe

Date	Instrument [A]			Remarks
	Time	Depth (m)	Level (mOD)	

Remarks

APPENDIX B: GAS AND GROUNDWATER MONITORING RESULTS

Churchtown Landfill
14-1170
12/01/2015

Ground Check Ltd

Monitoring Point Reference	Atmospheric Pressure (Pa)	Flow Range (l/hr)	Time passed (s)	Methane % v/v	Methane % LEL	Carbon Dioxide %v/v	Oxygen % v/v	Water Level (mBGL)
LG1A	998	2.0-0.1*	15	4.3	95.0	5.8	20.6	3.64
			30	3.8	87.0	5.0	20.7	
			60	2.9	66.0	3.9	20.7	
			90	2.2	50.1	2.6	20.7	
			120	1.5	34.9	2.1	20.8	
			150	1.4	32.1	1.7	20.8	
			180	1.3	30.4	1.5	20.8	
LG2A	998	3.0-0.1*	15	59.5	>>>	22.3	16.2	3.80
			30	59.9	>>>	22.9	17.0	
			60	59.9	>>>	16.8	23.0	
			90	60.2	>>>	23.0	16.7	
			120	60.2	>>>	22.9	16.7	
			150	60.3	>>>	22.9	16.7	
			180	60.3	>>>	22.8	16.7	
LG3A	998	4.0-1.6	15	59.2	>>>	23.0	17.5	4.09
			30	59.3	>>>	23.2	17.5	
			60	59.3	>>>	23.2	17.4	
			90	59.2	>>>	23.2	17.3	
			120	59.2	>>>	23.2	17.3	
			150	59.2	>>>	23.2	17.3	
			180	59.4	>>>	23.2	17.3	
LG5A	1000	0.3-0.1*	15	56.9	>>>	26.3	16.6	3.60
			30	57.2	>>>	26.1	16.5	
			60	57.3	>>>	26.1	16.4	
			90	57.3	>>>	25.9	16.4	
			120	57.5	>>>	25.9	16.4	
			150	57.5	>>>	25.9	16.4	
			180	57.6	>>>	25.8	16.4	
LG6A	1000	31.6-0.1*	15	57.7	>>>	26.3	16.6	2.40
			30	57.5	>>>	26.1	16.5	
			60	57.5	>>>	26.1	16.4	
			90	57.5	>>>	25.9	16.4	
			120	57.5	>>>	25.9	16.4	
			150	57.5	>>>	25.9	16.4	
			180	57.3	>>>	25.8	16.4	
LG7A	999	0.1	15	63.8	>>>	18.4	17.6	3.14
			30	64.0	>>>	18.4	17.4	
			60	64.1	>>>	18.4	17.4	
			90	64.1	>>>	18.4	17.3	
			120	64.2	>>>	18.4	17.3	
			150	64.2	>>>	18.4	17.3	
			180	64.2	>>>	18.4	17.3	
L1A	1000	31.6-0.1*	15	58.3	>>>	16.7	18.4	3.82
			30	58.5	>>>	17.0	18.5	
			60	58.6	>>>	17.0	18.5	
			90	58.6	>>>	17.1	18.6	
			120	58.6	>>>	17.1	18.6	
			150	58.7	>>>	17.1	18.6	
			180	58.6	>>>	17.1	18.6	
LG8	999	0.5-0.1*	15	4.2	84.1	4.2	20.0	3.85
			30	3.4	62.0	3.6	20.4	
			60	2.3	44.3	2.8	20.5	
			90	1.8	35.2	2.1	20.6	
			120	1.5	30.7	1.6	20.7	
			150	1.2	22.7	1.0	20.7	
			180	1.1	22.0	1.0	20.8	
LG9	999	0.1	15	2.7	54.0	3.0	20.4	3.70
			30	2.0	39.0	2.2	20.6	
			60	1.5	28.5	1.7	20.7	
			90	1.2	23.4	1.3	20.7	
			120	1.2	22.2	1.2	20.8	
			150	1.1	21.0	1.2	20.8	
			180	1.1	20.8	1.2	20.8	
R1	999	0.1	15	62.5	>>>	16.2	17.9	4.02
			30	63.8	>>>	16.3	17.8	
			60	63.9	>>>	16.3	17.8	
			90	64.0	>>>	16.4	17.7	
			120	64.0	>>>	16.4	17.7	
			150	64.1	>>>	16.5	17.7	
			180	64.1	>>>	16.5	17.6	

*Limit of detection for GFM430 used, actual reading = 0.0

APPENDIX C: GEOTECHNICAL LABORATORY TEST RESULTS

Ground Check Ltd

Laboratory Test Results

Site : Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal

Client : Donegal County Council

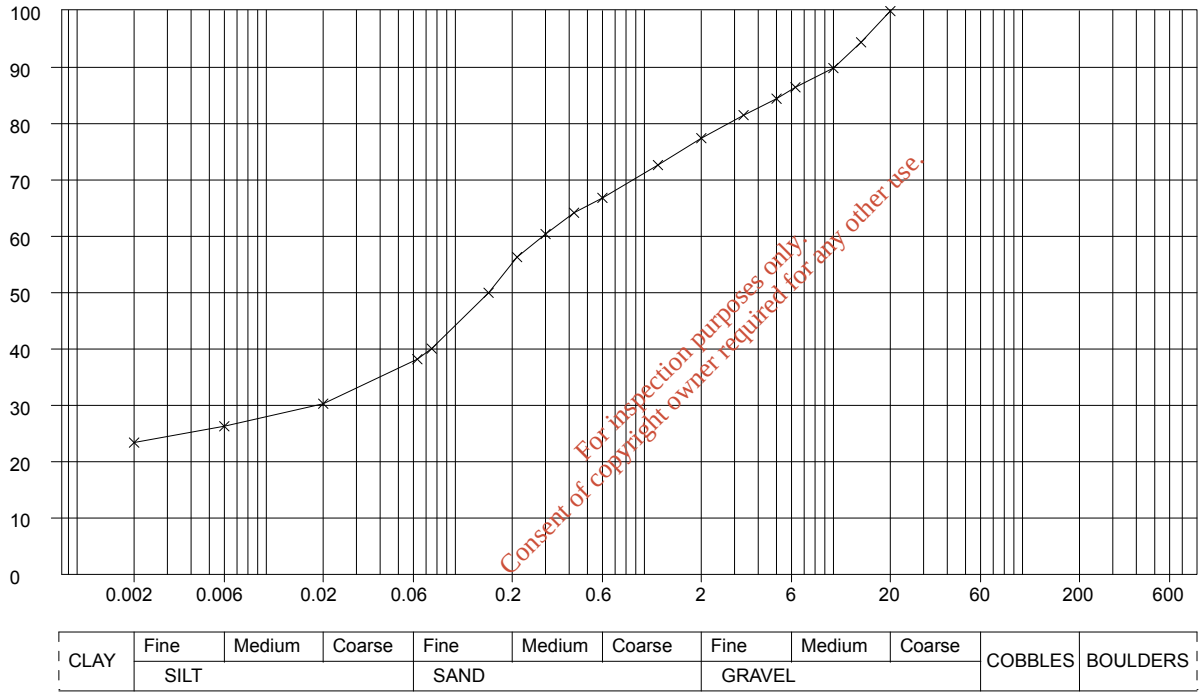
Engineer : TAL Civil Engineering Ltd

Job Number 14-1170

Sheet 1/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
L1A	1.00	B1	



Sieve / Particle Size	% Passing
20 mm	100.0
14 mm	94.5
10 mm	89.9
6.3 mm	86.5
5 mm	84.4
3.35 mm	81.5
2 mm	77.4
1.18 mm	72.7
600 µm	66.8
425 µm	64.2
300 µm	60.4
212 µm	56.3
150 µm	50.0
75 µm	40.1
63 µm	38.2
20 µm	30.3
6 µm	26.3
2 µm	23.4

Grading Analysis	
D85	5.4 mm
D60	291.2 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	-
Gravel	22.6%
Sand	39.6%
Silt	14.5%
Clay	23.4%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

Ground Check Ltd

Laboratory Test Results

Site : Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal

Client : Donegal County Council

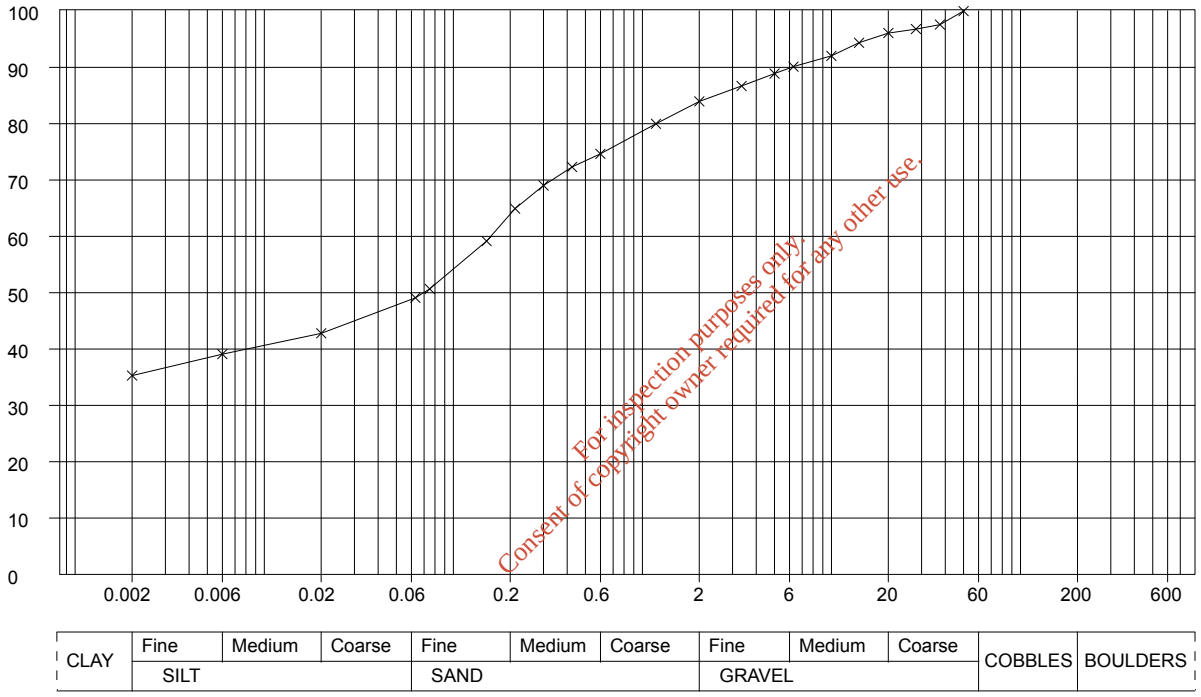
Engineer : TAL Civil Engineering Ltd

Job Number 14-1170

Sheet 2/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
LG1A	1.00	B1	



Sieve / Particle Size	% Passing
50 mm	100.0
37.5 mm	97.6
28 mm	96.8
20 mm	96.1
14 mm	94.4
10 mm	92.1
6.3 mm	90.1
5 mm	88.9
3.35 mm	86.7
2 mm	84.0
1.18 mm	80.0
600 µm	74.7
425 µm	72.3
300 µm	69.0
212 µm	64.9
150 µm	59.2
75 µm	50.7
63 µm	49.1
20 µm	42.8
6 µm	39.1
2 µm	35.3

Grading Analysis	
D85	2.5 mm
D60	158.8 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	-
Gravel	16.0%
Sand	35.1%
Silt	13.5%
Clay	35.3%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

Ground Check Ltd

Laboratory Test Results

Site : Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal

Client : Donegal County Council

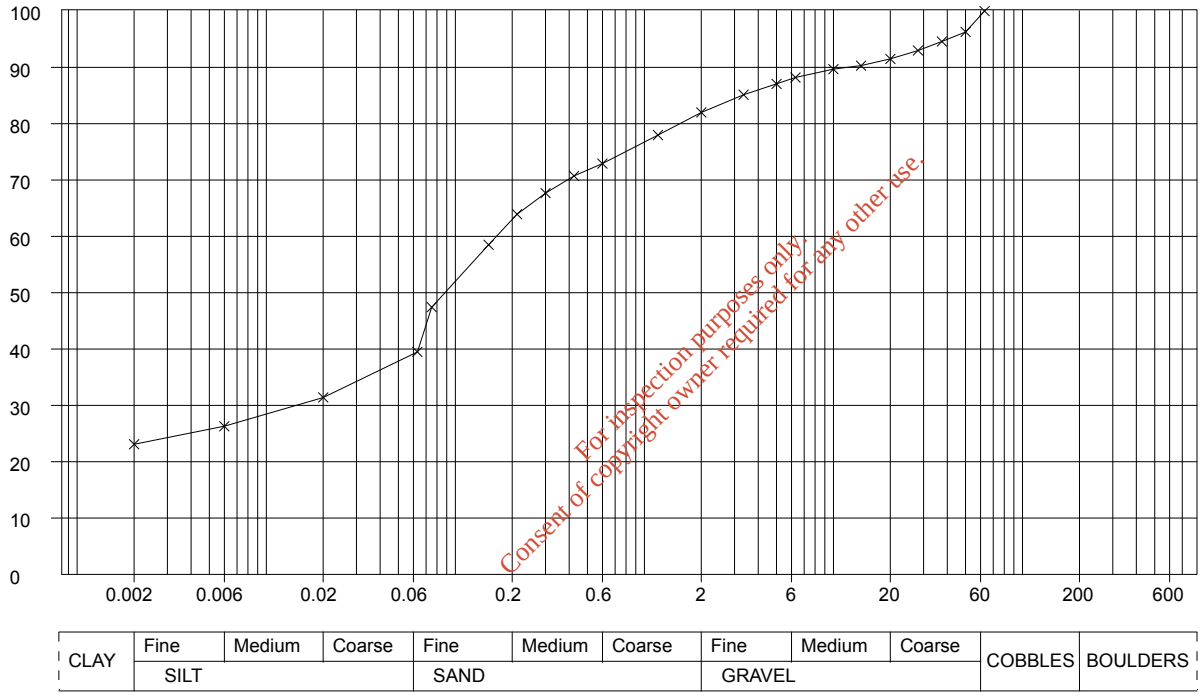
Engineer : TAL Civil Engineering Ltd

Job Number 14-1170

Sheet 3/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
LG2A	1.00	B1	



Sieve / Particle Size	% Passing
63 mm	100.0
50 mm	96.3
37.5 mm	94.6
28 mm	93.0
20 mm	91.5
14 mm	90.3
10 mm	89.7
6.3 mm	88.2
5 mm	87.1
3.35 mm	85.2
2 mm	82.0
1.18 mm	78.0
600 µm	72.9
425 µm	70.7
300 µm	67.7
212 µm	63.9
150 µm	58.5
75 µm	47.4
63 µm	39.5
20 µm	31.4
6 µm	26.3
2 µm	23.1

Grading Analysis	
D85	3.3 mm
D60	167.0 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	0.8%
Gravel	17.2%
Sand	42.9%
Silt	16.1%
Clay	23.1%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

Ground Check Ltd

Laboratory Test Results

Site : Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal

Client : Donegal County Council

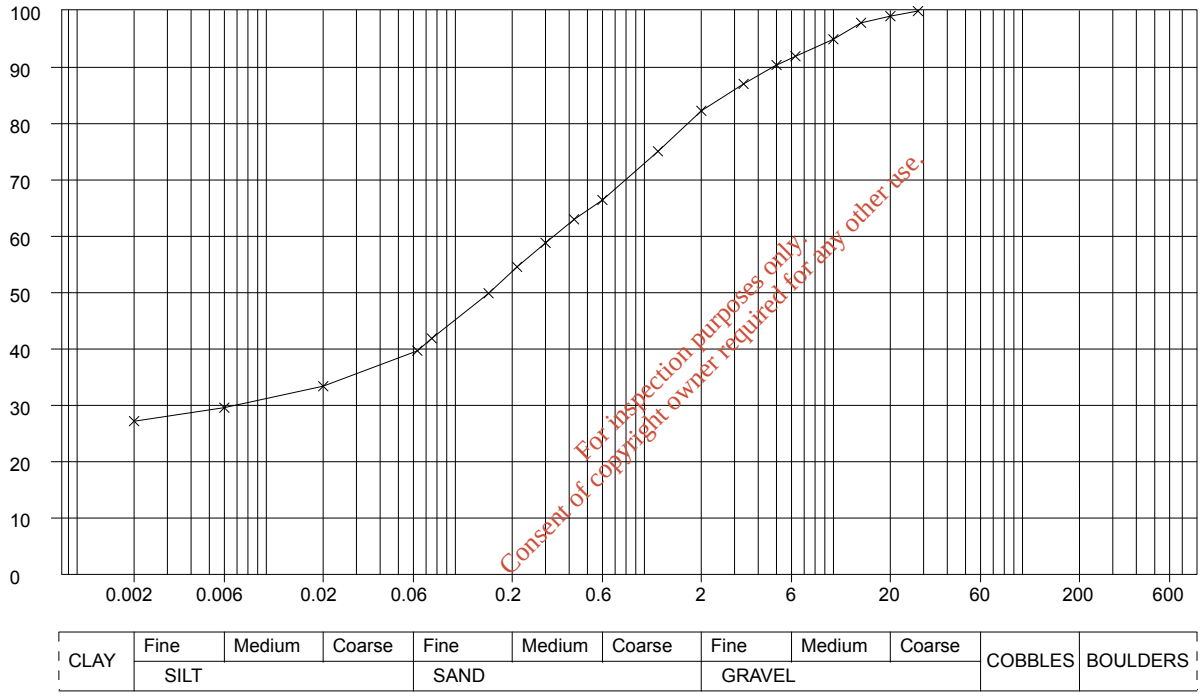
Engineer : TAL Civil Engineering Ltd

Job Number 14-1170

Sheet 4/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
LG3A	2.00	B2	



Sieve / Particle Size	% Passing
28 mm	100.0
20 mm	99.1
14 mm	97.9
10 mm	95.0
6.3 mm	92.0
5 mm	90.4
3.35 mm	87.1
2 mm	82.3
1.18 mm	75.1
600 µm	66.5
425 µm	63.0
300 µm	58.9
212 µm	54.6
150 µm	49.9
75 µm	41.9
63 µm	39.7
20 µm	33.4
6 µm	29.6
2 µm	27.2

Grading Analysis	
D85	2.8 mm
D60	334.5 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	-
Gravel	17.7%
Sand	42.9%
Silt	12.2%
Clay	27.2%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

Ground Check Ltd

Laboratory Test Results

Site : Site Restoration Contract, Churchtown Landfill, Lifford, County Donegal

Client : Donegal County Council

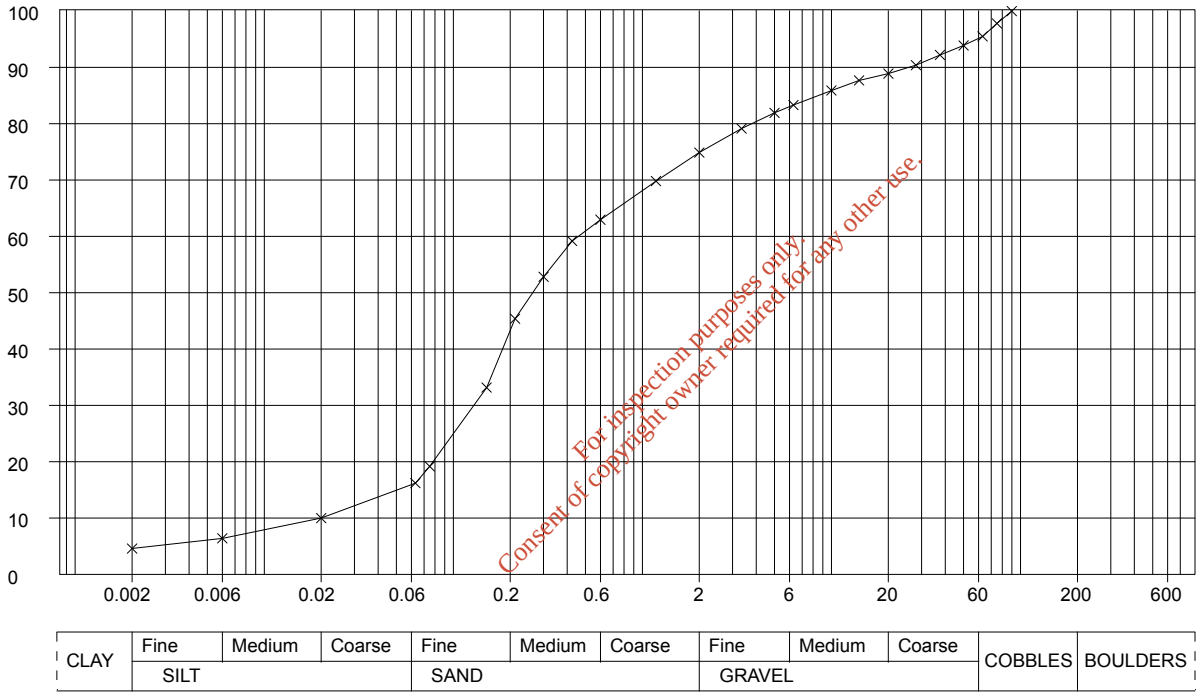
Engineer : TAL Civil Engineering Ltd

Job Number 14-1170

Sheet 5/5

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
LG9	2.00	D3	



Sieve / Particle Size	% Passing
90 mm	100.0
75 mm	97.8
63 mm	95.5
50 mm	93.9
37.5 mm	92.2
28 mm	90.4
20 mm	88.9
14 mm	87.7
10 mm	85.9
6.3 mm	83.3
5 mm	81.9
3.35 mm	79.2
2 mm	74.9
1.18 mm	69.8
600 µm	63.0
425 µm	59.2
300 µm	52.8
212 µm	45.4
150 µm	33.2
75 µm	19.2
63 µm	16.2
20 µm	10.0
6 µm	6.4
2 µm	4.6

Grading Analysis	
D85	8.7 mm
D60	462.6 µm
D10	20.0 µm
Uniformity Coefficient	23.1

Particle Proportions	
Cobbles + Boulders	4.8%
Gravel	20.3%
Sand	58.9%
Silt	11.3%
Clay	4.6%

Method of Preparation : BS 1377:PART 1:1990:7.3 Initial preparation 1990:7.4.5 Particle size tests

Method of Test : BS 1377:PART 2:1990:9 Determination of particle size distribution

Remarks :

Combined Geotechnical and Environmental Services

- ☑ Land Drilling
- ☑ Intrusive Site Investigations
- ☑ Laboratory Testing
- ☑ In-house Consultancy
- ☑ Contaminated Land

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STRATEX LTD

GEOTECHNICAL REPORT

STRATEX LTD

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Geotechnical Report

SUBJECT: GROUND INVESTIGATION

CLIENT: DONEGAL COUNTY COUNCIL

CONSULTING ENGINEERS: KIRK McCLURE MORTON

TITLE: CHURCHTOWN LANDFILL SITE
LIFFORD

REF: 898/2293

DATE: 23 SEPTEMBER 1998

CONTENTS

CLIENT: DONEGAL COUNTY COUNCIL

CONSULTING ENGINEERS: KIRK McCLURE MORTON

CHURCHTOWN LANDFILL SITE
LIFFORD
GROUND INVESTIGATION

The following factual report describes an investigation carried out at the above site in late August and early September 1998 on instructions from Kirk McClure Morton.

The investigation was carried out to facilitate monitoring installations and to characterise the geology and hydrogeology of the site. The contract provides for the formation of four cable tool percussion boreholes with associated sampling, testing and laboratory testing.

SITE AND GEOLOGY

The existing landfill site is located at Churchtown, Lifford, Co Donegal.

Geologically the site is underlain by rocks of Dalradian origin which are probably overlain by Glacial deposits and, possibly, Recent peaty materials.

FIELDWORK

Four boreholes were put down at the locations instructed as indicated approximately in figure 1. One of our Dando 150 Investigator shell and auger rigs was used, boring to produce a nominally 200 mm diameter hole. Borehole completion depths ranged from 9.00 to 14.60 metres below ground level and considerable obstruction time was incurred in Boreholes 1, 3 and 4, four attempts being made to drill Borehole 1 and three attempts to drill Borehole 3.

Three unsuccessful attempts were made at undisturbed 105 mm sampling within cohesive soil. The remaining soils were predominantly granular and Standard Penetration Tests (SPT) were performed generally at abut 1.50 metre intervals as well as within rock. Where full 0.3 metre penetration was not achieved, the number of blows for the quoted penetration is given. Disturbed samples were taken at intervals or at change of stratum for classification purposes and sealed in polythene containers. Water samples were taken in amber glass containers and sent to our testing laboratary.

Standpipes were installed in all boreholes to the depths shown on the logs for future groundwater sampling and monitoring. These were constructed in accardance with your standard detail and were capped at surface with raised steel covers with padlocks.

In-situ variable head permeability tests were performed in the standpipe installations in each borehole and test results are given in tabular form in Appendix 1.

LABORATORY TESTING

The water samples were despatched to our testing laboratory for analysis in accordance with the Engineer's specified suite of tests and results are included in Appendix 2.

STRATEX LIMITED

G Ferguson

G Ferguson M F Robb BSc CEng MICE FGS MIEI

STRATEX LTD
Site Investigation and Geotechnical Engineers

41a Tullyard Road, Drumbo, LISBURN
Co. Antrim, N Ireland BT27 5JN
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FIG 1 – SITE PLAN

SCALE 1: 2500

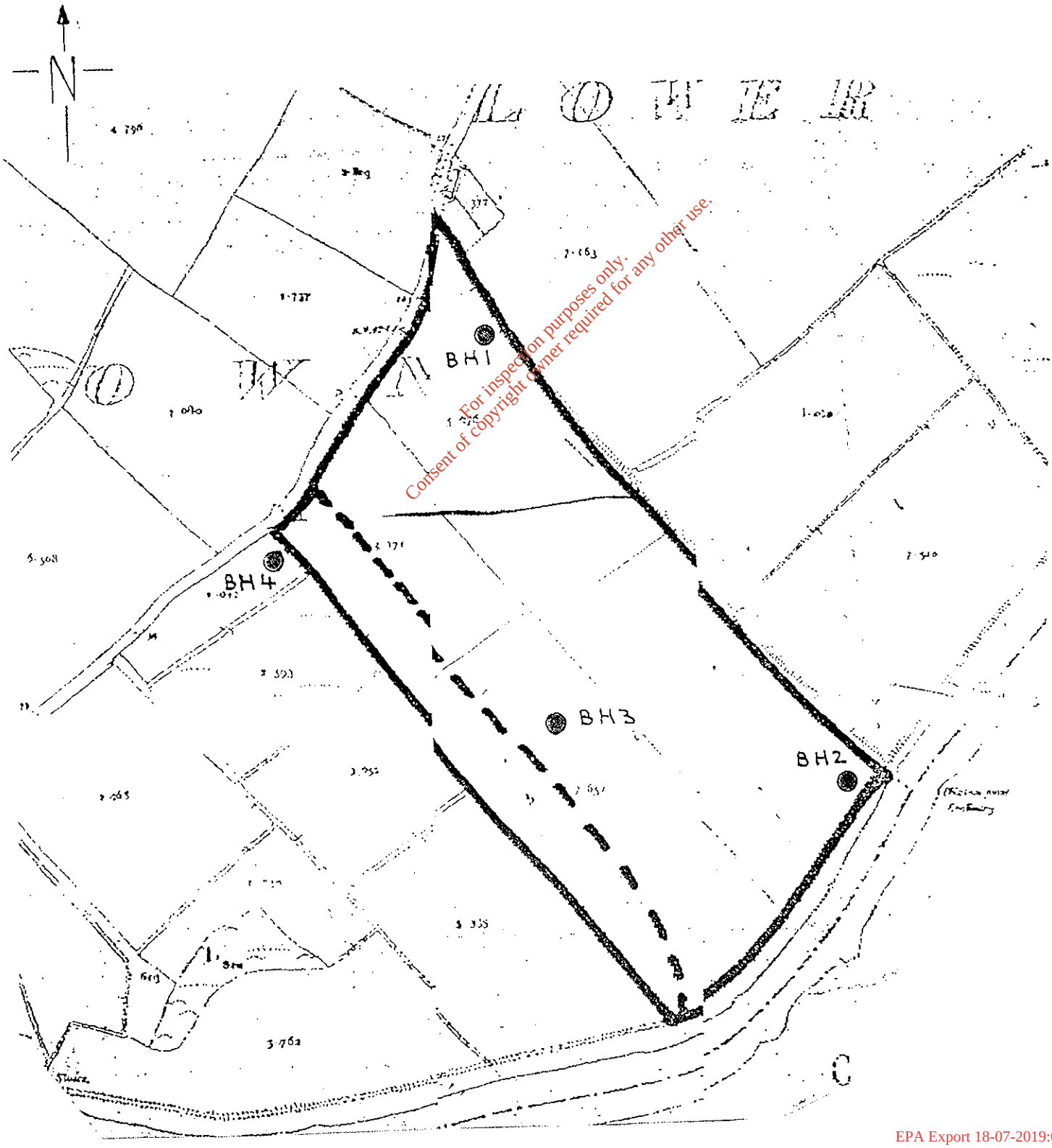
● Borehole

☐ Trial Pit

CLIENT DONEGAL COUNTY COUNCIL

CONS. ENGR. KIRK MCCLURE MORTON

SITE CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL



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Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 1

Sheet 1 of 3

Client DONEGAL COUNTY COUNCIL

Scale 1:50

Engineer KIRK MCCLURE MORTON

Site CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
25/08/98	TOPSOIL (0.20)	0.20			0.20	D	
	Domestic refuse, metal, timber, plastic, in a matrix of brown clayey, gravelly, sandy silt [FILL] [MADE GROUND] (4.80)				1.00	D	
26/08/98					2.00	D	
					3.00	D	
					3.60	W	
STRUCK water at 4.00m SLIGHT FLOW					4.00	D	
PM 4.00m		5.00			5.00	D	
27/08/98 AM 4.00m	Loose, greenish grey, slightly gravelly, silty, fine, medium and coarse grained SAND containing bands of grey, very sandy silt (4.00) [FLUVIO GLACIAL]				5.15-5.450		S N4
					5.30	W	
					5.50	D	
					6.00	D	
					6.60	W	
					7.00	D	
					7.50	D	
					7.65-7.950		S N5
STRUCK water at 8.00m SLIGHT FLOW					8.00	D	
		9.00			9.00	D	
	Loose, greenish grey, very silty, fine and medium grained SAND (2.00) [FLUVIO GLACIAL]				9.15-9.450		S N4
					10.00	D	

Remarks

Four attempts were made to drill borehole
First attempt met refusal at 1.00m depth
Second attempt met refusal at 1.20m depth
Third attempt met refusal at 1.50m depth

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 11.00m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 2

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 1

Sheet 2 of 3

Client: DONEGAL COUNTY COUNCIL

Engineer: KIRK MCCLURE MORTON

Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Scale: 1:50

Ground Level:

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
					10.50	D	
					10.65-10.95		S N2
	END OF BOREHOLE	11.00			11.00	D	

Remarks

Four attempts were made to drill borehole
First attempt met refusal at 1.00m depth
Second attempt met refusal at 1.20m depth
Third attempt met refusal at 1.50m depth

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 11.00m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achievod, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 2

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 1
Sheet 3 of 3

Client: DONEGAL COUNTY COUNCIL
Engineer: KIRK MCCLURE MORTON
Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Scale: 1:50
Ground Level:

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test

i. Obstruction time from 1.00m to 1.50m for 3.00 hours.
Obstruction time from 2.30m to 2.90m for 1.50 hours.
ii. Install standpipe to 5.00m.
Install standpipe to 11.00m.

GROUNDWATER OBSERVATIONS

Date	Time	Borehole Depth	Casing Depth	Water Level
26/08/98	PM	5.00	5.00	4.00
27/08/98	AM	5.00	5.00	4.00

All depths are given in metres

Remarks

Four attempts were made to drill borehole
First attempt met refusal at 1.00m depth
Second attempt met refusal at 1.20m depth
Third attempt met refusal at 1.50m depth

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 11.00m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 2

STRATEX LTD
Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 2
Sheet 1 of 3

Client: DONEGAL COUNTY COUNCIL
Engineer: KIRK MCCLURE MORTON
Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Scale: 1:50
Ground Level:

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
28/08/98	TOPSOIL (0.50)						
		0.50			0.50	D	
	Domestic refuse, cloth, metal, timberplastic, glass, in a matrix of brown, clayey, gravelly, sandy silt [FILL] [MADE GROUND] (6.00)				1.00	D	
					2.00	D	
					3.00	D	
					3.50	D	
					3.50	W	
STRUCK water at 3.80m SLIGHT TO MODERATE FLOW					3.80	W	
		6.50			6.50	D	
	Soft, dark brown, clayey, peaty SILT (1.50) [RECENT]				6.50-6.95	U	(NO REC)
					7.50	D	
					7.65-7.950		S N4
		8.00			8.00	D	
	Loose, dark brown, slightly gravelly, silty, fine, medium and coarse grained SAND (0.50) [FLUVIO GLACIAL]				8.20	D	
		8.50			8.50	D	
	Loose, dark brown, slightly silty, very sandy, fine grained GRAVEL (1.00) [FLUVIO GLACIAL]				9.00	D	
					9.15-9.450		S N5
PM 6.20m		9.50			9.50	D	
31/08/98 AM 4.90m	Loose, dark brown, slightly gravelly, fine, medium and coarse grained SAND (3.00) [FLUVIO GLACIAL]				10.00	D	

Remarks

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 12.50m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 3

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 2

Sheet 2 of 3

Client	DONEGAL COUNTY COUNCIL	Scale 1:50
Engineer	KIRK MCCLURE MORTON	
Site	CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL	Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
					10.50	D	
					10.65-10.95		S N4
					11.00	D	
					12.00	D	
					12.15-12.45		S N5
	END OF BOREHOLE	12.50					

Remarks

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 12.50m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 3

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 2
Sheet 3 of 3

Client: DONEGAL COUNTY COUNCIL
Scale: 1:50
Engineer: KIRK MCCLURE MORTON
Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL
Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test

i. Install standpipe to 6.50m.
Install standpipe to 12.50m.

GROUNDWATER OBSERVATIONS

Date	Time	Borehole Depth	Casing Depth	Water Level
28/08/98	PM	9.50	9.50	6.20
31/08/98	AM	9.50	9.50	4.90

All depths are given in metres

Remarks

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 3

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 12.50m

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Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 3
Sheet 1 of 3

Client: DONEGAL COUNTY COUNCIL
Engineer: KIRK MCCLURE MORTON
Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Scale: 1:50
Ground Level:

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
31/08/98	Brown, clayey, gravelly, sandy silt [FILL] [MADE GROUND] (0.20)	0.20			0.20	D	
	Domestic refuse, metal, plastic, timber, glass, cloth, in a matrix of brown, clayey, sandy silt [FILL] [MADE GROUND] (6.80)				1.00	D	
					2.00	D	
					3.00	D	
					3.50	D	
STRUCK water at 4.00m SLIGHT FLOW					4.00	D	
					4.00	W	
01/09/98					4.50	D	
		7.00			7.00	D	
	Dark brown, silty PEAT (0.50) [RECENT]				7.00-7.45	U	(NO REC)
		7.50			7.50	D	
	Loose, grey, silty SAND containing bands of grey, sandy silt (5.10) [FLUVIO GLACIAL]				7.40	W	
					8.00	D	
					9.00	D	
PM 6.10m					9.15-9.450		S N4
02/09/98 AM 3.50m					10.00	D	

Remarks

Three attempts were made to drill borehole
First attempt met refusal at 4.00m depth
Second attempt met refusal at 4.50m depth

Drilling Method: Shell & Auger: 14.60mm Diameter, Cased to: 14.60m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 4

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 3

Sheet 2 of 3

Client DONEGAL COUNTY COUNCIL

Scale 1:50

Engineer KIRK MCCLURE MORTON

Site CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
					10.50	D	
					10.65-10.950		S N6
					11.00	D	
					12.00	D	
					12.15-12.450		S N4
		12.60			12.60-12.600		S 50
	Dense, grey, sandy GRAVEL containing cobbles and large boulders (2.00) [FLUVIO GLACIAL]				12.60	D	
					13.00	D	
					13.50-13.680		S 50
					13.50	D	
					14.00	D	
		14.60					
	END OF BOREHOLE						

Remarks

Three attempts were made to drill borehole
First attempt met refusal at 4.00m depth
Second attempt met refusal at 4.50m depth

Drilling Method: Shell & Auger: 14.60mm Diameter, Cased to: 14.60m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 4

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 3

Sheet 3 of 3

Client: DONEGAL COUNTY COUNCIL

Scale: 1:50

Engineer: KIRK MCCLURE MORTON

Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test

i. Obstruction time from 3.50m to 4.00m for 1.25 hours.
Obstruction time from 4.30m to 4.50m for 1.50 hours.
Obstruction time from 5.10m to 6.30m for 4.00 hours.
Obstruction time from 12.70m to 13.40m for 3.00 hours.
ii. Install standpipe to 7.00m.
Install standpipe to 14.60m.

GROUNDWATER OBSERVATIONS

Date	Time	Borehole Depth	Casing Depth	Water Level
01/09/98	PM	9.50	9.50	6.10
02/09/98	AM	9.50	9.50	3.60

All depths are given in metres

Remarks

Three attempts were made to drill borehole
First attempt met refusal at 4.00m depth
Second attempt met refusal at 4.50m depth

Drilling Method: Shell & Auger: 14.60mm Diameter, Cased to: 14.60m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 4

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 4

Sheet 1 of 2

Client: DONEGAL COUNTY COUNCIL

Engineer: KIRK MCCLURE MORTON

Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Scale: 1:50

Ground Level:

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
03/09/98	TOPSOIL (0.10)	0.10			0.10	D	
	Soft, brownish grey, sandy, clayey, organic SILT (0.60) [RECENT]	0.70			0.70	D	
					0.80	W	
	Soft, dark brown, silty PEAT (1.30) [RECENT]				1.00	D	
					1.50	D	
					1.50-1.95	U	(NO REC)
		2.00			2.00	D	
	Soft, dark brown, silty, sandy PEAT (0.30) [RECENT]	2.30			2.30	D	
	Loose, grey, silty SAND containing bands of greenish grey, sandy silt (4.70) [FLUVIO GRACIAL]				3.00	D	
					3.15-3.450		S N8
					3.80	D	
					4.00	D	
STRUCK water at 4.30m SLIGHT FLOW					4.50	D	
					4.65-4.950		S N4
					5.00	D	
					6.00	D	
					6.15-6.450		S N4
		7.00			6.90	D	
	Medium dense, brown, silty, sandy GRAVEL containing cobbles and boulders (1.20) [FLUVIO GLACIAL]				7.00	D	
					7.50	D	
					7.65-7.950		S N13
					8.00	D	
STRUCK water at 8.20m STRONG FLOW		8.20					
	Light brown, highly to moderately weathered PSAMMITE (0.80) [MOINIAN]						
		9.00			9.00-9.280		S 50
	END OF BOREHOLE				9.00	D	

Remarks

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 9.40m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 5

STRATEX LTD

Telephone: Belfast (01232) 826734

Borehole Log

Borehole No. 4

Sheet 2 of 2

Client: DONEGAL COUNTY COUNCIL

Scale: 1:50

Engineer: KIRK MCCLURE MORTON

Site: CHURCHTOWN LANDFILL SITE, LIFFORD, COUNTY DONEGAL

Ground Level

Date and Water Level	Description	Depth (m)	Legend	Reduced Level	Samples/Tests: Depth (m)	Sample Type	Test
	i. Obstruction time from 7.10m to 7.40m for 1.00 hour. Obstruction time from 8.40m to 8.90m for 1.50 hours. ii. Install standpipe to 9.00m.						

Remarks

Drilling Method: Shell & Auger: 200mm Diameter, Cased to: 9.40m

Sample/Test Key

S	Standard Penetration Test	D	Disturbed Sample
V	Vane Test	B	Bulk Sample
C	Core Recovery (%)	W	Water Sample
r	Rock Quality Designation (RQD %)	P	Piston
		U	Tube

SPT: Where full 0.3m penetration has not been achieved, the number of blows for the quoted penetration is given (not N-value).

Job No. 2293

Figure 5

APPENDIX 1

PERMEABILITY TEST RESULTS

CHURCHTOWN LANDFILL SITE, LIFFORD

GROUND INVESTIGATION

APPENDIX 1

RESULTS OF RISING HEAD PERMEABILITY TEST

BOREHOLE NO 1 DATE: 27.8.98

TIME (mins)	DEPTH TO WATER SURFACE FROM GROUND LEVEL (m)
0	6.20
1	5.72
2	5.47
3	5.27
4	5.14
5	5.03
6	4.93
7	4.86
8	4.79
9	4.72
10	4.67
11	4.62
12	5.57
13	5.51
14	4.48
15	4.45
16	4.43
17	4.39
18	4.36
19	4.33
20	4.31
21	4.28
22	4.26
23	4.24
24	4.22
25	4.20
26	4.19
27	4.18
28	4.17
29	4.16
30	4.15
31	4.14
32	4.13
33	4.12
34	4.11

BOREHOLE NO 1 (continued) DATE: 27.08.98

TIME (mins)	DEPTH TO WATER SURFACE FROM GROUND LEVEL (m)
35	4.10
36	4.09
37	4.08
38	4.07
39	4.06
40	4.05
41	4.04
42	4.03
43	4.02
44	4.01
45	4.00
46	3.99
47	3.99
48	3.98
49	3.98
50	3.97
51	3.97
52	3.96
53	3.96
54	3.96
55	3.95
56	3.94
57	3.94
58	3.93
59	3.93
60	3.93

COEFF. OF PERMEABILITY (k) = 3.3 X 10 $^{-6}$ m/s

BOREHOLE NO 3 DATE: 2.09.98

TIME (mins)	DEPTH TO WATER SURFACE FROM GROUND LEVEL (m)
0	6.00
1	5.80
2	5.80
3	5.80
4	5.77
5-60	5.77

WATER FLOW TOO STRONG TO BALE OUT ANY DEEPER

COEFF. OF PERMEABILITY (k) = 4.0 X 10 $^{-6}$ m/s

BOREHOLE NO 4

DATE: 4.09.98

TIME (mins)	DEPTH TO WATER SURFACE FROM GROUND LEVEL (m)
0	1.52
1	1.20
2	1.11
3	1.02
4	0.98
5	0.94
6	0.89
7	0.84
8	0.73
9	0.70
10	0.67
11	0.64
12	0.61
13	0.59
14	0.58
15	0.50
16	0.56
17	0.55
18	0.54
19	0.51
20	0.50
21	0.49
22	0.48
23	0.47
24	0.46
25	0.45
26	0.44
27	0.43
28	0.42
29	0.42
30	0.41
31	0.41
32	0.41
33	0.40
34	0.40
35	0.40
36	0.40
37	0.39
38	0.39
39	0.39
40	0.39
41	0.39
42	0.39

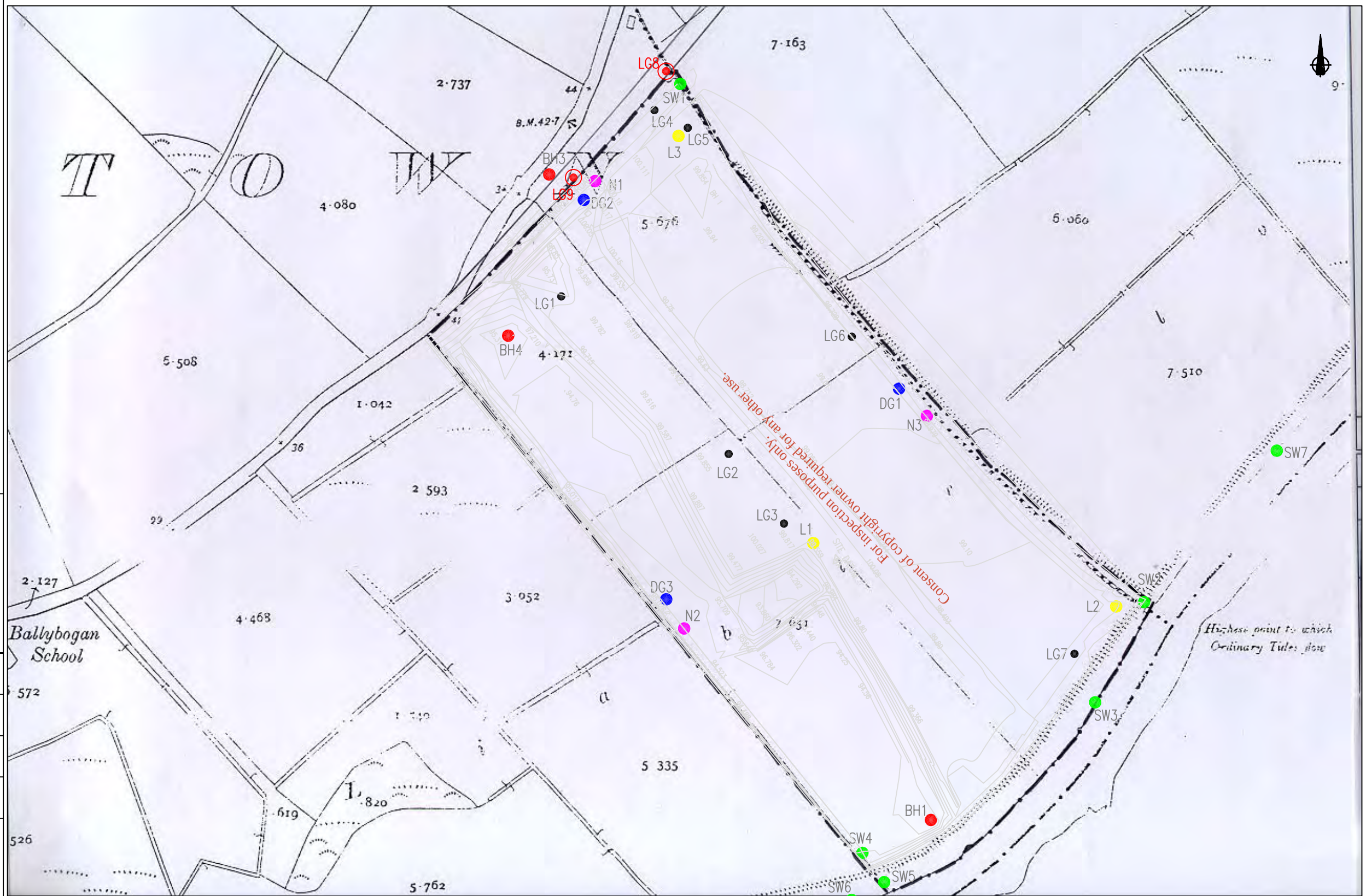
BOREHOLE NO 4 (continued) DATE: 4.09.98

TIME (mins)	DEPTH TO WATER SURFACE FROM GROUND LEVEL (m)
43	0.38
44	0.38
45	0.58
46	0.38
47	0.38
48	0.37
49	0.37
50	0.37
51	0.37
52	0.37
53	0.37
54	0.36
55	0.36
56	0.36
57	0.36
58	0.36
59	0.36
60	0.36

COEFF. OF PERMEABILITY (K) = 2.6 X 10 $^{-3}$ m/s

APPENDIX 2

CONTAMINATION TEST RESULTS



NOTES

LG	GAS MONITORING POINTS
L	LEACHATE SAMPLING POINTS
BH	GROUNDWATER MONITORING POINT
SW	SURFACE WATER MONITORING
DG	DUST MONITORING POINTS
N	NOISE MONITORING POINTS
LG	NEW BOREHOLE LOCATION

REV	DESCRIPTION	BY DATE	CHECK DATE

DRAWN BY PMcM DATE AUG 04	CHECK BY AMcG DATE AUG 04	APPROVED DJD DATE OCT 04
PLOT SCALE 1:2500	SCHEDULES	SHEET SIZE A3

CLIENT
DONEGAL COUNTY COUNCIL

PROJECT
CHURCHTOWN LANDFILL SITE

TITLE
MONITORING POINTS

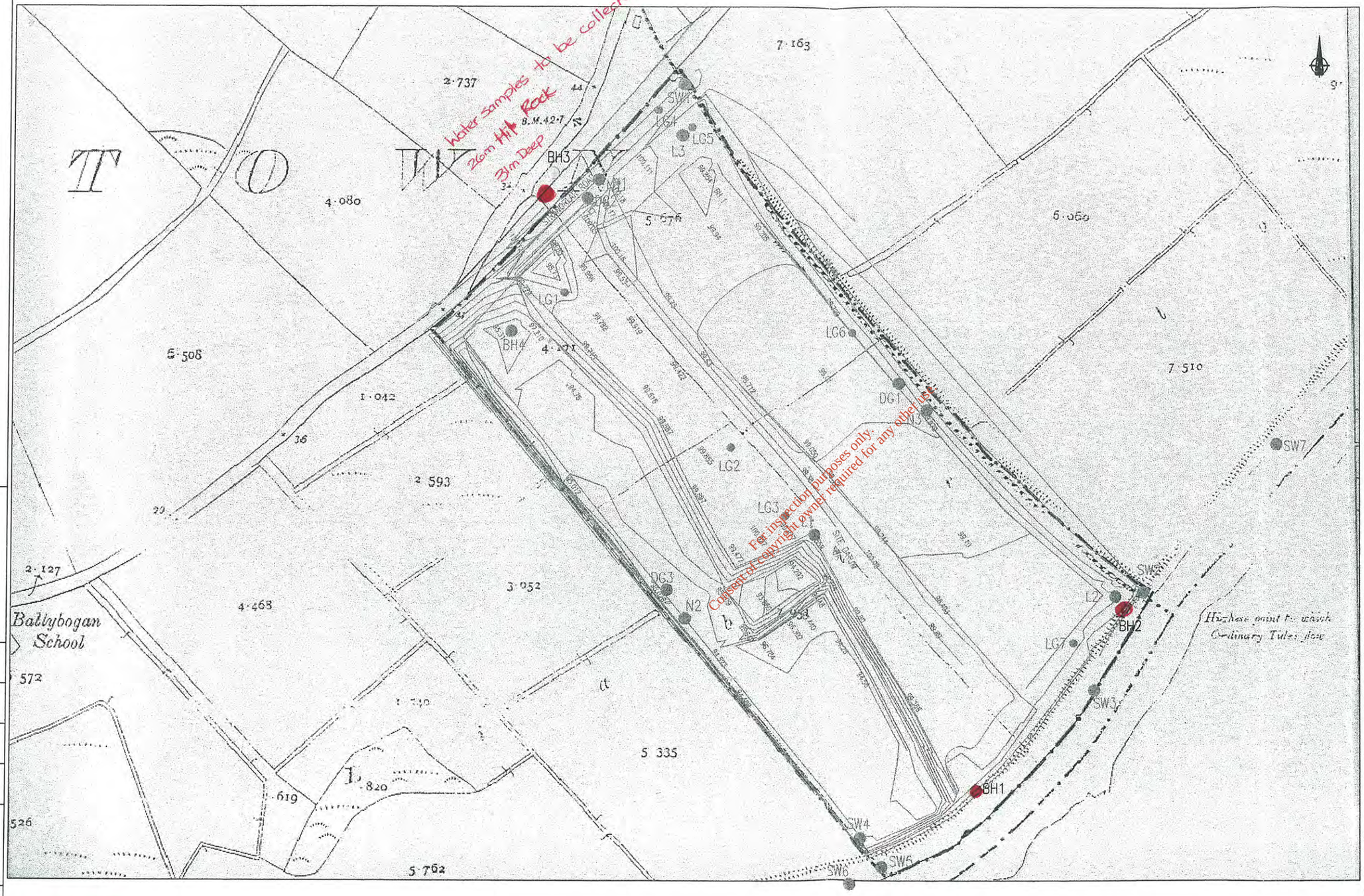
RPS Kirk McClure Morton
CONSULTING ENGINEERS
ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST BT12 6RZ
TEL: 028 9066 7914
FAX: 028 9066 8286
www.kirkmcclueremorton.com

ARCHITECT	
DRAWING No.	5234.63/107
REVISION	

DWG. STATUS	
PRELIM.	●
TENDER	
CONST.	
RECORD	

100mm
100mm

Water samples to be collected 8th June 2001
26m Hit Rock
31m Deep



NOTES

- LG GAS MONITORING POINTS
- L LEACHATE SAMPLING POINTS
- GW GROUNDWATER MONITORING POINT
- SW SURFACE WATER MONITORING
- DG DUST MONITORING POINTS
- N NOISE MONITORING POINTS
- ADDITIONAL BOREHOLE

REV	DESCRIPTION	BY DATE	CHECK DATE
A	BOREHOLE LOCATIONS AMENDED	K.A.D. 06/01	K.A.G. 06/01

DRAWN BY K.A.D. DATE 9/02/01	CHECK BY K.G. DATE 9/02/01	APPROVED A.B. DATE 10/02/01

BASE DRAWING SCALE 1:2500

SCHEDULE SHEETS

CLIENT
DONEGAL COUNTY COUNCIL

PROJECT
CHURCHTOWN LANDFILL SITE

TITLE
PROPOSED LOCATION OF ADDITIONAL BOREHOLES

KIRK McCLURE MORTON
CONSULTING ENGINEERS
ELMWOOD HOUSE 74 BOUCHER ROAD BELFAST BT12 6RZ
TEL: 028 90 667914 FAX: 028 90 668286

ARCHITECT

DRAWING No. 3026.54/108

REVISION A

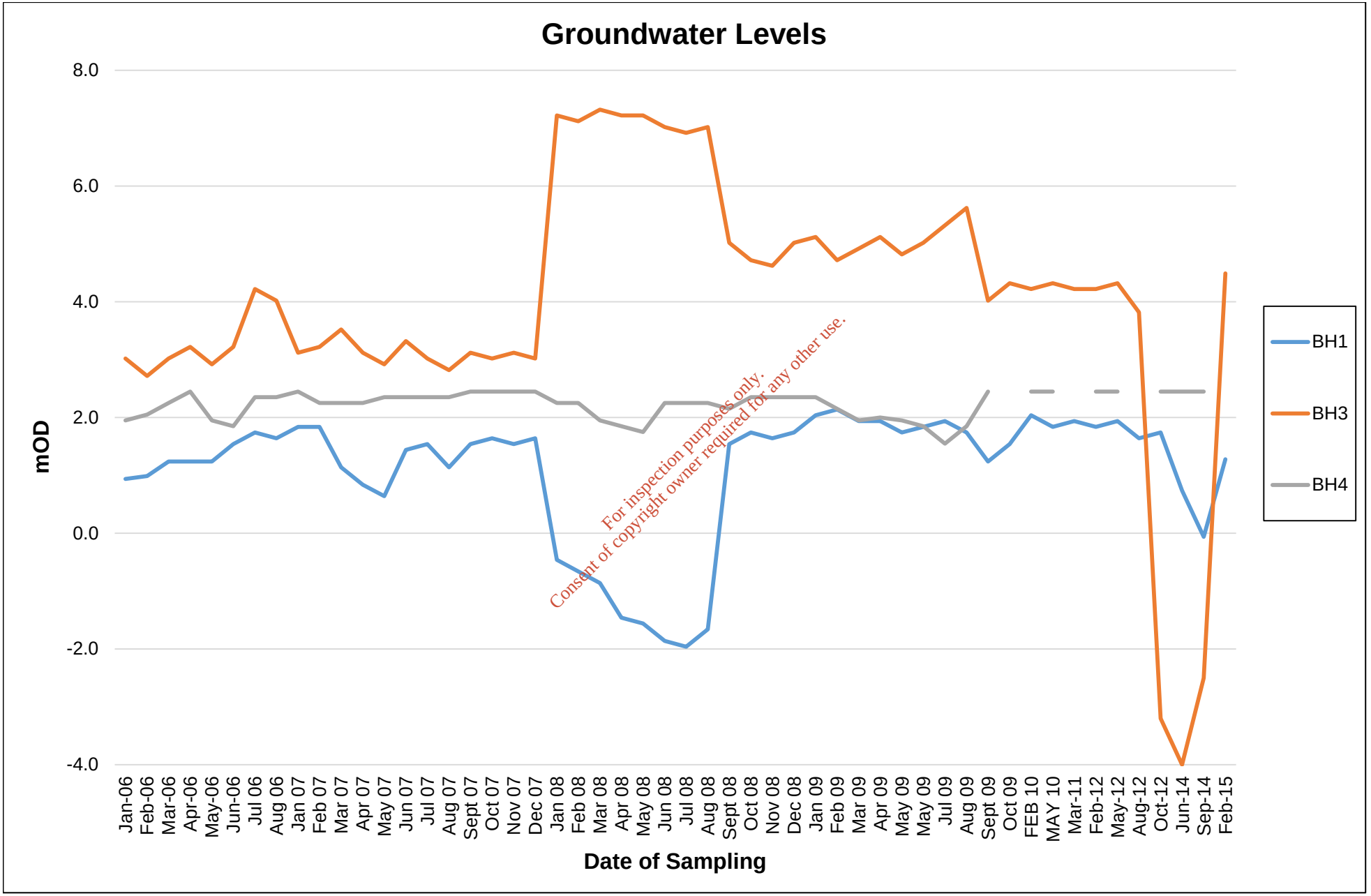
DWG. STATUS	
PRELIM.	●
TENDER	
CONST.	
RECORD	

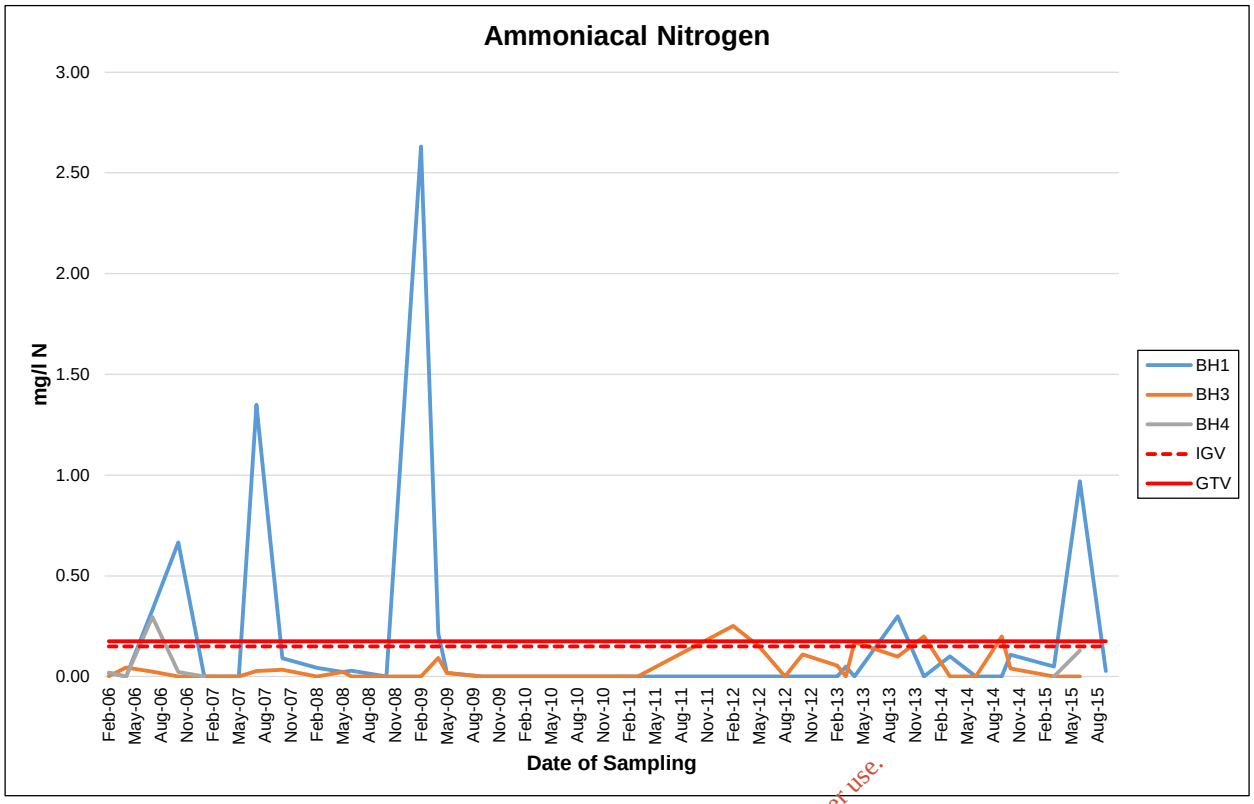
BEGAN DRILLING 10.00am THURSDAY 6th JUNE 2001
FINISHED DRILLING 2.45pm THORSDAY 6th JUNE 2001
COVER & BENTONITE SEAL COMPLETED pm THURSDAY 6th JUNE 2001
ACCESS TO BE AGREED FOR BH1 & BH2

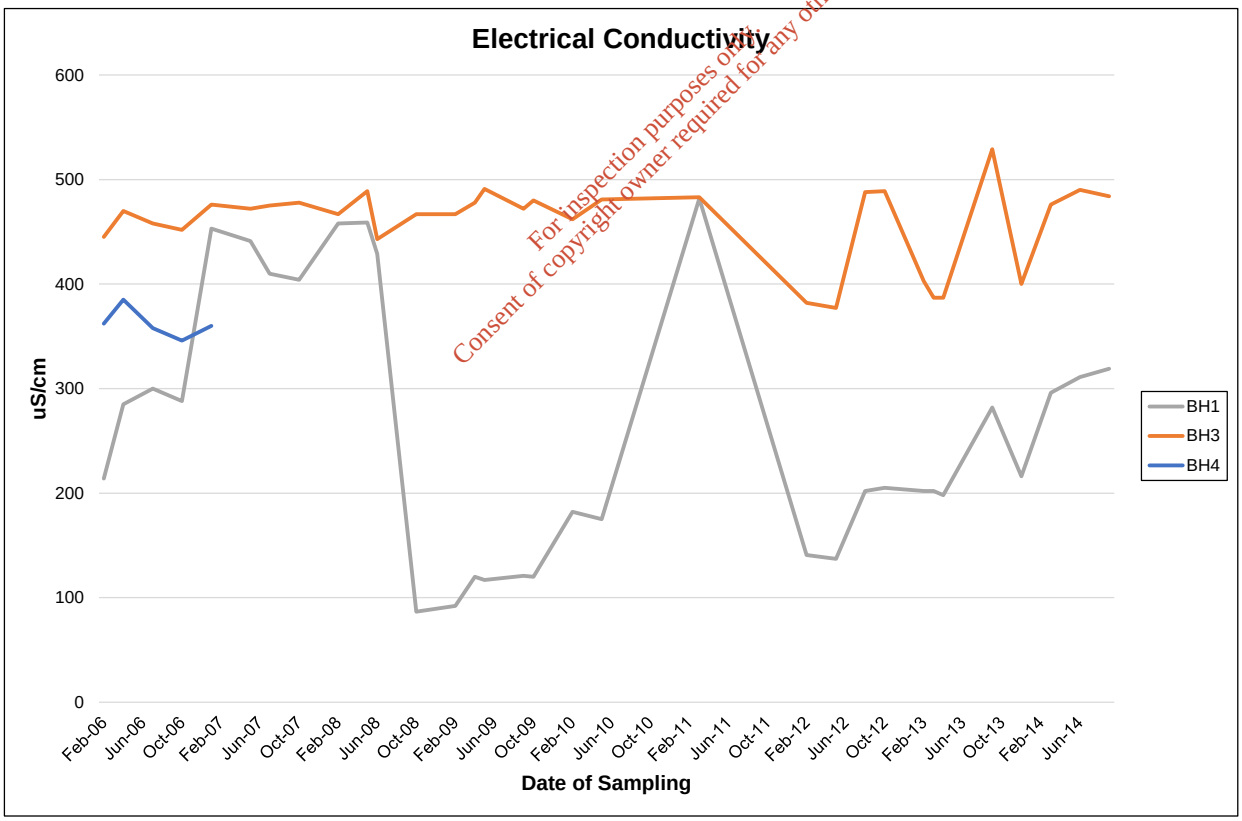
100mm
100mm

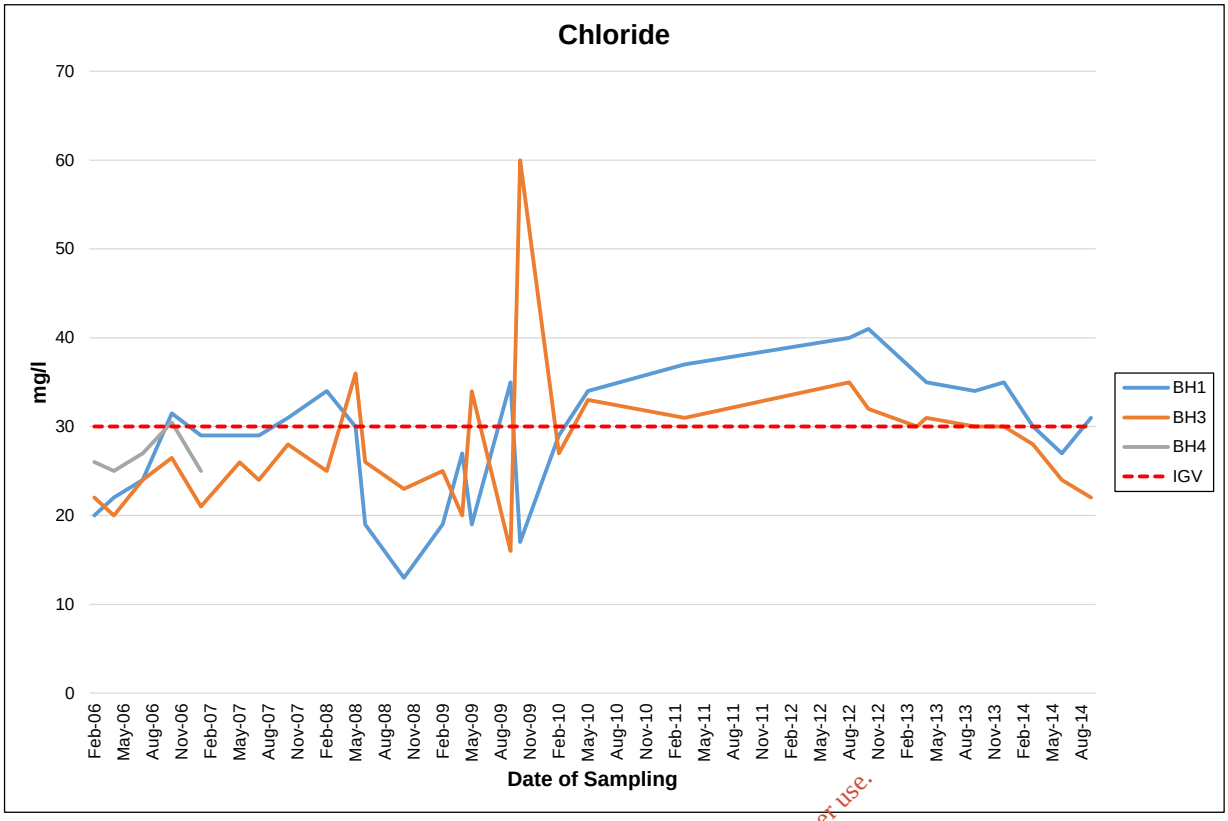
A3C-REV 1

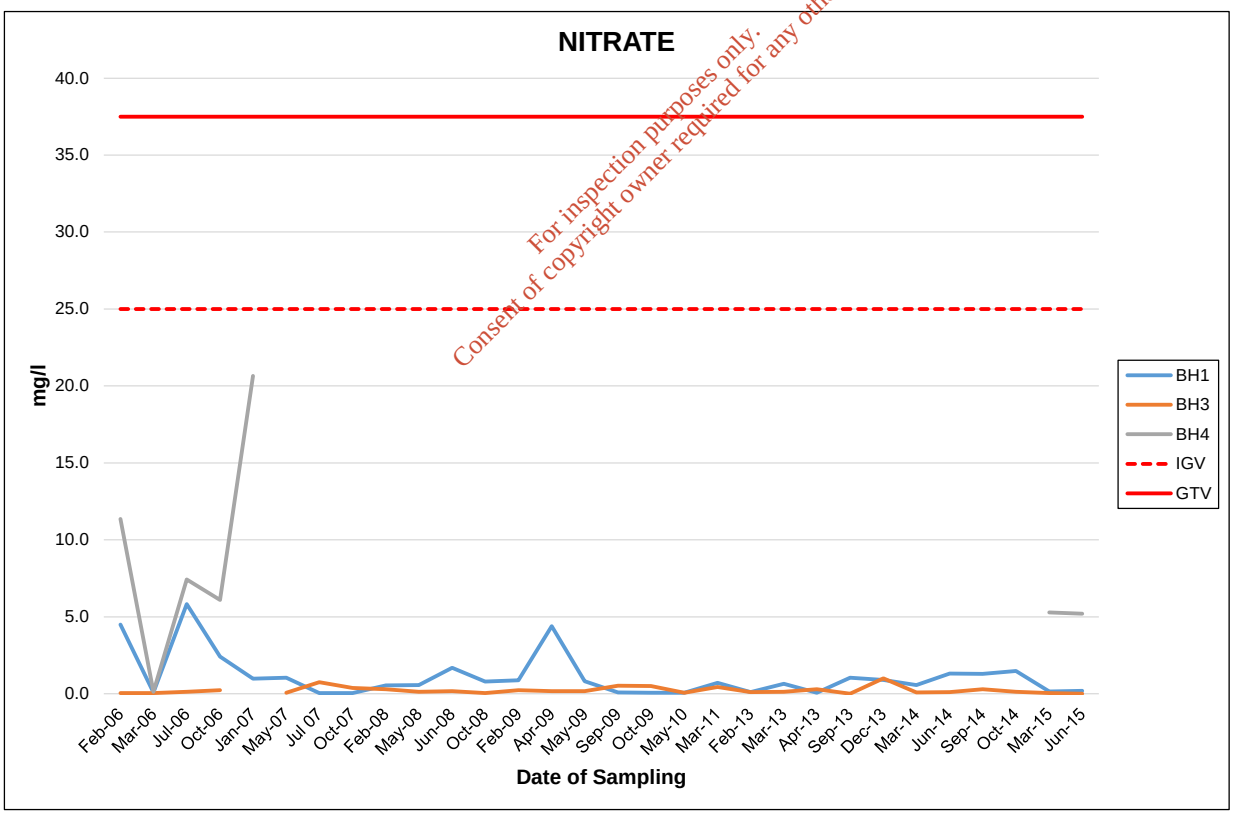
APPENDIX D

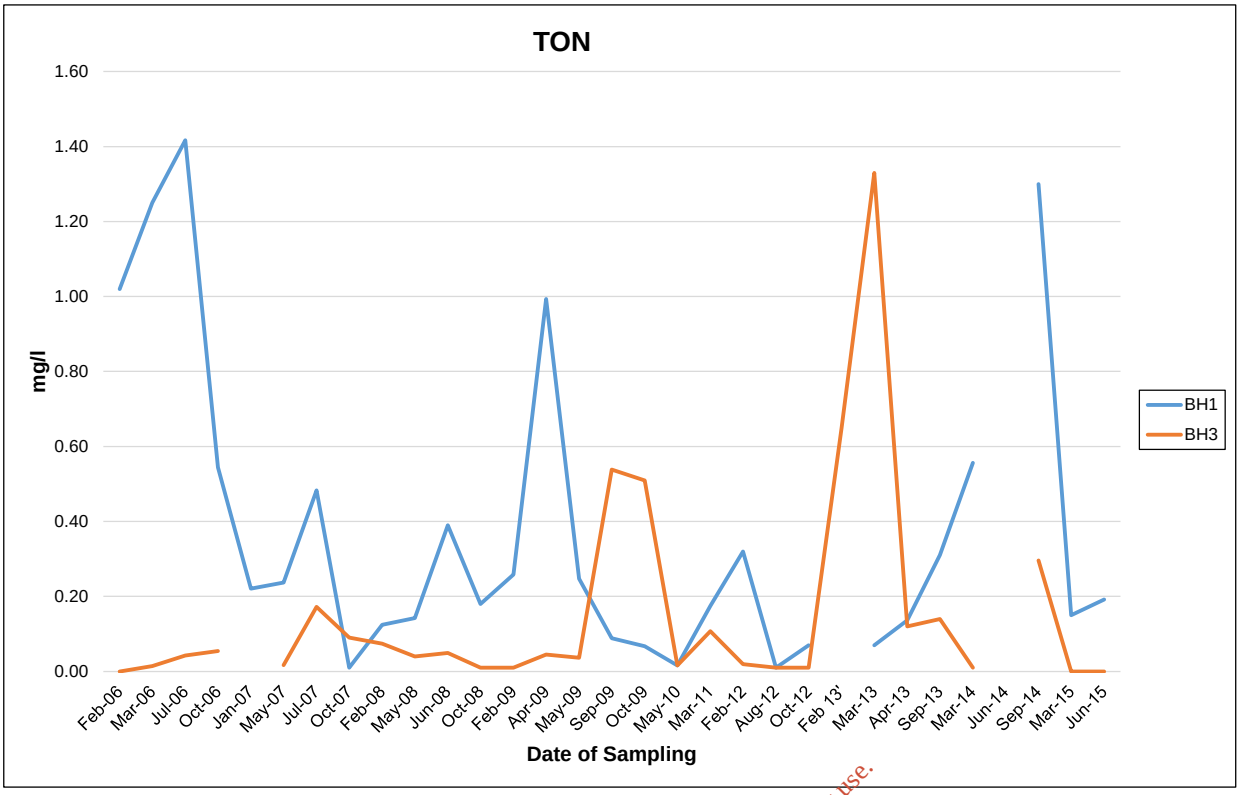


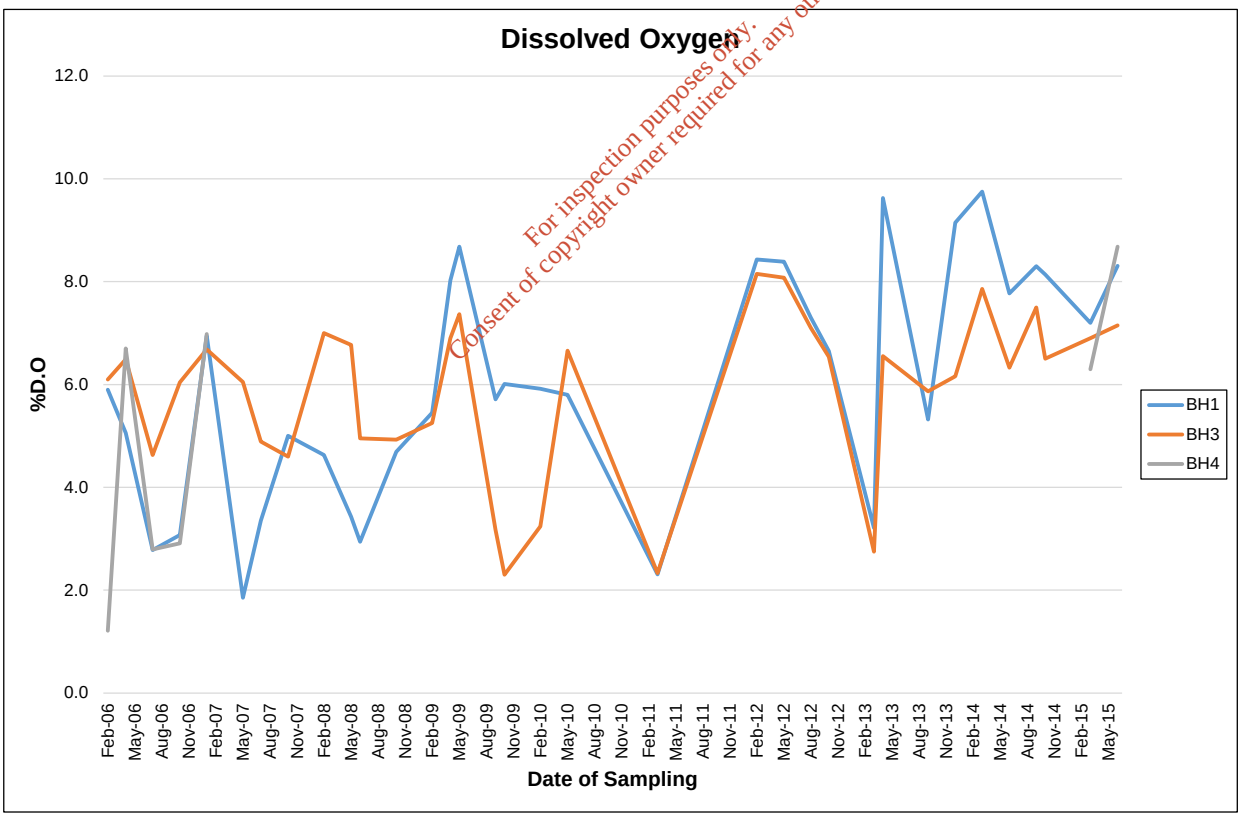


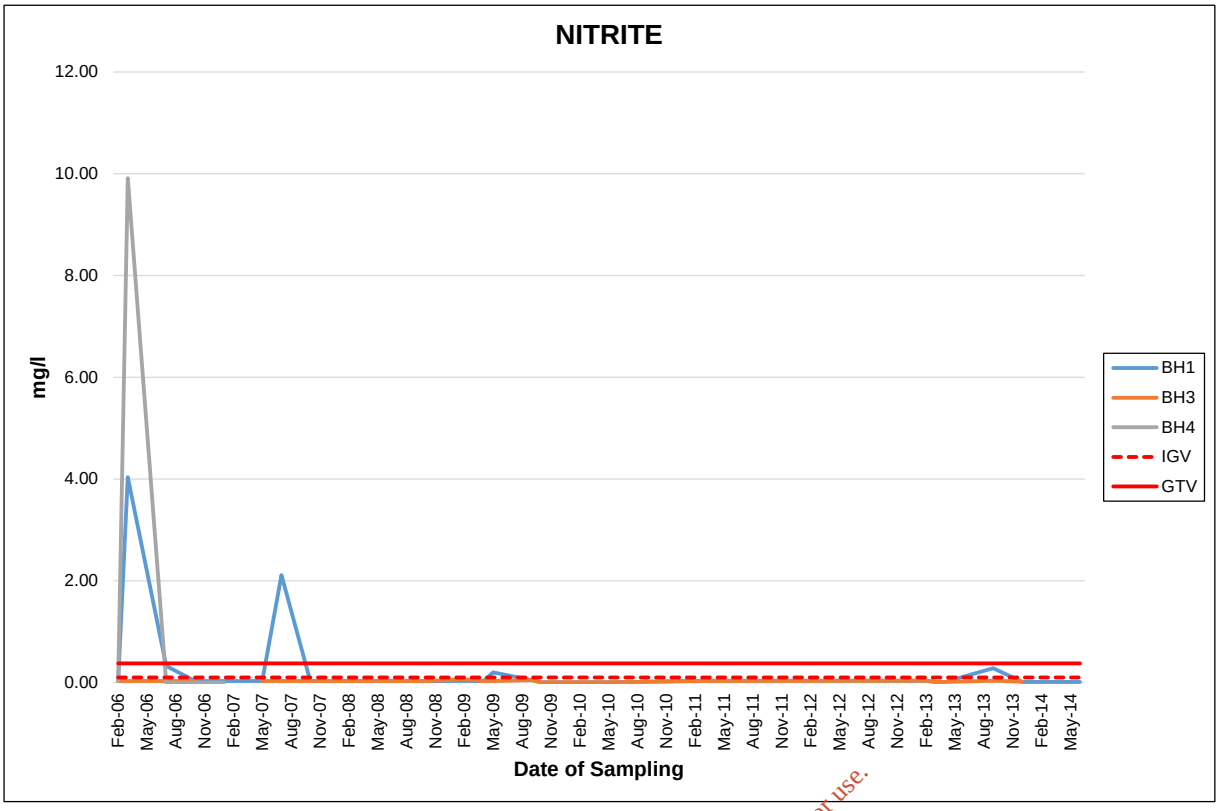


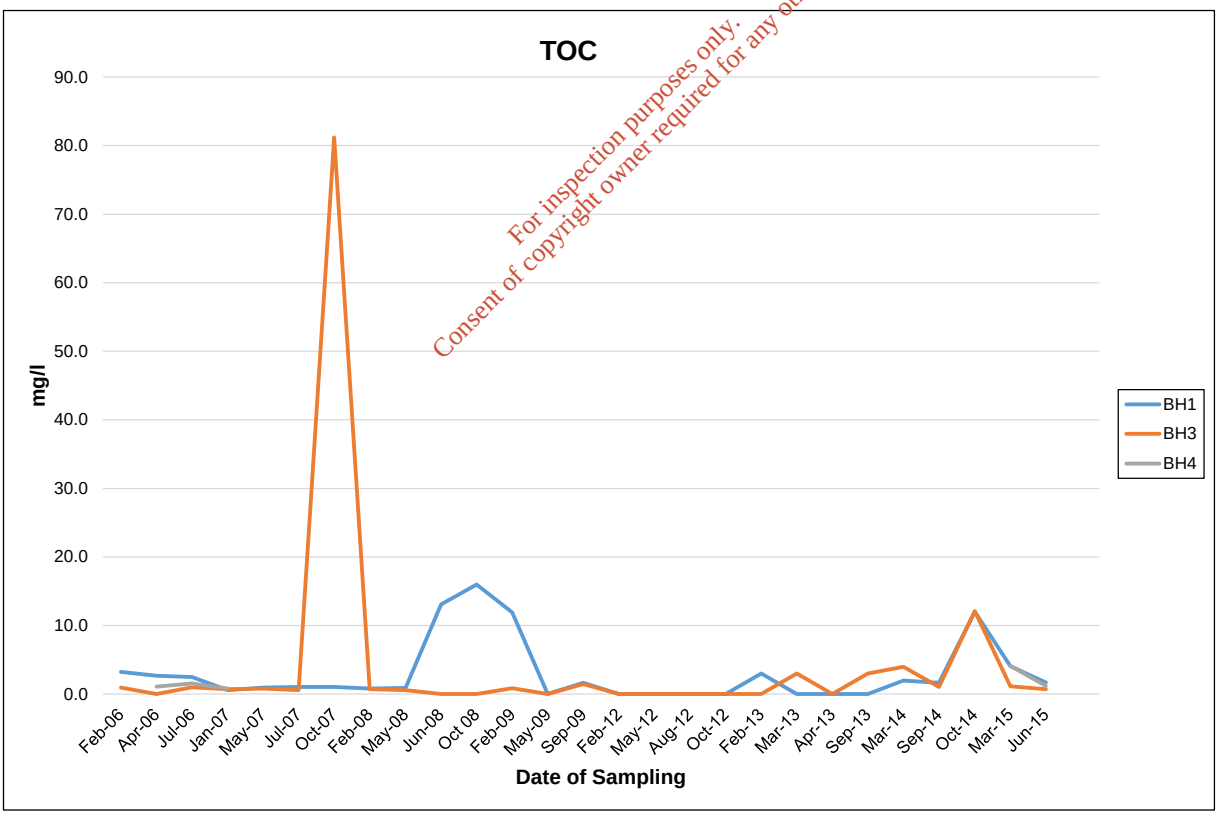


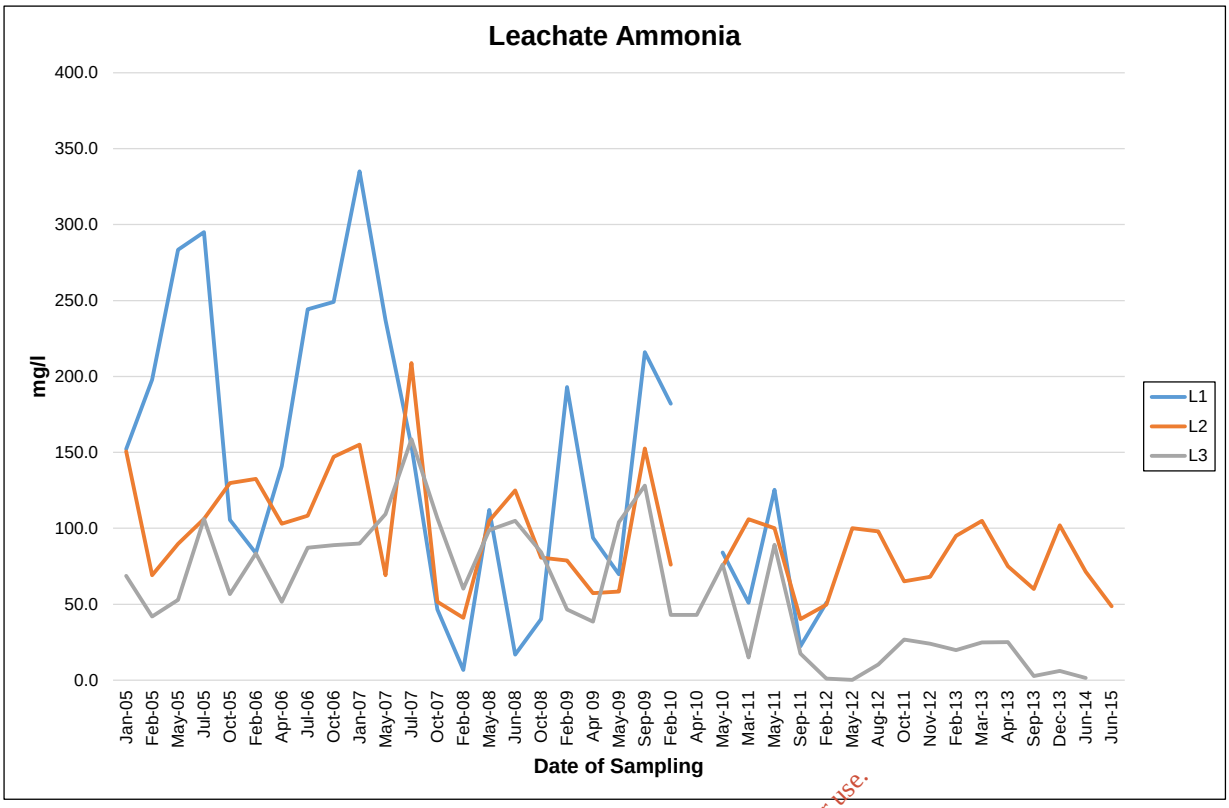


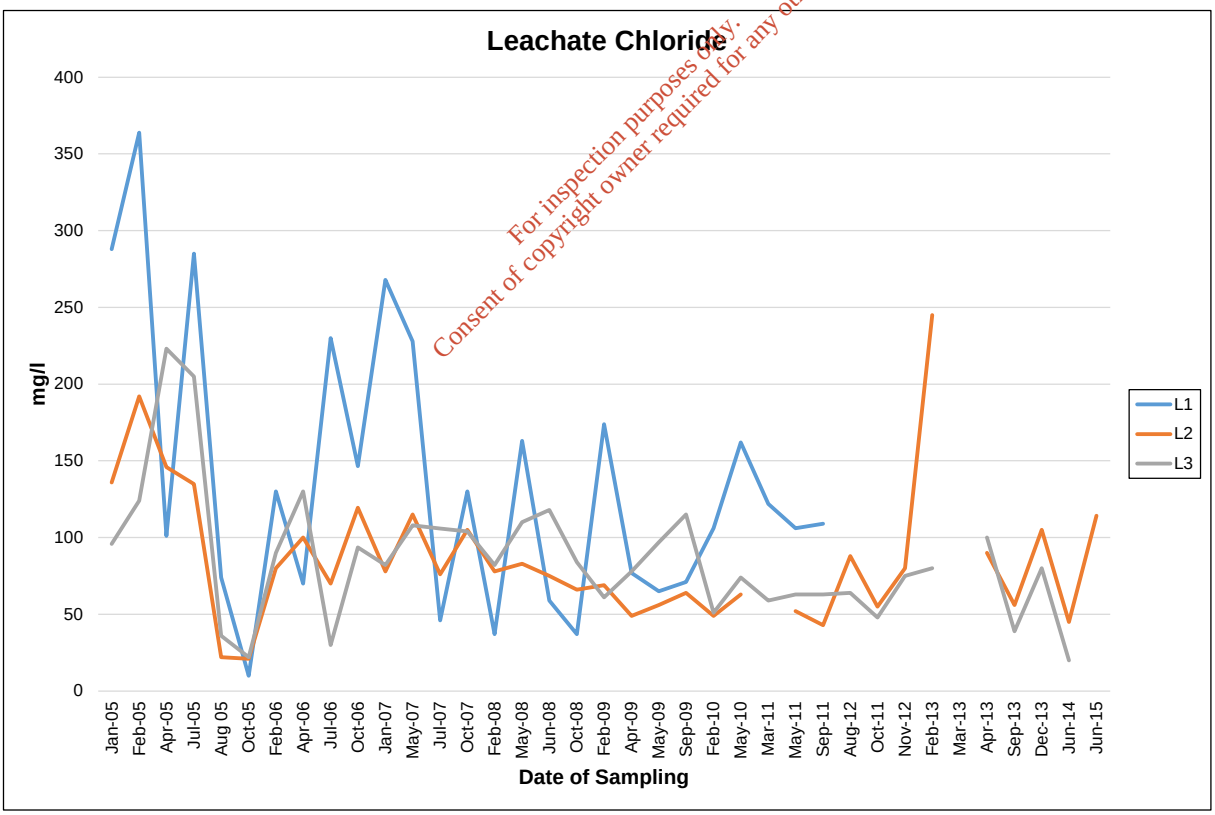


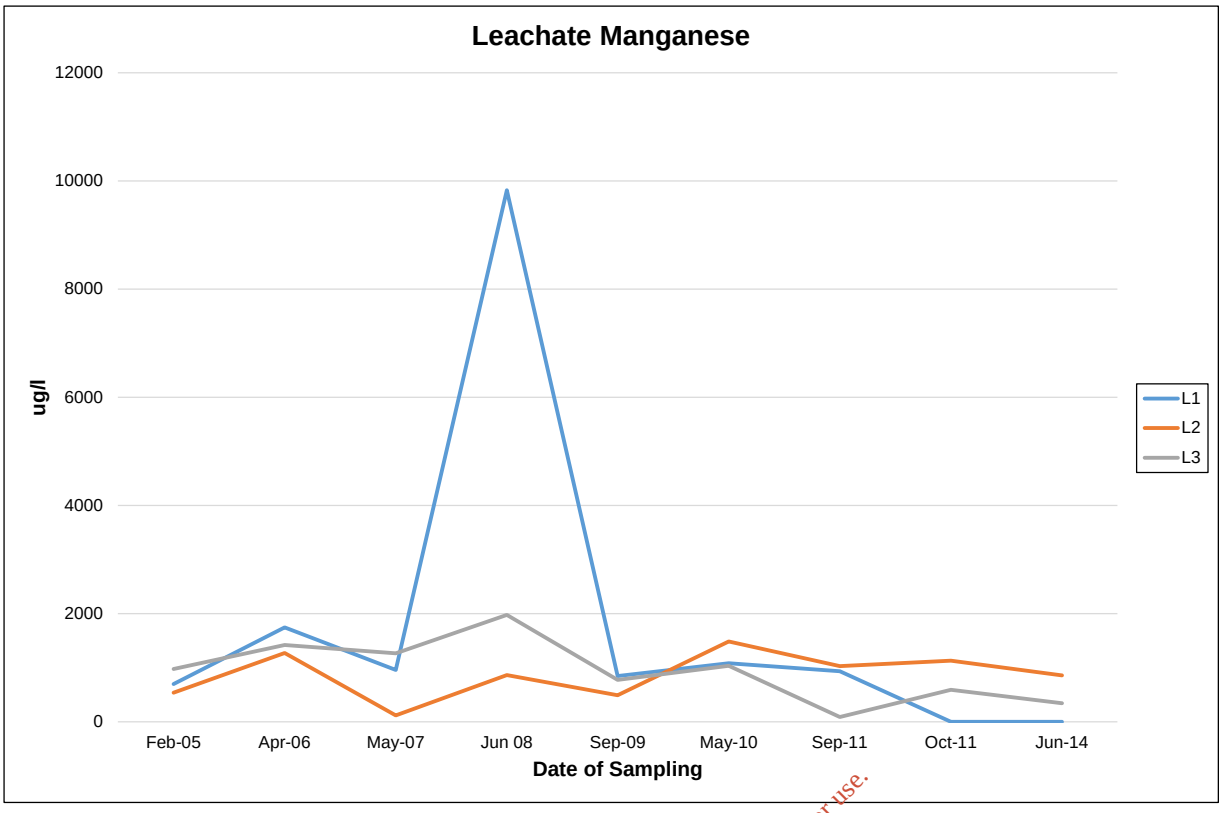


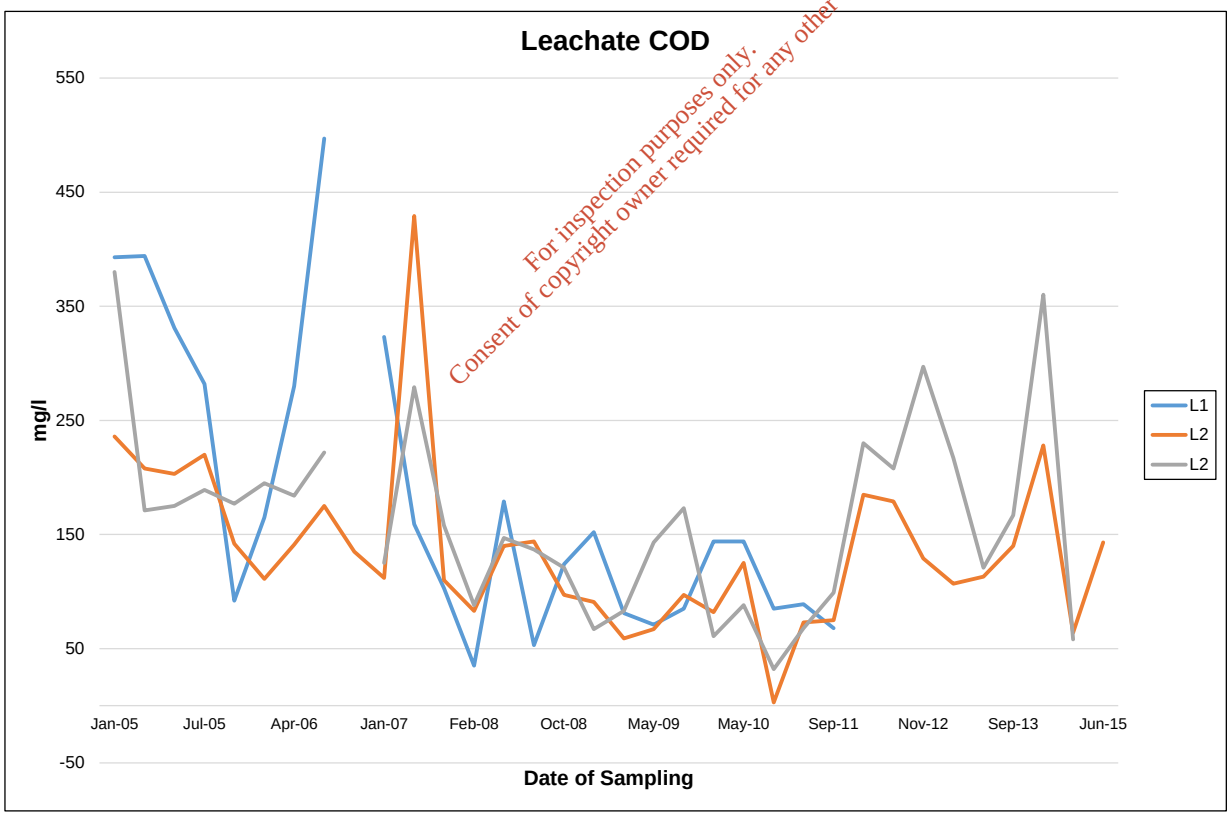


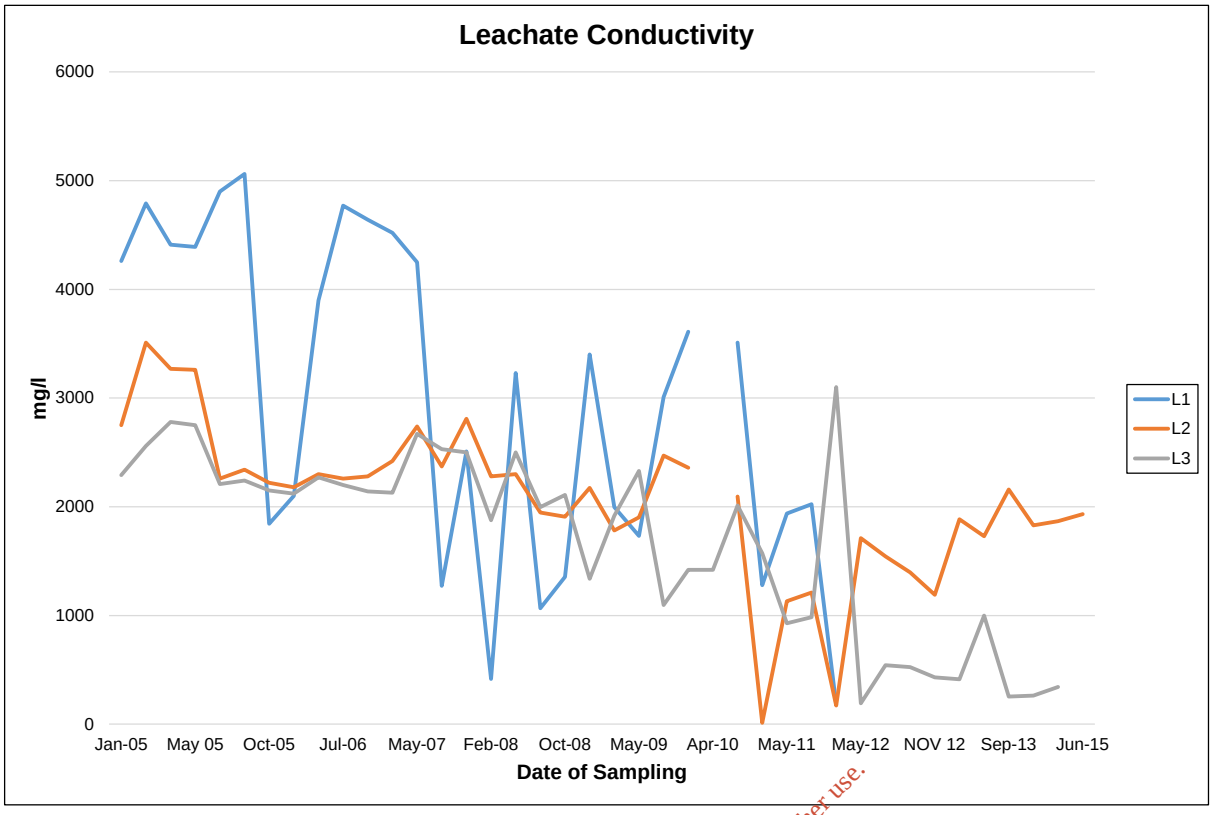


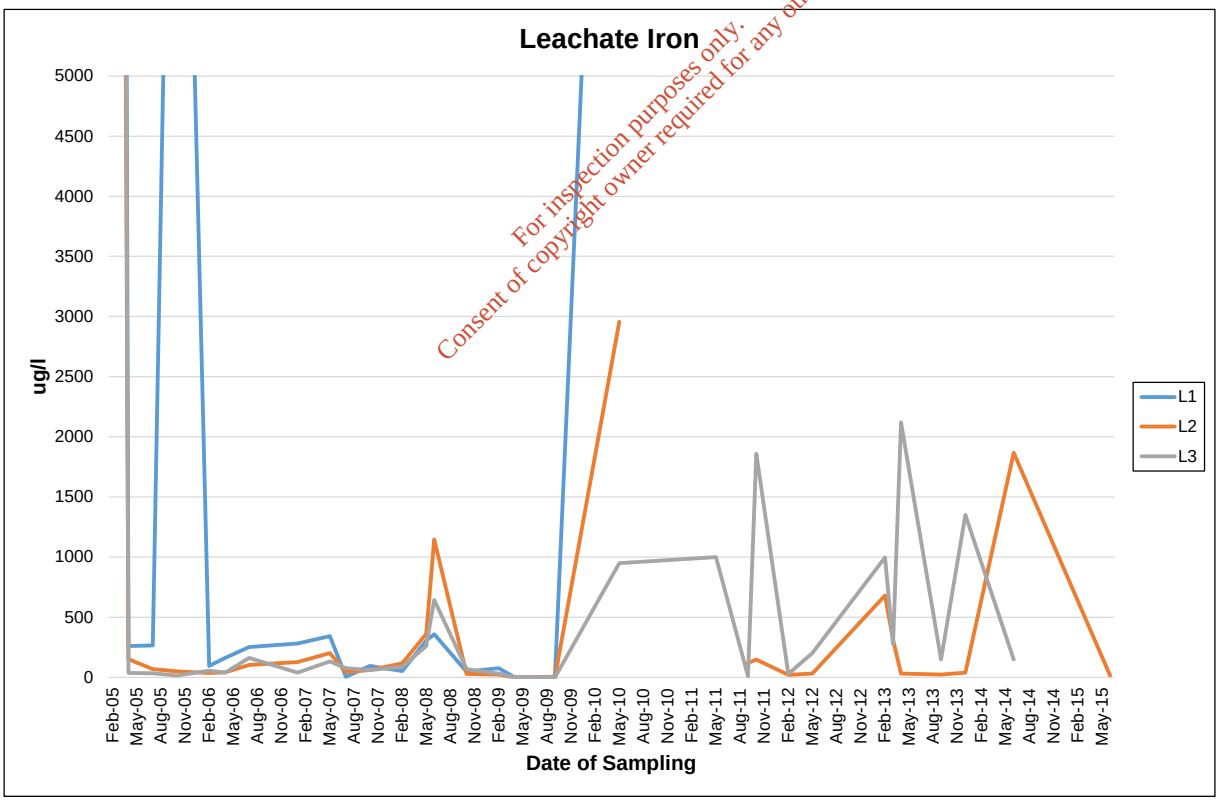


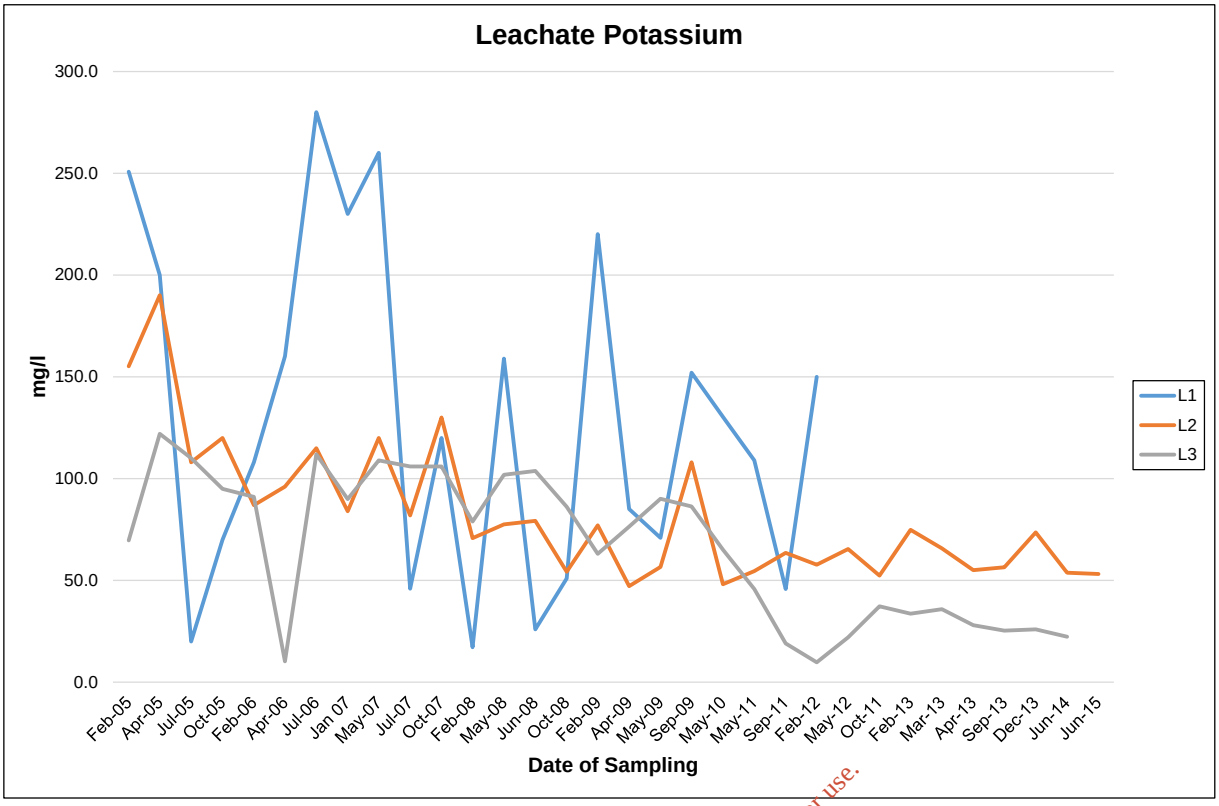


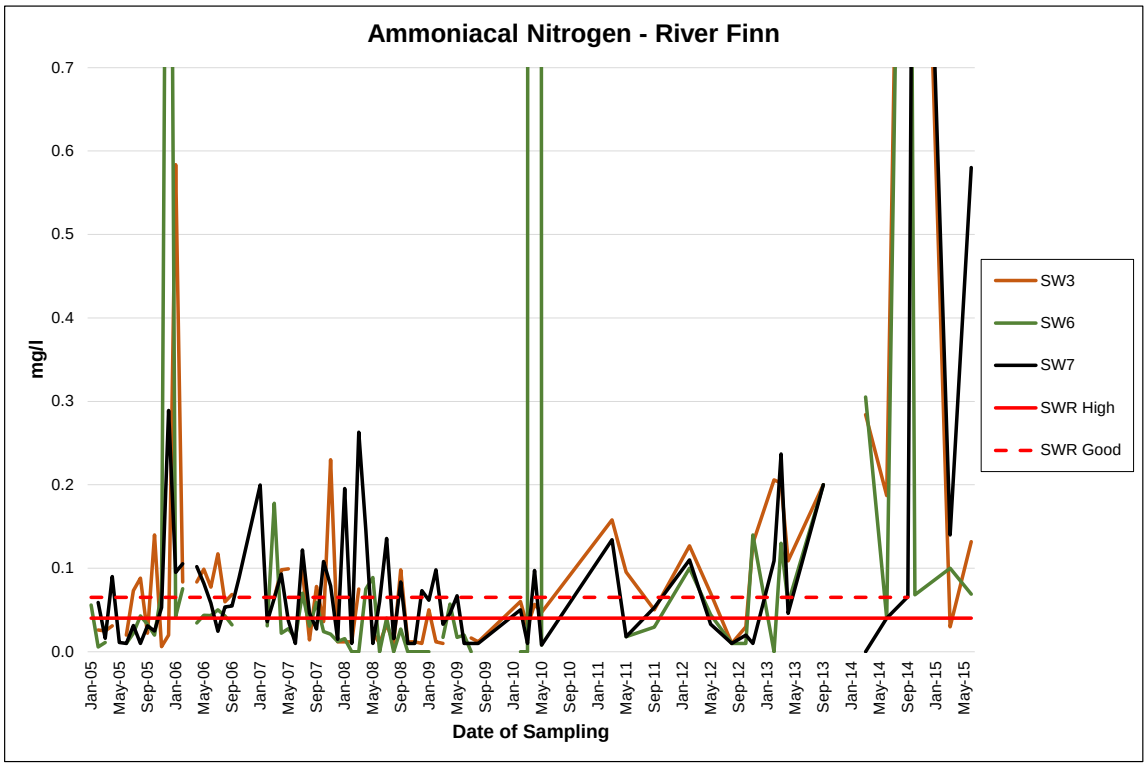


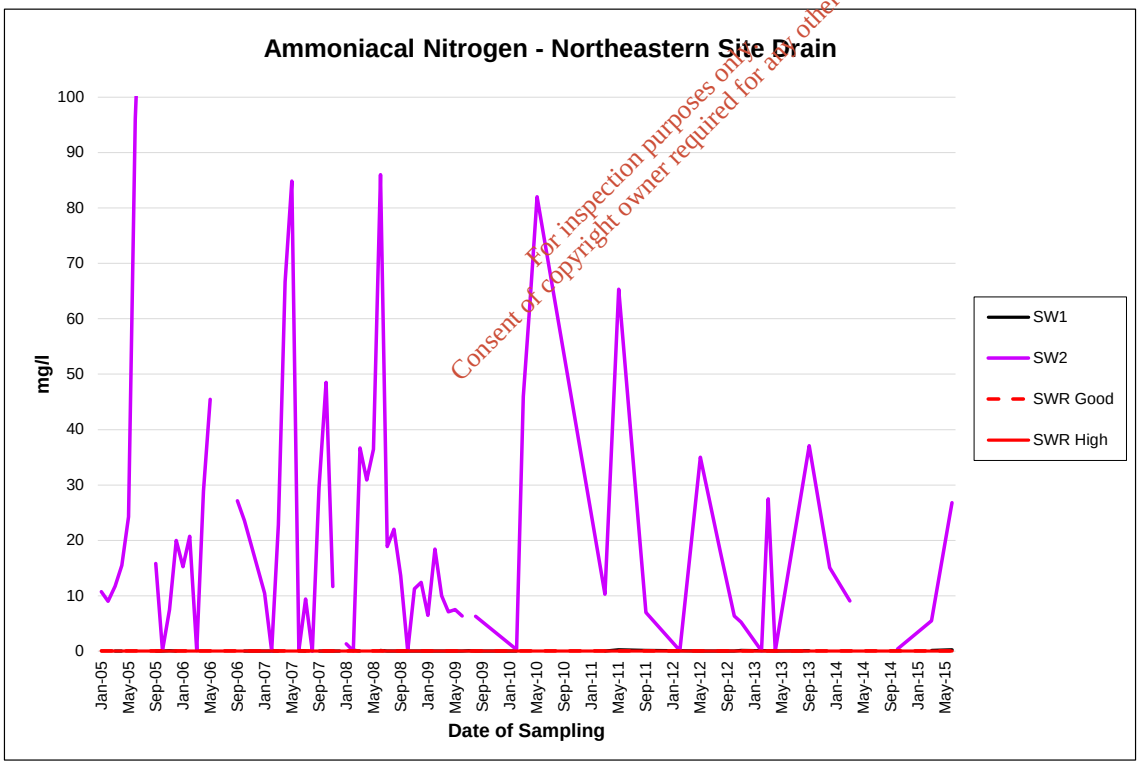


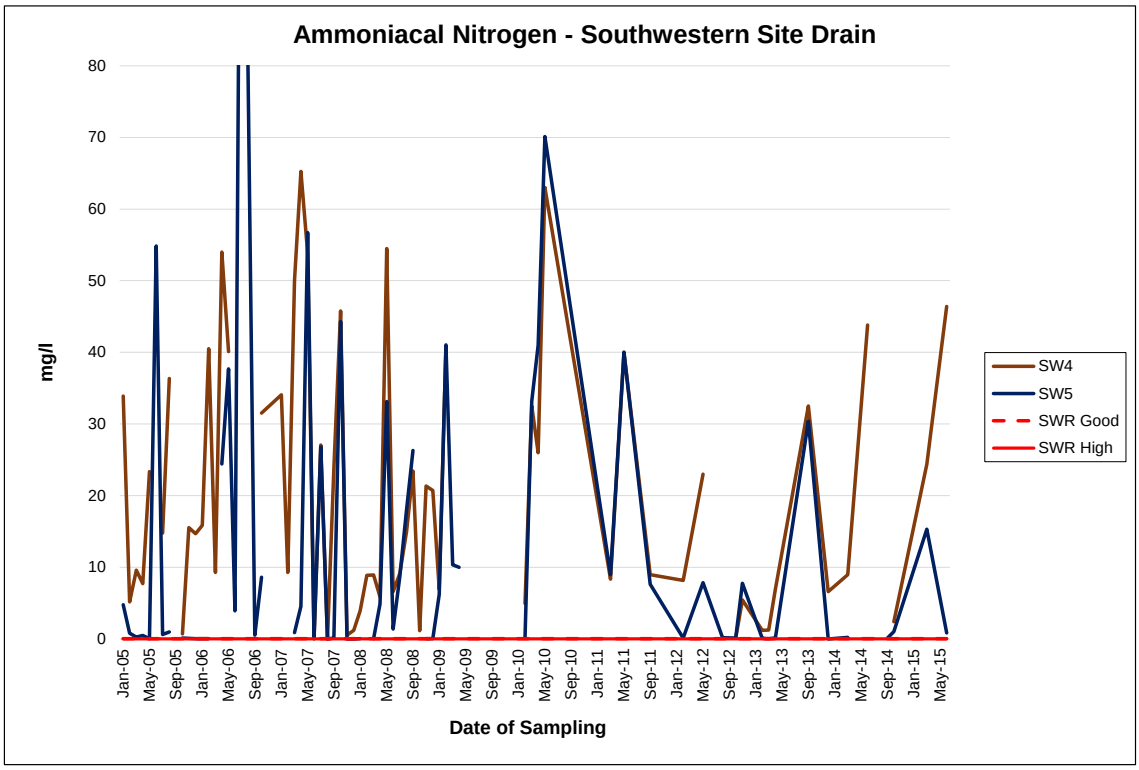


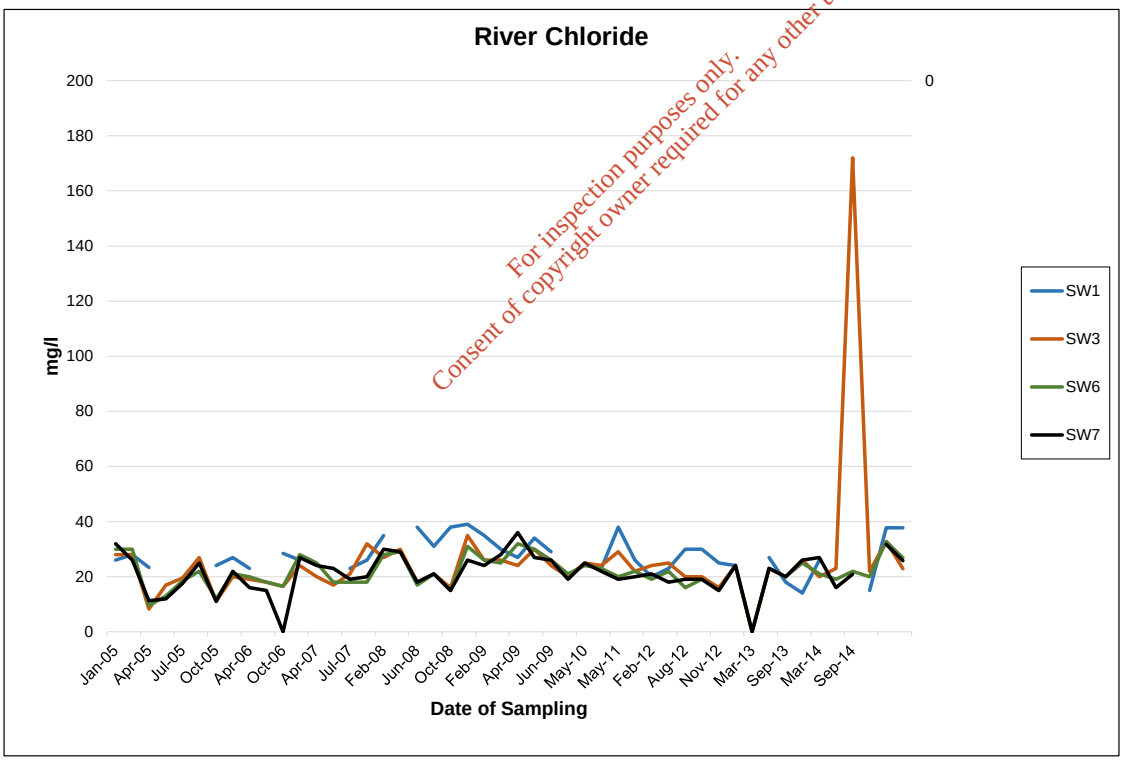


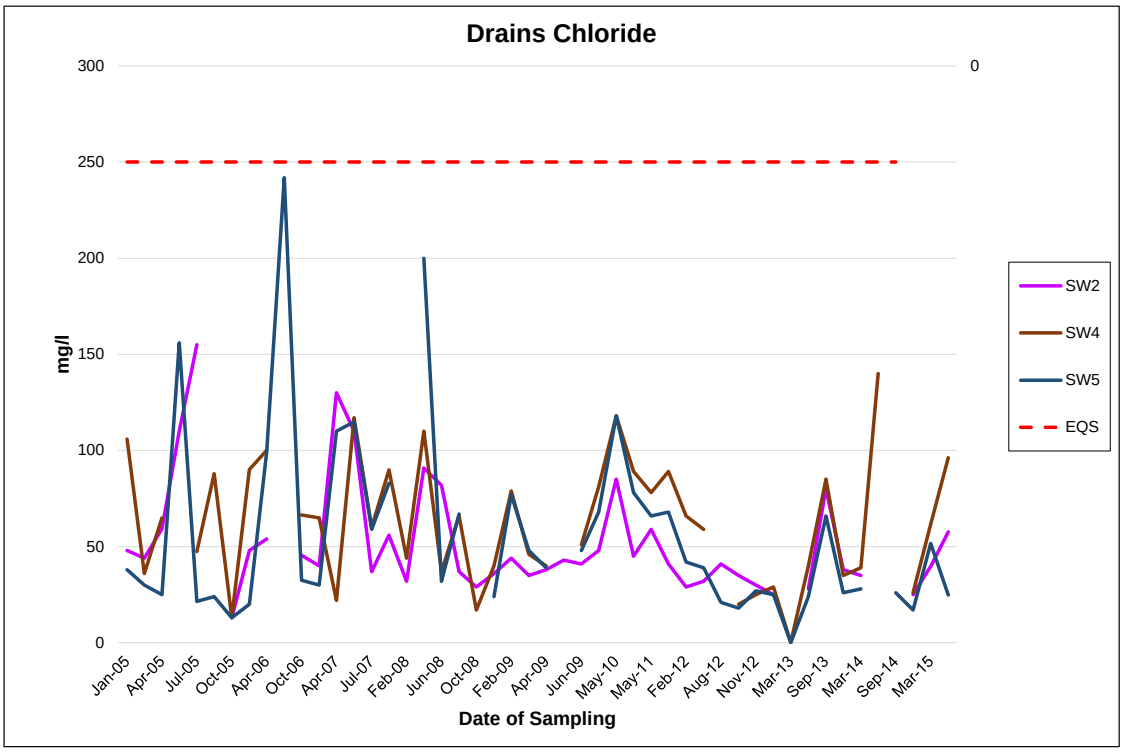


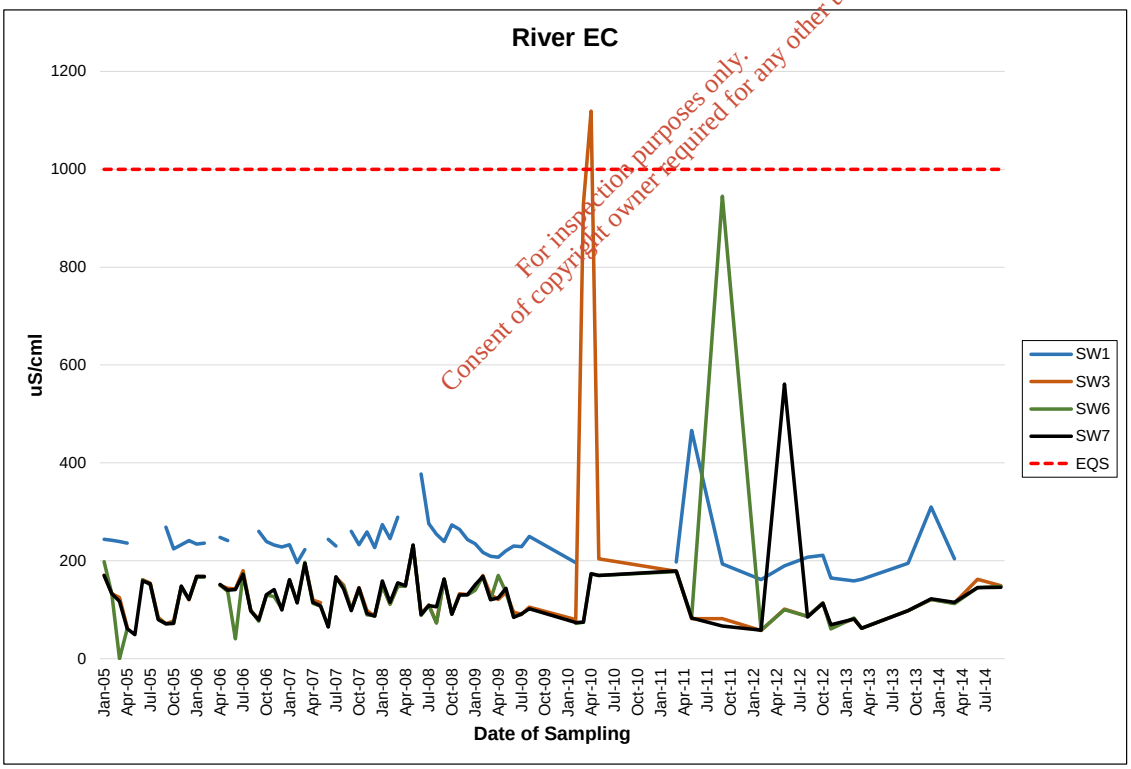


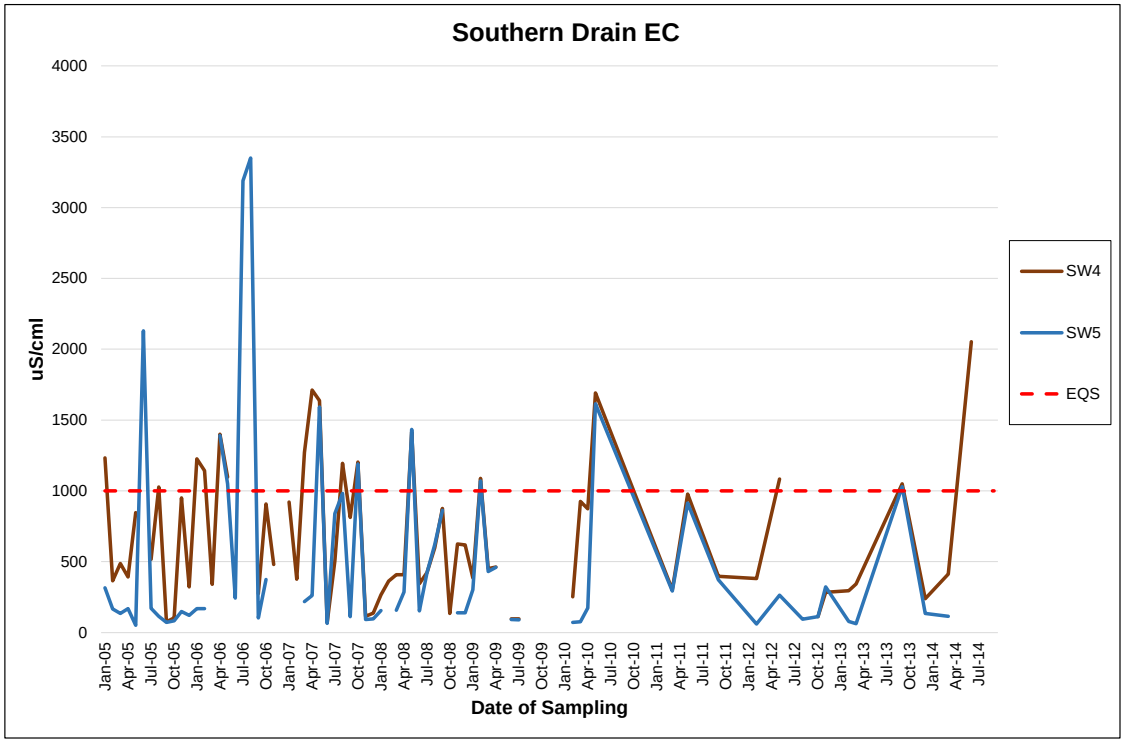


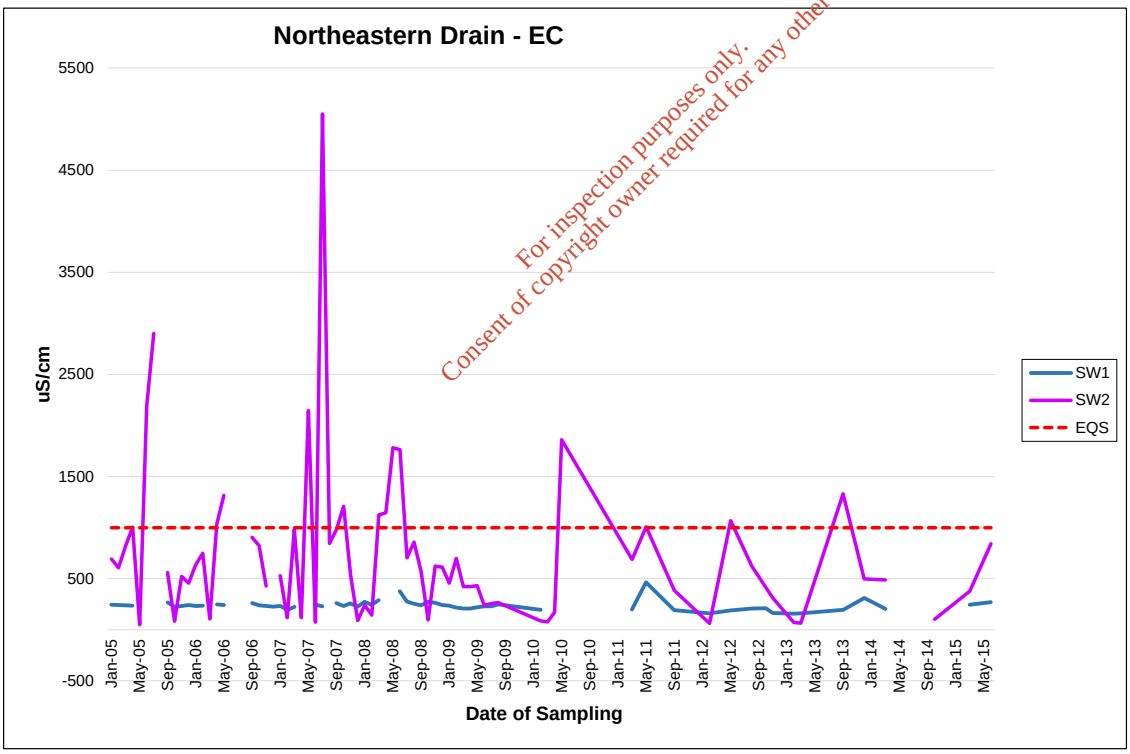


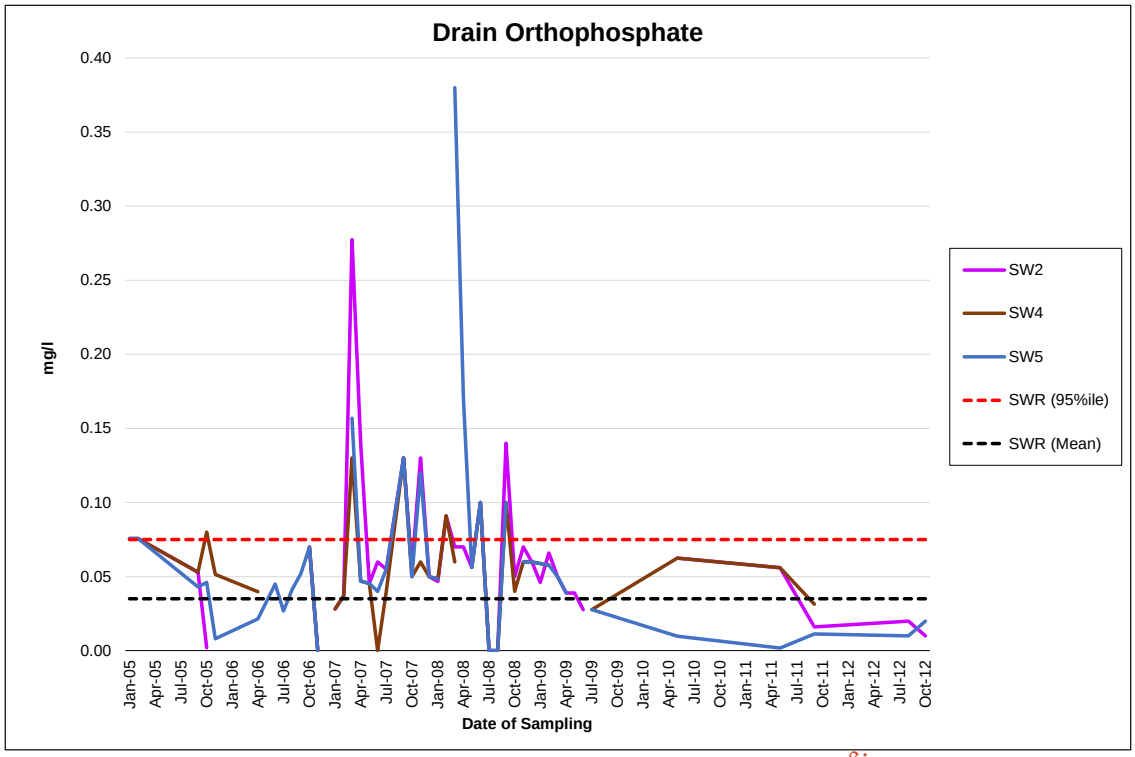


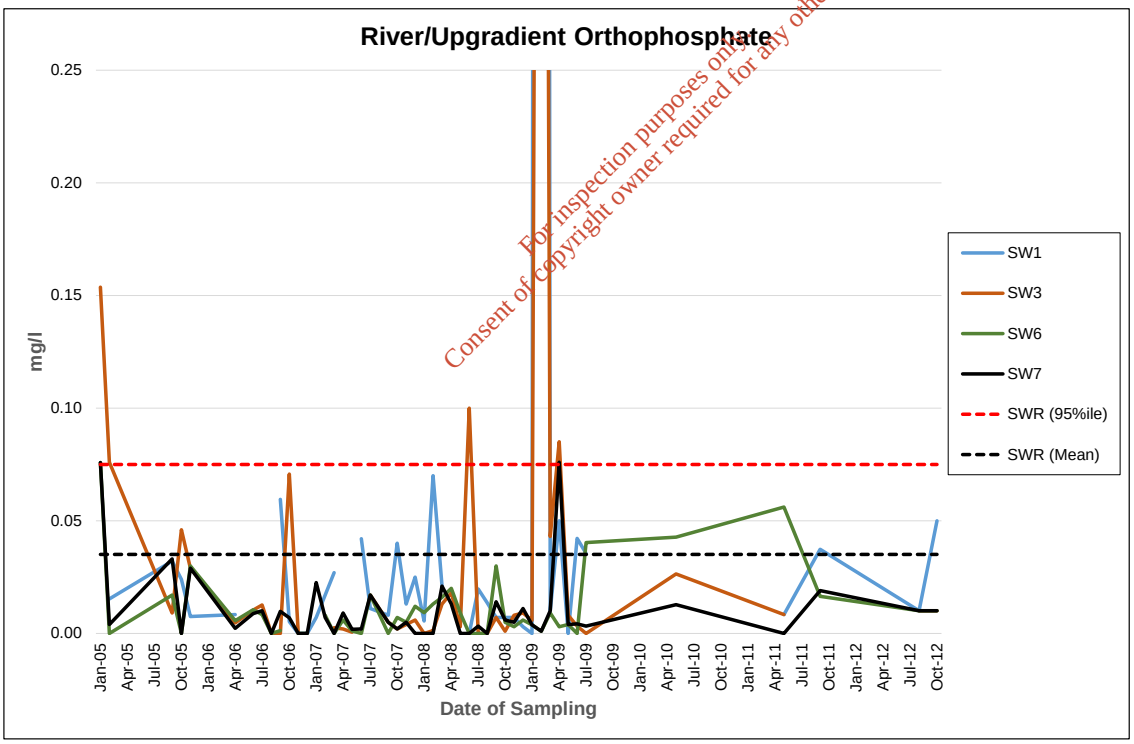


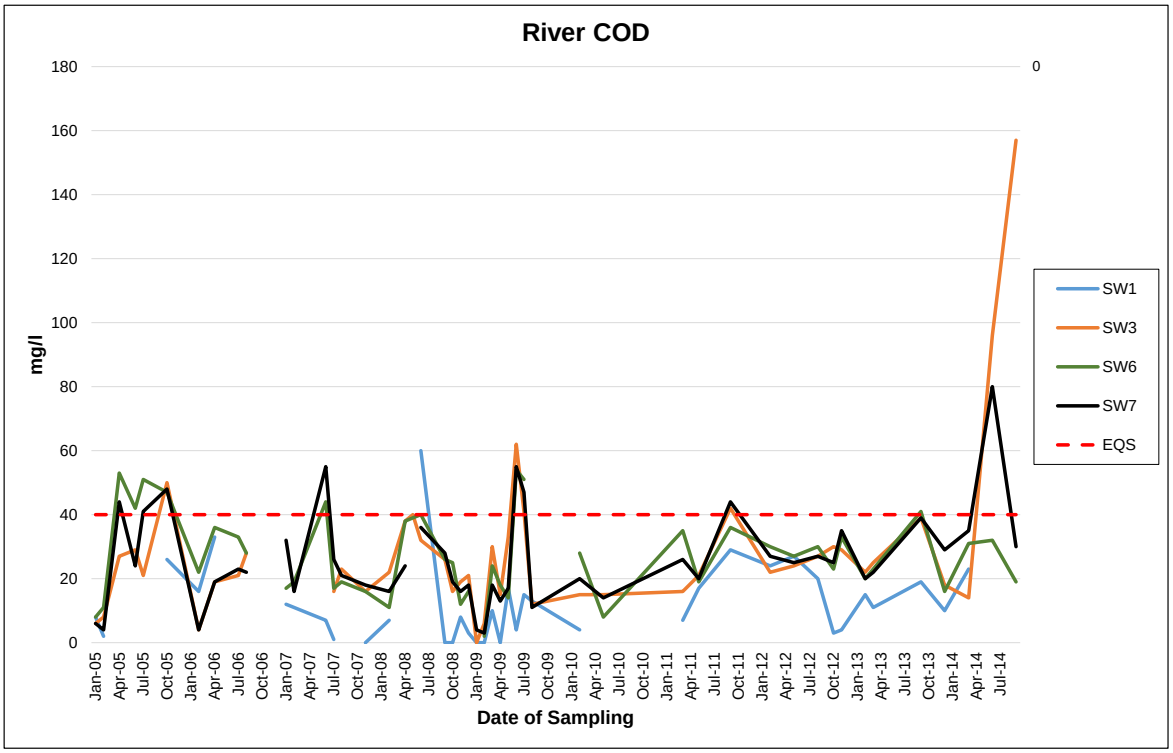


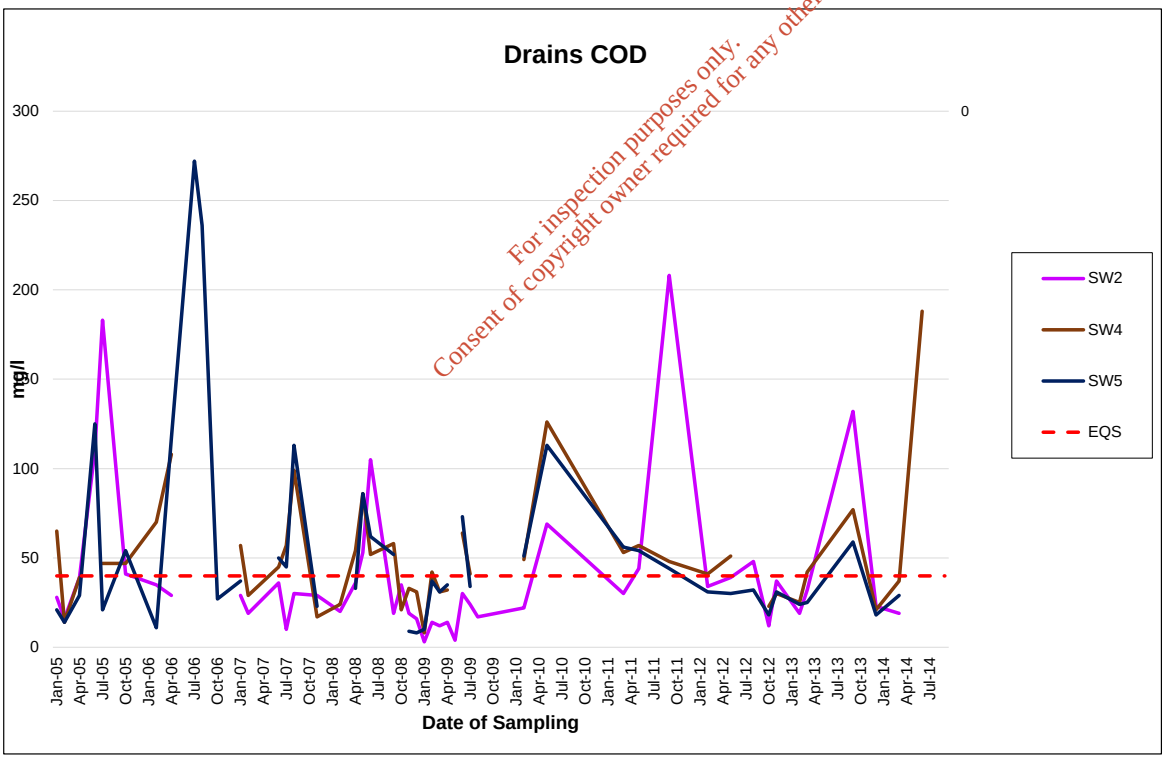


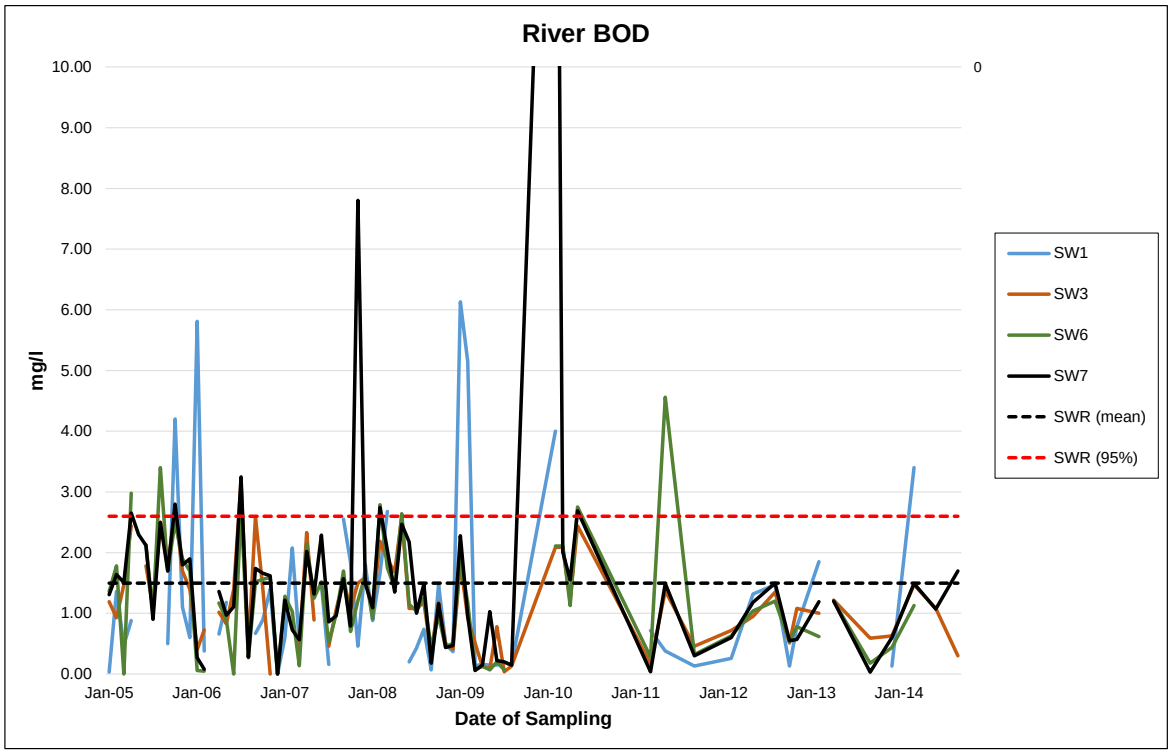


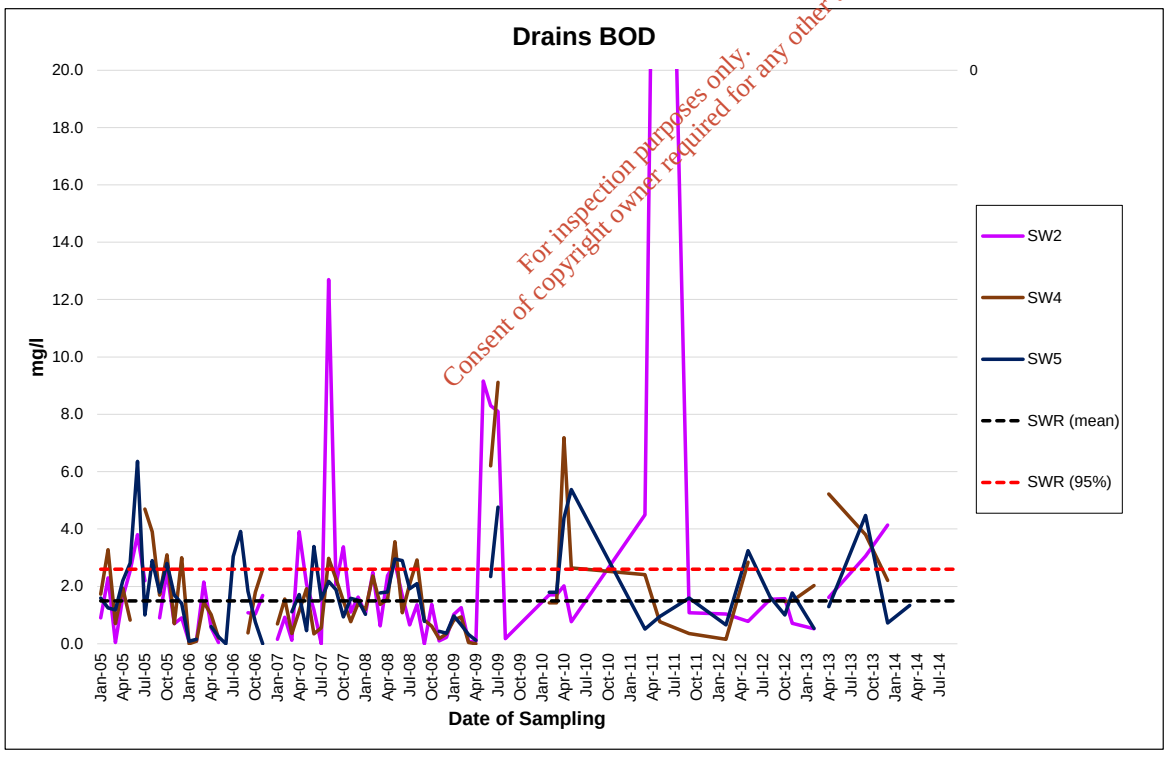


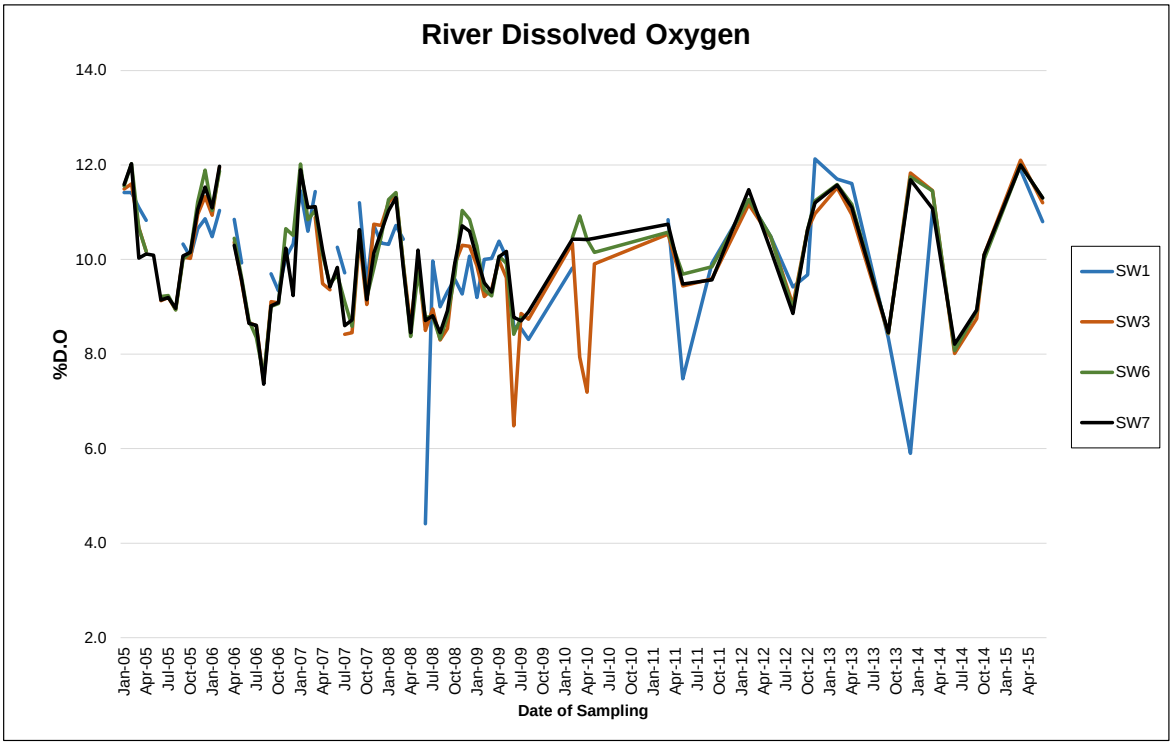


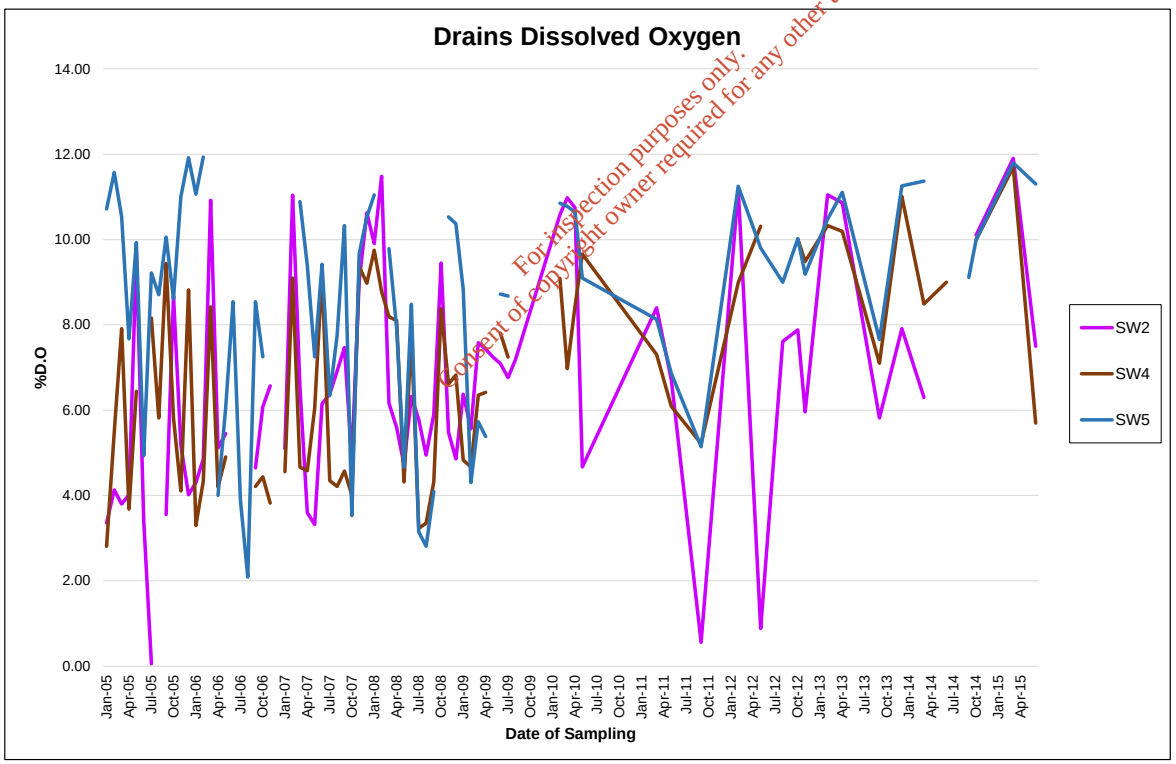


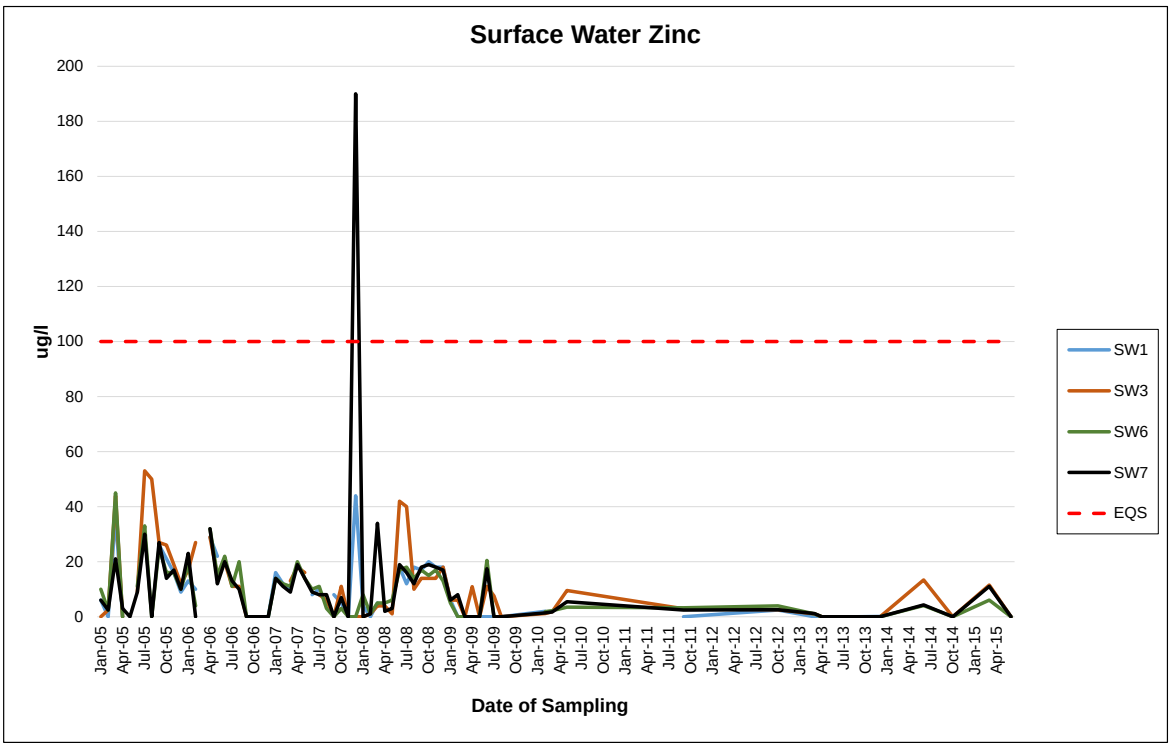


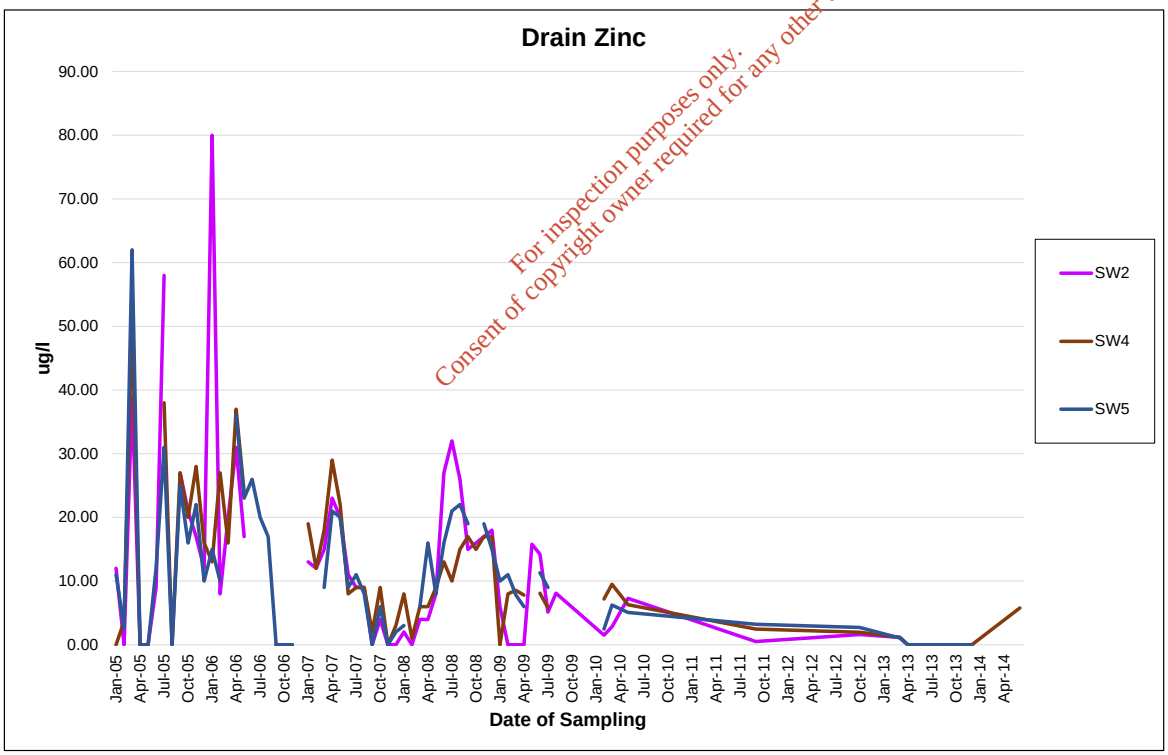


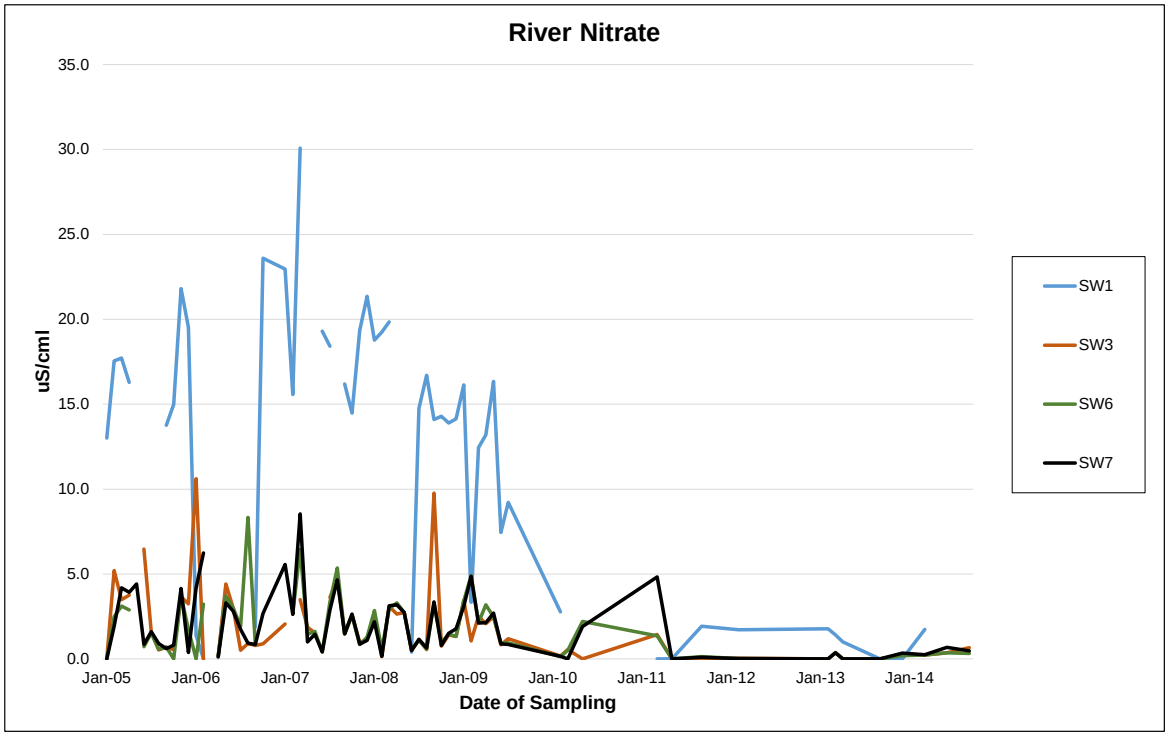


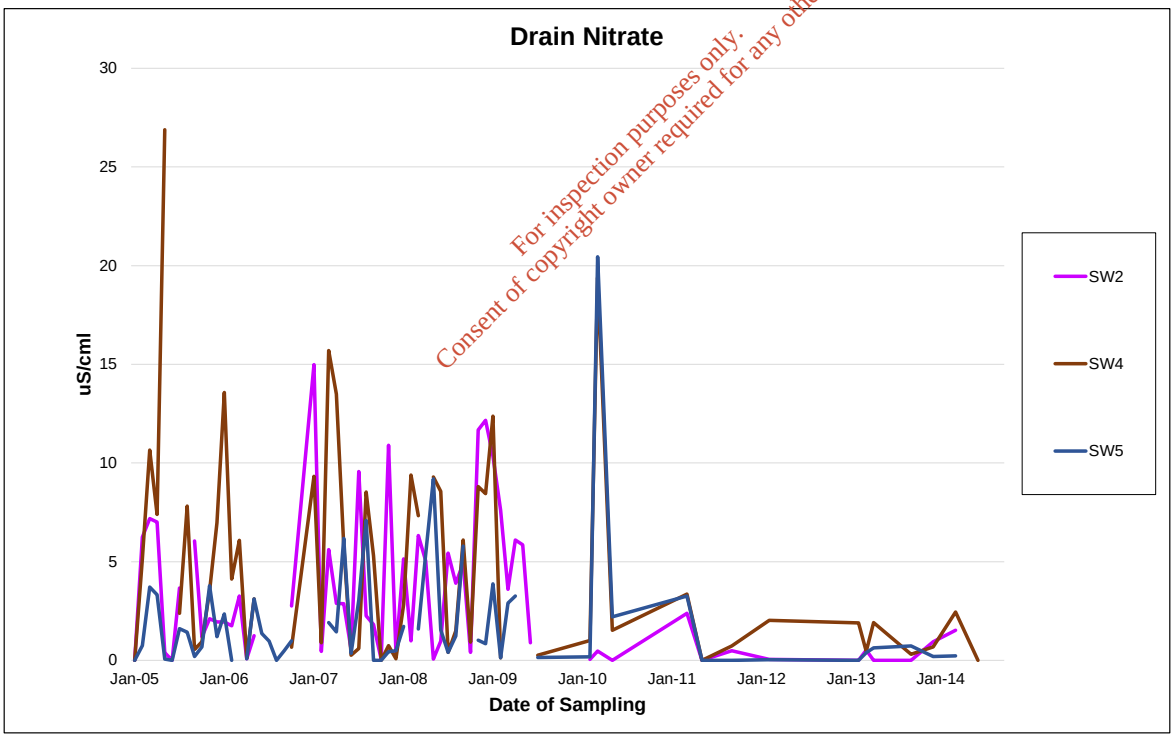












APPENDIX E

Assimilative Capacity Assessment

Q (flow)=KiA	Darcy's Law		
I (hydraulic gradient)	0.019		conservative gradient between BH1 and BH3
k (hydraulic permeability)	3.70E-06	m/s	average between BH1 and BH3
A (cross section area of flux)	600	m^2	100m x 6m
Qflux (groundwater flux under landfill towards river)	4.22E-05	m^3/s	
Qflux	3.64E+00	m^3/day	
Qflux	3.64E+03	litres/day	
Qriver (River flow)	4.00E-01	m^3/sec	
Qriver	3.46E+04	m^3/day	
Qriver	3.46E+07	litres/day	
Groundwater Contaminatn Flux to River (Ammonical Nitrogen)	QxCd		
Cup(Sept 13) - Conc Ammoniacal nitrogen upstream in River	0.2	mg/l	
Custream (June 15) - Conc Ammoniacal nitrogen upstream in River	0.069	mg/l	
Cd (sept 13) - Ammoniacal Nitrogen @ BH1	0.3	mg/l	
Cd (June 15) - Ammoniacal Nitrogen @ BH1	0.97	mg/l	
Predicted Ammoniacal Nitrogen Conc in river downstream (Sept 13)	Cdown	0.2	
Predicted Ammoniacal Nitrogen Conc in river downstream (june 15)	Cdown	1.04	
Actual Ammoniacal Nitrogen Conc in river downstream (Sept 13)	Cdown (Sept 13)	0.2	
Actual Ammoniacal Nitrogen Conc in river downstream (June 15)	Cdown (June 15)	0.58	
River/Gwflux	9483.17	dilution rate	
Predicted Reduction in Gflux (sept 15)	0.0001	mg/l	
% of reduced level relative to actual flux (sept 15)	0.01%		
Reduction in Gflux (June 13)	0.0000	mg/l	
% of reduced level relative to actual flux (June 13)	0.02%		

Appendix C

Surface Water Results

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		**Surface Water**											
Site No		**SW1**											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		7.2					6.54					7.37	
Temp	**C**	13.8					14.5					9.6	
Electrical Conductivity	**uS/cm**	273					1329					222	
Ammonical Nitrogen	**mg/l**	0.409					20.252					0.099	
COD	**mg/l**	11					86					12	
BOD	**mg/l**	< 1					2.9					1.1	
Dissolved Oxygen	**mg/l**	11.03					1.46					10.87	
SS	**mg/l**	6					138					< 5	
Residue on Evaporator	**mg/l**												
Calcium	**ug/l**												
Cadmium	**ug/l**												
Chromium	**ug/l**												
Chloride	**mg/l**	49.63					120					20	
Chlorine	**mg/l**												
Copper	**ug/l**	< 0.003					0.006					0.108	
Cyanide	**mg/l**												
Total Iron	**ug/l**												
Lead	**ug/l**												
Magnesium	**ug/l**												
Manganese	**ug/l**												
Mercury	**ug/l**												
Nickel	**mg/l**												
Potassium	**mg/l**												
Sodium	**mg/l**												
Sulphate	**mg/l**												
Zinc	**ug/l**	112.7					0.032					0.003	
Total Alkalinity as CaCO3	**mg/l**												
Total Organic Carbon	**mg/l**												
Total Oxidised Nitrogen	**mg/l**												
Arsenic	**mg/l**												
Barium	**mg/l**												
Boron	**ug/l**												
Fluoride	**mg/l**												
Total Phenols	**mg/l**	< 0.1										< 0.001	
Phosphorous	**mg/l**												
Selenium	**mg/l**												
Silver	**mg/l**												
Mircrotox	**Toxic Units**												
Microtox	**Toxic Units**												
Nitrite	**mg/l**	< 0.005					< 0.005					< 0.013	
Nitrate	**mg/l**	5.9					1					6.78	
Phosphate - ORTHO	**mg/l**												
Phosphate - TOTAL	**mg/l**												
Total Coliforms													
Facel Coliforms													
Depth	**m**												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW2											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		7.69					7.06					7.1	
Temp	C	10.3					15.7					9.5	
Electrical Conductivity	uS/cm	96.1					1409					381	
Ammonical Nitrogen	mg/l	0.041					42.576					4.788	
COD	mg/l	28					73					20	
BOD	mg/l	1					8.8					1.5	
Dissolved Oxygen	mg/l	11.48					2.12					7.28	
SS	mg/l	6					28					5	
Residue on Evaporator	mg/l												
Calcium	ug/l												
Cadmium	ug/l												
Chromium	ug/l												
Chloride	mg/l	29.78					55					26	
Chlorine	mg/l												
Copper	ug/l	< 0.003					0.013					0.022	
Cyanide	mg/l												
Total Iron	ug/l												
Lead	ug/l												
Magnesium	ug/l												
Manganese	ug/l												
Mercury	ug/l												
Nickel	mg/l												
Potassium	mg/l												
Sodium	mg/l												
Sulphate	mg/l												
Zinc	ug/l	102					0.002					0.002	
Total Alkalinity as CaCO3	mg/l												
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l												
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l	< 0.1										1.1	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					0.095					0.061	
Nitrate	mg/l	0.52					1					5.55	
Phosphate - ORTHO	mg/l												
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW3											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		7.91					7.41			8.8		7.36	
Temp	C	9.9					17.6			14.1		9.5	
Electrical Conductivity	uS/cm	62.2					107.7			95.9		146.4	
Ammonical Nitrogen	mg/l	0.019					0.263			0.073		0.042	
COD	mg/l	21					72			30		29	
BOD	mg/l	1					1.1			< 1		1.7	
Dissolved Oxygen	mg/l	12.13					6.79			8.9		10.43	
SS	mg/l	6.5					44			15		< 5	
Residue on Evaporator	mg/l												
Calcium	ug/l									8			
Cadmium	ug/l									0			
Chromium	ug/l									< 0.001			
Chloride	mg/l	19.85					21			12		14	
Chlorine	mg/l												
Copper	ug/l	< 0.003					0.014			12		0.016	
Cyanide	mg/l												
Total Iron	ug/l									1.6			
Lead	ug/l									0.0005			
Magnesium	ug/l									2			
Manganese	ug/l									0.2			
Mercury	ug/l									0.00079			
Nickel	mg/l												
Potassium	mg/l									1.1			
Sodium	mg/l									9.6			
Sulphate	mg/l									6.4			
Zinc	ug/l	91.9					0.02			5.6		0.003	
Total Alkalinity as CaCO3	mg/l									18			
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l									0.175			
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l	< 0.1										< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					< 0.005					< 0.013	
Nitrate	mg/l	0.16					1					0.67	
Phosphate - ORTHO	mg/l									< 0.009			
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW4											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH												7.15	
Temp	C											9.7	
Electrical Conductivity	uS/cm											236	
Ammonical Nitrogen	mg/l											0.728	
COD	mg/l											33	
BOD	mg/l											1.7	
Dissolved Oxygen	mg/l											9.95	
SS	mg/l											21	
Residue on Evaporator	mg/l												
Calcium	ug/l												
Cadmium	ug/l												
Chromium	ug/l												
Chloride	mg/l											23	
Chlorine	mg/l												
Copper	ug/l											0.008	
Cyanide	mg/l												
Total Iron	ug/l												
Lead	ug/l												
Magnesium	ug/l												
Manganese	ug/l												
Mercury	ug/l												
Nickel	mg/l												
Potassium	mg/l												
Sodium	mg/l												
Sulphate	mg/l												
Zinc	ug/l											0.011	
Total Alkalinity as CaCO3	mg/l												
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l												
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l											< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l											0.013	
Nitrate	mg/l											0.68	
Phosphate - ORTHO	mg/l												
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW5											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH												7.23	
Temp	C											9.4	
Electrical Conductivity	uS/cm											147	
Ammonical Nitrogen	mg/l											0.031	
COD	mg/l											27	
BOD	mg/l											1.3	
Dissolved Oxygen	mg/l											10.8	
SS	mg/l											7	
Residue on Evaporator	mg/l												
Calcium	ug/l												
Cadmium	ug/l												
Chromium	ug/l												
Chloride	mg/l											14	
Chlorine	mg/l												
Copper	ug/l											0.007	
Cyanide	mg/l												
Total Iron	ug/l												
Lead	ug/l												
Magnesium	ug/l												
Manganese	ug/l												
Mercury	ug/l												
Nickel	mg/l												
Potassium	mg/l												
Sodium	mg/l												
Sulphate	mg/l												
Zinc	ug/l											0.003	
Total Alkalinity as CaCO3	mg/l												
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l												
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l											< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l											< 0.013	
Nitrate	mg/l											0.93	
Phosphate - ORTHO	mg/l												
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW6											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH												7.18	
Temp	C											9.4	
Electrical Conductivity	uS/cm											142.1	
Ammonical Nitrogen	mg/l											0.061	
COD	mg/l											326	
BOD	mg/l											1.2	
Dissolved Oxygen	mg/l											10.47	
SS	mg/l											400	
Residue on Evaporator	mg/l												
Calcium	ug/l												
Cadmium	ug/l												
Chromium	ug/l												
Chloride	mg/l											14	
Chlorine	mg/l												
Copper	ug/l											0.047	
Cyanide	mg/l												
Total Iron	ug/l												
Lead	ug/l												
Magnesium	ug/l												
Manganese	ug/l												
Mercury	ug/l												
Nickel	mg/l												
Potassium	mg/l												
Sodium	mg/l												
Sulphate	mg/l												
Zinc	ug/l											0.203	
Total Alkalinity as CaCO3	mg/l												
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l												
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l											< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l											0.019	
Nitrate	mg/l											0.69	
Phosphate - ORTHO	mg/l												
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Surface Water											
Site No		SW7											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		8.37					7.3			7.61		7.17	
Temp	C	9.7					17.7			14		9.5	
Electrical Conductivity	uS/cm	62.8					107.5			94.8		147.3	
Ammonical Nitrogen	mg/l	0.016					0.305			0.071		0.04	
COD	mg/l	21					101			27		28	
BOD	mg/l	1					1.7			< 1		1.5	
Dissolved Oxygen	mg/l	12.14					6.9			9.11		10.82	
SS	mg/l	6					96			< 5		12	
Residue on Evaporator	mg/l												
Calcium	ug/l									8.4			
Cadmium	ug/l									< 0.0001			
Chromium	ug/l									< 0.001			
Chloride	mg/l	22.83					16			14		14	
Chlorine	mg/l												
Copper	ug/l	< 0.003					0.017			11		0.004	
Cyanide	mg/l												
Total Iron	ug/l									1.3			
Lead	ug/l									0.0004			
Magnesium	ug/l									2			
Manganese	ug/l									0.1			
Mercury	ug/l									0.00027			
Nickel	mg/l												
Potassium	mg/l									1			
Sodium	mg/l									9.1			
Sulphate	mg/l									7.1			
Zinc	ug/l	6.1					0.03			3.4		0.006	
Total Alkalinity as CaCO3	mg/l									20			
Total Organic Carbon	mg/l												
Total Oxidised Nitrogen	mg/l									< 0.138			
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l												
Fluoride	mg/l												
Total Phenols	mg/l	< 0.1										< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					< 0.005					< 0.013	
Nitrate	mg/l	< 0.15					3.2					0.82	
Phosphate - ORTHO	mg/l									< 0.009			
Phosphate - TOTAL	mg/l												
Total Coliforms													
Facel Coliforms													
Depth	m												

Appendix D

Discharged Effluent Results

Churchtown ICW and Willows Monitoring

Sample	Station	Sample Date	mg/l
192500033	Pond 1 outfall	08 January 2019	45.2
192500034	Pond 1A outfall	08 January 2019	16.8
192500035	Pond 2A Outfall	08 January 2019	1.47
192500036	Pond 3 A Outfall	08 January 2019	1.03
192500037	Pond 4 A Outfall	08 January 2019	0.031
192500038	Pond 5 A outfall	08 January 2019	0.008
192500039	Pond 1B Outfall	08 January 2019	32.7
192500040	Pond 2B Outfall	08 January 2019	0.368
192500041	Pond 3B Outfall	08 January 2019	0.043
192500042	Pond 4B Outfall	08 January 2019	0.003
192500043	Pond 5B Discharge Monitoring Point.	08 January 2019	0.008
192500044	Northern Willow Discharge Monitoring Point.	08 January 2019	0.013
192500046	Southern Willow Discharge Monitoring Point	08 January 2019	0.358
192500177	Pond 1 outfall	18 January 2019	52.5
192500178	Pond 1A outfall	18 January 2019	34.9
192500179	Pond 2A Outfall	18 January 2019	3.21
192500180	Pond 3 A Outfall	18 January 2019	0.546
192500181	Pond 4 A Outfall	18 January 2019	0.31
192500182	Pond 5 A outfall	18 January 2019	0.042
192500183	Pond 1B Outfall	18 January 2019	41
192500184	Pond 2B Outfall	18 January 2019	3.34
192500185	Pond 3B Outfall	18 January 2019	0.079
192500186	Pond 4B Outfall	18 January 2019	0.007
192500187	Pond 5B Discharge Monitoring Point.	18 January 2019	0.004
192500188	Northern Willow Discharge Monitoring Point.	18 January 2019	0.04
192500189	Southern Willow Discharge Monitoring Point	18 January 2019	0.46
192500367	Pond 1 outfall	25 January 2019	12.1
192500368	Pond 1A outfall	25 January 2019	19.5
192500369	Pond 2A Outfall	25 January 2019	11.7
192500370	Pond 3 A Outfall	25 January 2019	1.89
192500371	Pond 4 A Outfall	25 January 2019	0.8
192500372	Pond 5 A outfall	25 January 2019	0.6
192500373	Pond 1B Outfall	25 January 2019	12.3
192500374	Pond 2B Outfall	25 January 2019	11.8
192500375	Pond 3B Outfall	25 January 2019	1.08
192500376	Pond 4B Outfall	25 January 2019	0.122
192500377	Pond 5B Discharge Monitoring Point.	25 January 2019	0.009
192500378	Northern Willow Discharge Monitoring Point.	25 January 2019	0.06
192500379	Southern Willow Discharge Monitoring Point	25 January 2019	0.45
192500422	Pond 1 outfall	01 February 2019	18.7
192500423	Pond 1A outfall	01 February 2019	4.87
192500424	Pond 2A Outfall	01 February 2019	0.085
192500425	Pond 3 A Outfall	01 February 2019	0.014
192500426	Pond 4 A Outfall	01 February 2019	0.035
192500427	Pond 5 A outfall	01 February 2019	0.123
192500428	Pond 1B Outfall	01 February 2019	20.8

192500429	Pond 2B Outfall	01 February 2019	3.98
192500430	Pond 3B Outfall	01 February 2019	2.47
192500431	Pond 4B Outfall	01 February 2019	0.453
192500432	Pond 5B Discharge Monitoring Point.	01 February 2019	0.031
192500433	Northern Willow Discharge Monitoring Point.	01 February 2019	0.07
192500434	Southern Willow Discharge Monitoring Point	01 February 2019	0.65
192500600	Pond 1 outfall	07 February 2019	12.3
192500601	Pond 1A outfall	07 February 2019	6.23
192500602	Pond 2A Outfall	07 February 2019	0.492
192500603	Pond 3 A Outfall	07 February 2019	0.015
192500604	Pond 4 A Outfall	07 February 2019	0.019
192500605	Pond 5 A outfall	07 February 2019	0.018
192500606	Pond 1B Outfall	07 February 2019	13.4
192500607	Pond 2B Outfall	07 February 2019	0.312
192500608	Pond 3B Outfall	07 February 2019	0.369
192500609	Pond 4B Outfall	07 February 2019	0.15
192500610	Pond 5B Discharge Monitoring Point.	07 February 2019	0.012
192500611	Northern Willow Discharge Monitoring Point.	07 February 2019	0.06
192500612	Southern Willow Discharge Monitoring Point	07 February 2019	0.82
192500680	Pond 1 outfall	13 February 2019	7.24
192500681	Pond 1A outfall	13 February 2019	0.1
192500682	Pond 2A Outfall	13 February 2019	0.023
192500683	Pond 3 A Outfall	13 February 2019	0.015
192500684	Pond 4 A Outfall	13 February 2019	0.021
192500685	Pond 5 A outfall	13 February 2019	0.023
192500686	Pond 1B Outfall	13 February 2019	4.13
192500687	Pond 2B Outfall	13 February 2019	0.302
192500688	Pond 3B Outfall	13 February 2019	0.299
192500689	Pond 4B Outfall	13 February 2019	0.021
192500690	Pond 5B Discharge Monitoring Point.	13 February 2019	0.012
192500691	Northern Willow Discharge Monitoring Point.	13 February 2019	0.07
192500692	Southern Willow Discharge Monitoring Point	13 February 2019	0.62
192500828	Pond 1 outfall	01 March 2019	64.4
192500829	Pond 1A outfall	01 March 2019	34.7
192500830	Pond 2A Outfall	01 March 2019	8.47
192500831	Pond 3 A Outfall	01 March 2019	0.303
192500832	Pond 4 A Outfall	01 March 2019	0.104
192500833	Pond 5 A outfall	01 March 2019	0.042
192500834	Pond 1B Outfall	01 March 2019	35.5
192500835	Pond 2B Outfall	01 March 2019	0.436
192500836	Pond 3B Outfall	01 March 2019	0.079
192500837	Pond 4B Outfall	01 March 2019	0.071
192500838	Pond 5B Discharge Monitoring Point.	01 March 2019	0.02
192500839	Northern Willow Discharge Monitoring Point.	01 March 2019	0.011
192500840	Southern Willow Discharge Monitoring Point	01 March 2019	0.015
192501056	Pond 1 outfall	08 March 2019	26.4
192501057	Pond 1A outfall	08 March 2019	31.5

192501058	Pond 2A Outfall	08 March 2019	9.8
192501059	Pond 3 A Outfall	08 March 2019	1.902
192501060	Pond 4 A Outfall	08 March 2019	0.045
192501061	Pond 5 A outfall	08 March 2019	0.02
192501062	Pond 1B Outfall	08 March 2019	18.1
192501063	Pond 2B Outfall	08 March 2019	8.62
192501064	Pond 3B Outfall	08 March 2019	0.069
192501065	Pond 4B Outfall	08 March 2019	0.022
192501066	Pond 5B Discharge Monitoring Point.	08 March 2019	0.011
192501067	Northern Willow Discharge Monitoring Point.	08 March 2019	0.011
192501068	Southern Willow Discharge Monitoring Point	08 March 2019	0.126
192501171	Pond 1 outfall	19 March 2019	7.42
192501172	Pond 1A outfall	19 March 2019	0.022
192501173	Pond 2A Outfall	19 March 2019	0.027
192501174	Pond 3 A Outfall	19 March 2019	0.027
192501175	Pond 4 A Outfall	19 March 2019	0.026
192501176	Pond 5 A outfall	19 March 2019	0.025
192501177	Pond 1B Outfall	19 March 2019	6.44
192501178	Pond 2B Outfall	19 March 2019	0.294
192501179	Pond 3B Outfall	19 March 2019	0.081
192501180	Pond 4B Outfall	19 March 2019	0.04
192501181	Pond 5B Discharge Monitoring Point.	19 March 2019	0.069
192501182	Northern Willow Discharge Monitoring Point.	19 March 2019	0.26
192501183	Southern Willow Discharge Monitoring Point	19 March 2019	0.18
192501318	Pond 1 outfall	29 March 2019	54.6
192501319	Pond 1A outfall	29 March 2019	13.1
192501320	Pond 2A Outfall	29 March 2019	0.128
192501321	Pond 3 A Outfall	29 March 2019	0.036
192501322	Pond 4 A Outfall	29 March 2019	0.035
192501323	Pond 5 A outfall	29 March 2019	0.028
192501324	Pond 1B Outfall	29 March 2019	31.7
192501325	Pond 2B Outfall	29 March 2019	0.146
192501326	Pond 3B Outfall	29 March 2019	0.025
192501327	Pond 4B Outfall	29 March 2019	0.024
192501328	Pond 5B Discharge Monitoring Point.	29 March 2019	0.02
192501329	Northern Willow Discharge Monitoring Point.	29 March 2019	0.852
192501330	Southern Willow Discharge Monitoring Point	29 March 2019	0.011
192501442	Pond 1 outfall	12 April 2019	62
192501443	Pond 1A outfall	12 April 2019	43.7
192501444	Pond 2A Outfall	12 April 2019	24.3
192501445	Pond 3 A Outfall	12 April 2019	11.6
192501446	Pond 4 A Outfall	12 April 2019	4.8
192501447	Pond 5 A outfall	12 April 2019	0.07
192501448	Pond 1B Outfall	12 April 2019	62.2
192501449	Pond 2B Outfall	12 April 2019	12.9
192501450	Pond 3B Outfall	12 April 2019	0.035
192501451	Pond 4B Outfall	12 April 2019	0.042
192501452	Pond 5B Discharge Monitoring Point.	12 April 2019	0.015

192501453	Northern Willow Discharge Monitoring Point.	12 April 2019	0.008
192501454	Southern Willow Discharge Monitoring Point	12 April 2019	0.006
192501613	Pond 1 outfall	16 April 2019	41.5
192501614	Pond 1A outfall	16 April 2019	29.3
192501615	Pond 2A Outfall	16 April 2019	27
192501616	Pond 3 A Outfall	16 April 2019	12.6
192501617	Pond 4 A Outfall	16 April 2019	2.9
192501618	Pond 5 A outfall	16 April 2019	0.029
192501619	Pond 1B Outfall	16 April 2019	59.6
192501620	Pond 2B Outfall	16 April 2019	14.1
192501621	Pond 3B Outfall	16 April 2019	0.031
192501622	Pond 4B Outfall	16 April 2019	0.015
192501623	Pond 5B Discharge Monitoring Point.	16 April 2019	0.015
192501624	Northern Willow Discharge Monitoring Point.	16 April 2019	0.015
192501625	Southern Willow Discharge Monitoring Point	16 April 2019	0.015
192501636	Pond 1 outfall	24 April 2019	74
192501637	Pond 1A outfall	24 April 2019	38.4
192501638	Pond 2A Outfall	24 April 2019	16.1
192501639	Pond 3 A Outfall	24 April 2019	3.09
192501640	Pond 4 A Outfall	24 April 2019	0.545
192501641	Pond 5 A outfall	24 April 2019	0.034
192501642	Pond 1B Outfall	24 April 2019	63.6
192501643	Pond 2B Outfall	24 April 2019	15.7
192501644	Pond 3B Outfall	24 April 2019	0.03
192501645	Pond 4B Outfall	24 April 2019	0.02
192501646	Pond 5B Discharge Monitoring Point.	24 April 2019	0.018
192501627	Northern Willow Discharge Monitoring Point.	24 April 2019	2.48
192501628	Southern Willow Discharge Monitoring Point	24 April 2019	0.015
	Pond 1 outfall		
	Pond 1A outfall		
	Pond 2A Outfall		
	Pond 3 A Outfall		
	Pond 4 A Outfall		
	Pond 5 A outfall	24 May 2019	No sample available
	Pond 1B Outfall		
	Pond 2B Outfall		
	Pond 3B Outfall		
	Pond 4B Outfall		
192501970	Pond 5B Discharge Monitoring Point.	24 May 2019	0.02
192501971	Northern Willow Discharge Monitoring Point.	24 May 2019	0.093
	Southern Willow Discharge Monitoring Point	24 May 2019	No sample available
192502077	Pond 1 outfall	30 May 2019	74.8
192502078	Pond 1A outfall	30 May 2019	12.3
192502079	Pond 2A Outfall	30 May 2019	3.04
192502080	Pond 3 A Outfall	30 May 2019	0.043
192502081	Pond 4 A Outfall	30 May 2019	0.033
192502082	Pond 5 A outfall	30 May 2019	0.024
192502083	Pond 1B Outfall	30 May 2019	53

192502084	Pond 2B Outfall	30 May 2019	1.92
192502085	Pond 3B Outfall	30 May 2019	0.02
192502086	Pond 4B Outfall	30 May 2019	0.016
192502087	Pond 5B Discharge Monitoring Point.	30 May 2019	0.02
192502088	Northern Willow Discharge Monitoring Point.	30 May 2019	0.051
192502089	Southern Willow Discharge Monitoring Point	30 May 2019	0.019
192502274	Pond 1 outfall	07 May 2019	30.4
192502275	Pond 1A outfall	07 May 2019	18.1
192502276	Pond 2A Outfall	07 May 2019	6.46
192502277	Pond 3 A Outfall	07 May 2019	0.501
192502278	Pond 4 A Outfall	07 May 2019	0.158
192502279	Pond 5 A outfall	07 May 2019	0.033
192502280	Pond 1B Outfall	07 May 2019	24
192502281	Pond 2B Outfall	07 May 2019	14.4
192502282	Pond 3B Outfall	07 May 2019	0.34
192502283	Pond 4B Outfall	07 May 2019	0.023
192502284	Pond 5B Discharge Monitoring Point.	07 May 2019	0.016
192502285	Northern Willow Discharge Monitoring Point.	07 May 2019	0.016
192502286	Southern Willow Discharge Monitoring Point	07 May 2019	0.026
192502385	Pond 1 outfall	14 June 2019	46.8
192502386	Pond 1A outfall	14 June 2019	8.77
192502387	Pond 2A Outfall	14 June 2019	2.04
192502388	Pond 3 A Outfall	14 June 2019	0.038
192502389	Pond 4 A Outfall	14 June 2019	0.133
192502390	Pond 5 A outfall	14 June 2019	0.026
192502391	Pond 1B Outfall	14 June 2019	38.4
192502392	Pond 2B Outfall	14 June 2019	3.55
192502393	Pond 3B Outfall	14 June 2019	0.032
192502394	Pond 4B Outfall	14 June 2019	0.049
192502395	Pond 5B Discharge Monitoring Point.	14 June 2019	0.024
192502396	Northern Willow Discharge Monitoring Point.	14 June 2019	0.1
192502397	Southern Willow Discharge Monitoring Point	14 June 2019	0.015
192502447	Pond 1 outfall	20 June 2019	86.6
192502448	Pond 1A outfall	20 June 2019	10.1
192502449	Pond 2A Outfall	20 June 2019	0.874
192502450	Pond 3 A Outfall	20 June 2019	0.033
192502451	Pond 4 A Outfall	20 June 2019	0.033
192502452	Pond 5 A outfall	20 June 2019	0.023
192502453	Pond 1B Outfall	20 June 2019	55
192502454	Pond 2B Outfall	20 June 2019	0.677
192502455	Pond 3B Outfall	20 June 2019	0.047
192502456	Pond 4B Outfall	20 June 2019	0.025
192502457	Pond 5B Discharge Monitoring Point.	20 June 2019	0.015
192502458	Northern Willow Discharge Monitoring Point.	20 June 2019	0.674
192502459	Southern Willow Discharge Monitoring Point	20 June 2019	0.021
	Pond 1 outfall		
	Pond 1A outfall		

	Pond 2A Outfall		
	Pond 3 A Outfall		
	Pond 4 A Outfall		
	Pond 5 A outfall	26 June 2019	0.038
	Pond 1B Outfall		
	Pond 2B Outfall		
	Pond 3B Outfall		
	Pond 4B Outfall		
No sample	Pond 5B Discharge Monitoring Point.	26 June 2019	No discharge
	Northern Willow Discharge Monitoring Point.	26 June 2019	<0.015
No sample	Southern Willow Discharge Monitoring Point	26 June 2019	No discharge
192502788	Pond 1 outfall	05 July 2019	72.4
192502789	Pond 1A outfall	05 July 2019	1.52
No sample	Pond 2A Outfall	05 July 2019	No discharge
192502790	Pond 3 A Outfall	05 July 2019	0.164
192502791	Pond 4 A Outfall	05 July 2019	0.051
No sample	Pond 5 A outfall	05 July 2019	No discharge
192502792	Pond 1B Outfall	05 July 2019	0.373
192502793	Pond 2B Outfall	05 July 2019	0.614
192502794	Pond 3B Outfall	05 July 2019	0.33
192502795	Pond 4B Outfall	05 July 2019	0.135
No sample	Pond 5B Discharge Monitoring Point.	05 July 2019	No discharge
No sample	Northern Willow Discharge Monitoring Point.	05 July 2019	No discharge
No sample	Southern Willow Discharge Monitoring Point	05 July 2019	No discharge
192502882	Pond 1 outfall	12 July 2019	71.2
192502883	Pond 1A outfall	12 July 2019	4.64
192502884	Pond 2A Outfall	12 July 2019	0.527
192502885	Pond 3 A Outfall	12 July 2019	0.181
192502886	Pond 4 A Outfall	12 July 2019	0.123
192502887	Pond 5 A outfall	12 July 2019	0.068
192502888	Pond 1B Outfall	12 July 2019	21.1
192502889	Pond 2B Outfall	12 July 2019	0.798
192502890	Pond 3B Outfall	12 July 2019	0.056
192502891	Pond 4B Outfall	12 July 2019	0.092
192502892	Pond 5B Discharge Monitoring Point.	12 July 2019	0.048
192502893	Northern Willow Discharge Monitoring Point.	12 July 2019	<0.015
192502894	Southern Willow Discharge Monitoring Point	12 July 2019	0.084

Appendix E

Groundwater Results

Location		Churchtown, Lifford, Co Donegal											
Sample Type		Ground Water											
Site No		BH1											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		7.85					7.25			7.18		7.11	
Temp	C	9.8					15.3			13.7		10.2	
Electrical Conductivity	uS/cm	95.1					137			149		152	
Ammonical Nitrogen	mg/l	0.012					0.053			0.011		< 0.005	
COD	mg/l												
BOD	mg/l												
Dissolved Oxygen	mg/l	6.5					6.29			2.12		6.24	
SS	mg/l												
Residue on Evaporator	mg/l												
Calcium	ug/l									18			
Cadmium	ug/l									<0.1			
Chromium	ug/l									<1.0			
Chloride	mg/l	19.85					14			14		13	
Chlorine	mg/l												
Copper	ug/l									0.009			
Cyanide	mg/l									<10			
Total Iron	ug/l									93			
Lead	ug/l									<0.3			
Magnesium	ug/l									3.6			
Manganese	ug/l									78			
Mercury	ug/l									0.22			
Nickel	mg/l												
Potassium	mg/l	3					2.7			3.4		3	
Sodium	mg/l	24.6					9.5			10.2		11.6	
Sulphate	mg/l									7.4			
Zinc	ug/l									4.2			
Total Alkalinity as CaCO3	mg/l									53			
Total Organic Carbon	mg/l	8.51					9			8.81		7.82	
Total Oxidised Nitrogen	mg/l	0.26					1.1			0.569		0.92	
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l									<0.02			
Fluoride	mg/l									<0.10			
Total Phenols	mg/l	< 0.1								<4.0		< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					< 0.005			<0.013		< 0.005	
Nitrate	mg/l	0.26					1.1			0.57		0.92	
Phosphate - ORTHO	mg/l									<0.009			
Phosphate - TOTAL	mg/l												
Total Coliforms										488			
Facel Coliforms										40			
Depth	m	1.9					1.4			1.5		1.2	

Location		Churchtown, Lifford, Co Donegal											
Sample Type		Surface Water											
Site No		BH3											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		7.93					7.4			6.91		7.14	
Temp	C	10.2					13.1			12.5		10.3	
Electrical Conductivity	uS/cm	494					540			536		520	
Ammonical Nitrogen	mg/l	0.009					0.032			0.013		0.026	
COD	mg/l												
BOD	mg/l												
Dissolved Oxygen	mg/l	7.55					6.04			3.82		3.52	
SS	mg/l												
Residue on Evaporator	mg/l												
Calcium	ug/l									92			
Cadmium	ug/l									<0.1			
Chromium	ug/l									<1.0			
Chloride	mg/l	37.72					19			13		24	
Chlorine	mg/l												
Copper	ug/l									0.005			
Cyanide	mg/l									<10			
Total Iron	ug/l									<20			
Lead	ug/l									<0.3			
Magnesium	ug/l									12.2			
Manganese	ug/l									4.6			
Mercury	ug/l									0.06			
Nickel	mg/l												
Potassium	mg/l	1.9					1.8			1.6		1.7	
Sodium	mg/l	15.4					15.3			14.7		15.5	
Sulphate	mg/l									6.5			
Zinc	ug/l									3.8			
Total Alkalinity as CaCO3	mg/l									200			
Total Organic Carbon	mg/l	1.17					3.25			1.34		0.99	
Total Oxidised Nitrogen	mg/l	0.23					0.84			<0.138		0.18	
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l									<0.02			
Fluoride	mg/l									<0.10			
Total Phenols	mg/l	< 0.1								<1.0			
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					< 0.005			<0.013		< 0.005	
Nitrate	mg/l	0.23					0.86			<0.12		0.18	
Phosphate - ORTHO	mg/l									<0.009			
Phosphate - TOTAL	mg/l												
Total Coliforms										2420			
Facel Coliforms										10			
Depth	m	4					5.2			5.9		4.6	

Location		*Churchtown, Lifford, Co Donegal*											
Sample Type		Ground Water											
Site No		BH4											
Date of Sample		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
Lab No													
pH		6.86					7.49			6.54		6.69	
Temp	C	10.3					12.9			14		10.3	
Electrical Conductivity	uS/cm	412					547			406		562	
Ammonical Nitrogen	mg/l	0.007					0.07			0.12		0.035	
COD	mg/l												
BOD	mg/l												
Dissolved Oxygen	mg/l	6.48					6.35			2.66		5.76	
SS	mg/l												
Residue on Evaporator	mg/l												
Calcium	ug/l									64			
Cadmium	ug/l									<0.1			
Chromium	ug/l									<1.0			
Chloride	mg/l	74.44					23			28		79	
Chlorine	mg/l												
Copper	ug/l									<0.003			
Cyanide	mg/l									<10			
Total Iron	ug/l									<20			
Lead	ug/l									<0.3			
Magnesium	ug/l									6.3			
Manganese	ug/l									46			
Mercury	ug/l									0.05			
Nickel	mg/l												
Potassium	mg/l	2.5					1.8			3.4		3.6	
Sodium	mg/l	8.7					15.7			16.9		33.4	
Sulphate	mg/l									40			
Zinc	ug/l									5.4			
Total Alkalinity as CaCO3	mg/l									104			
Total Organic Carbon	mg/l	1.24					0.6			3.08		1.47	
Total Oxidised Nitrogen	mg/l	8.8					0.89			10.528		7.9	
Arsenic	mg/l												
Barium	mg/l												
Boron	ug/l									<0.02			
Fluoride	mg/l									<0.10			
Total Phenols	mg/l	< 0.1								<1.0		< 0.001	
Phosphorous	mg/l												
Selenium	mg/l												
Silver	mg/l												
Mircrotox	Toxic Units												
Microtox	Toxic Units												
Nitrite	mg/l	< 0.005					< 0.005			<0.013		< 0.005	
Nitrate	mg/l	8.8					0.91			10.52		7.9	
Phosphate - ORTHO	mg/l									<0.009			
Phosphate - TOTAL	mg/l												
Total Coliforms										1986			
Facel Coliforms										10			
Depth	m	0					0.2			0.9		0.1	