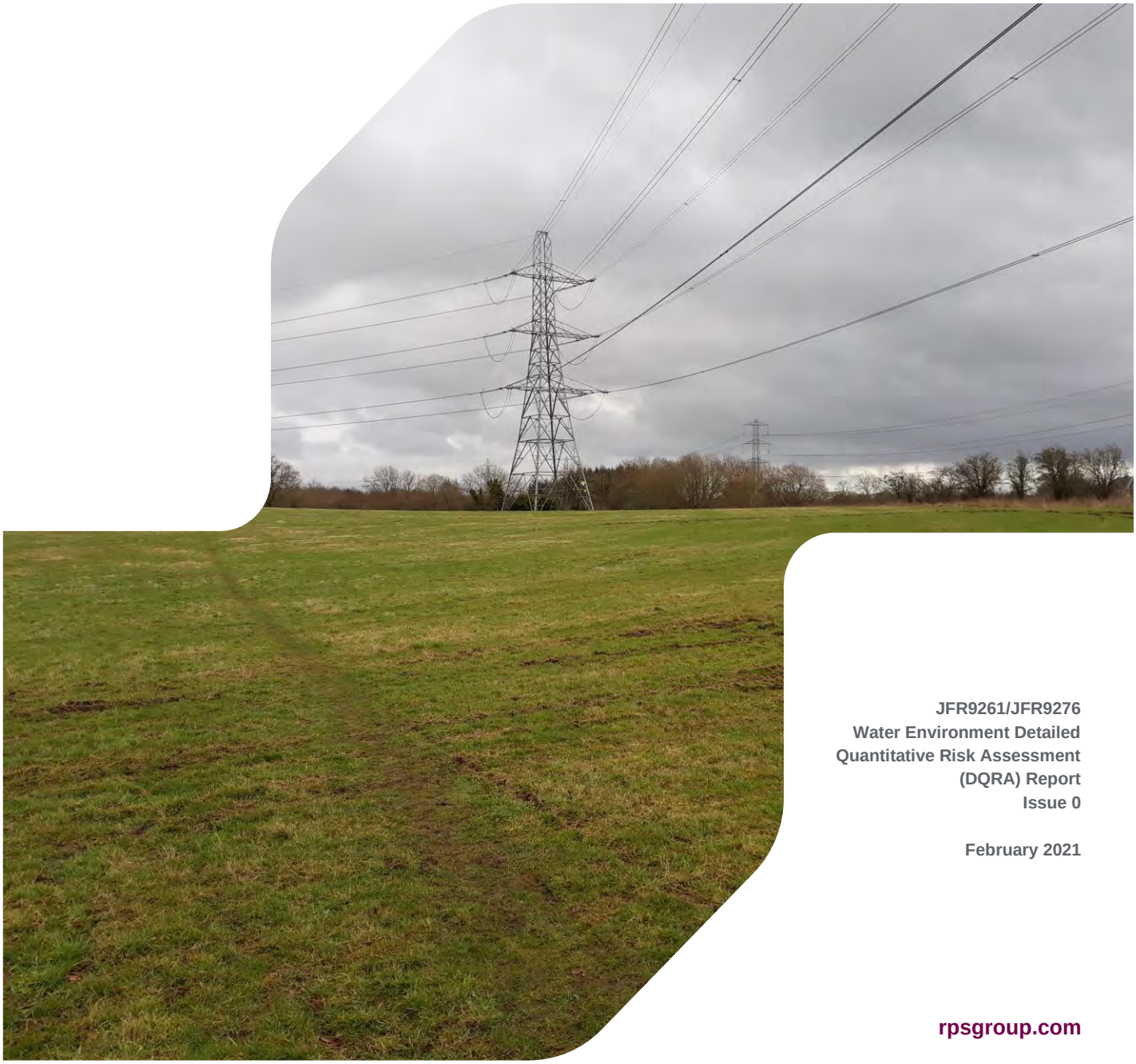
WATER ENVIRONMENT DETAILED QUANTITATIVE RISK ASSESSMENT REPORT

PATHER FARM CEMETERY, WISHAW

North Lanarkshire Council



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EXECUTIVE SUMMARY

Background

RPS was commissioned by North Lanarkshire Council (NLC) in May 2019 to undertake a Phase 1 Desk Study review, Phase 2 ground investigation and reporting, and Phase 3 Detailed Quantitative Risk Assessment (DQRA) for the water environment, for land intended for cemetery development in North Lanarkshire. NLC awarded the works under contract ref. LS-16-033.

This report relates to a Phase 3 DQRA carried out for the site and presents the results of a detailed assessment of the potential risks posed to the water environment by the identified potential contaminants of concern at the site.

Detailed Quantitative Risk Assessment of the Water Environment

This DQRA was carried out using the Environment Agency's ***Remedial Targets Worksheet v3.2***, which is based on a staged approach (referred to as ***Levels***) to determine risk-based remedial targets for soil and groundwater. The staged approach is used to identify unacceptable risks of pollution to the water environment and facilitates discussion and establishment of remedial targets for the water environment. With each Level of assessment, additional attenuation processes are taken into account (e.g., dilution and dispersion) which affect the predicted contaminant concentrations along the pathway to a receptor or a compliance point.

The objective of this DQRA was to assess the potential impact that the proposed use of the site for burials would pose to a hypothetical compliance point located 250m away from the site.

<u>Contaminants identified from RPS' Ground Investigation</u>

The potential contaminants that were identified during ground investigation are; metals (arsenic, cadmium, chromium, lead, selenium and nickel), total petroleum hydrocarbons (TPH, aliphatic fractions) and ammonia. These metals recorded elevated concentrations in groundwater samples, while detectable concentrations of TPHs were recorded in groundwater samples obtained from a single borehole. Potential pollutant pathways which may provide preferential pathways for contaminant/leachate transport were considered to include the underlying Made Ground, superficial deposits (Glacial Till) and weathered bedrock. The moderately productive aquifer (bedrock) was considered a receptor. A hypothetical compliance point located 250m downgradient of the site was agreed with the Scottish Environment Protection Agency (SEPA).

The predicted concentrations in groundwater at a hypothetical compliance point 250m away from the site are extremely low compared to the corresponding Tier 1 assessment threshold values (i.e., Resource Protection Values, RPV). Therefore, no plausible risk to the hypothetical compliance point has been identified from these contaminants.

A sensitivity analysis was carried out for some conceptualised input parameters (focusing on the most sensitive parameters); the outcome of the sensitivity analysis indicates that the derived remedial targets are not significantly affected by changes in values of the conceptualised input parameters. Therefore, the values of the conceptualised input parameters used in the models are considered reasonably representative of the site conditions.

<u>Potential Contaminants of Concern from Burials</u>

In order to aid calculation of overall cumulative contamination loading from burial lairs, the site was divided into six separate zones; burials are proposed in site zones 1 to 5. At the time of writing this report, the total numbers of lairs in site zones 3 to 5 had not been confirmed by NLC. Therefore, contamination loading could only be estimated for site zones 1 and 2.

Potential contamination loading from burials (site zones 1 and 2) was estimated for ammonia, mercury and formaldehyde, which are key contaminants of concern for burial sites. The mass loading for these contaminants were used to estimate the corresponding porewater concentrations, from theoretical calculations based on soil/water partitioning coefficients.

The estimated porewater concentrations were used in the DQRA models. The outcome of the DQRA has indicated that the estimated concentrations of ammonia, mercury and formaldehyde in porewater do not give rise to significant concentrations at a hypothetical compliance point located 250m away (along the groundwater flow path).

Microbial Pathogens

Microbial pathogens do not have physico-chemical parameters that are required for contaminant fate and transport modelling, and therefore pathogens from burials could not be modelled as part of the DQRA. If deemed necessary, consideration may be given to additional periodic groundwater quality monitoring for pathogens once burials have started at the site. This should be discussed and agreed with the SEPA.

Pathogen concentrations presented in this report provide background baseline conditions to be compared against any future sampling.

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1 INTRODUCTION

1.1 Background

1.1.1 The context of the project is summarised in the table below:

Table 1.1 Project Context

Item	Details
Client	North Lanarkshire Council
Commission Date	May 2019
Project	Phase 1 DTS review, Phase 2 site investigation works and reporting, and Phase 3 Detailed Quantitative Risk Assessment (DQRA) of the water environment.
Context	Planning
Site Name	Pather Farm Cemetery, Wishaw
Location	Pather Farm Wishaw North Lanarkshire ML2 0RX ***(post code close to the site***)

1.1.2 The location of the site is presented in Drawing 1.

1.1.3 RPS was commissioned by North Lanarkshire Council (NLC) in May 2019 to undertake a Phase 1 Desk Study review, Phase 2 ground investigation and reporting, and Phase 3 Detailed Quantitative Risk Assessment (DQRA) of the water environment, for land intended for cemetery development in North Lanarkshire. NLC awarded the works under contract ref. LS-16-033.

1.1.4 The site is currently an open parcel of land, comprising a former farmland. It is bound to the north/northeast by an active railway line, to the south by a dismantled railway line track with open land and residential properties beyond, to the east by a stream and open land with Overtown Road beyond, and to the west by open land with residential properties beyond. Dimsdale Road runs north to south within the site along the western site boundary.

1.1.5 An overhead powerline is located over part of the southern, south eastern and eastern boundaries of the site.

1.1.6 RPS has already prepared both Phase 1 desk study report (July 2019) and an updated Phase 2 interpretative report (November 2020). Phase 1 desk study report presents the site's background information and environmental setting. The updated Phase 2 report presents the findings of two-staged intrusive ground investigations carried out at the site and subsequent interpretative assessment. Contaminants of concern (COCs) with elevated concentrations above the adopted assessment criteria (i.e., drinking water standards, DWS) that were recorded at the site including arsenic, cadmium, chromium, lead, selenium and nickel.

1.1.7 In addition, detectable concentrations of total petroleum hydrocarbons (TPHs) were recorded in the second set of groundwater samples from borehole RC2, after the first round of groundwater samples did not record any TPH in the same borehole. The detectable TPHs have also been considered COCs in this assessment. These COCs were carried forward to Phase 3 DQRA for further detailed and site-specific risk assessment. A Tier 1 risk assessment of the groundwater test results is presented in Appendix A.

1.1.8 This Phase 3 DQRA report presents the results of a detailed assessment of the potential risks posed by the identified COCs to the water environment at the Pather Farm site. It also predicts the potential impact to groundwater that would result from the use of the site as a cemetery.

1.2 Proposed Development

1.2.1 It is understood that NLC are proposing to use the site as a cemetery. Currently, the proposed site layout plan provided by NLC (Drawing No. LS-19-025-002, dated January 2020) shows the following proposed features at the site:

- Phases 1 and 2 lair internment areas, and future (Phase 3) internment areas. It is understood that Phase 1 of the cemetery would comprise 976 burial lairs, Phase 2 would comprise 640 burial lairs, and Phase 3 (consisting of 3 separate zones) would comprise 1030 burial lairs;
- Woodland meadow burial area (which is part of Phase 3 internment area), in the northern corner of the site;
- New services building and entrance lawn (in the northern part of the site);
- Car park (in the northern part of the site);
- Access roads and walkways;
- Soil deposition area (to the south-western part of the site);
- Indicative surface water attenuation areas (located in the southern parts of the site);
- Woodland meadow burial area (in the northern part of the site); and
- Environmental enhancement areas (in the southern and eastern parts of the site).

1.2.2 According to the information provided by the NLC, it is anticipated that the average annual burial rate will be 240 burials per year.

1.2.3 The proposed site layout plan (NLC Drawing No. LS-19-025-P002) is attached as Drawing 2 to this report.

1.3 Objective

1.3.1 The overall objective of the Phase 3 DQRA was to carry out further site-specific risk assessment of the potential contaminants of concern identified in groundwater samples obtained from beneath the Pather Farm site. The outcome of the DQRA was to demonstrate whether (or not) the identified potential pollutants would pose significant adverse impacts to the water environment (based on an agreed compliance point).

1.3.2 The DQRA was undertaken in general accordance with the key standard guidelines and documents detailed in the References section of this report (although not necessarily exclusively). These include PAN33 Guidance, Part IIA of the Environmental Protection Act (1990) and the Scottish Environment Protection Agency (SEPA) Guidance LUPS GU32.

1.4 Previous Assessments

1.4.1 Previous environmental investigations conducted for the site (on behalf of NLC) include:

- Preliminary Risk Assessment (PRA) Land Quality Report, Pather Farm, Wishaw, North Lanarkshire (WSP, October 2016).
- Phase 1 Desk Study Report Review, Pather Farm Cemetery, Wishaw (RPS, July 2019).
- Geo-Environmental Ground Investigation Interpretative Report, Pather Farm Cemetery, Wishaw (RPS, October 2019).

- Updated Geo-Environmental Ground Investigation Interpretative Report, Pather Farm Cemetery, Wishaw (RPS, November 2020).

1.4.2 Pertinent information from these reports have been referenced or summarised where appropriate herein. However, further reference to these previous reports should also be made, as necessary, in the interpretation of the findings and recommendations made within this DQRA report.

1.4.3 The exploratory hole location plan associated with the RPS ground investigation at the site is presented as Drawing 3.

1.5 Limitations

1.5.1 This report has been prepared for the sole use of North Lanarkshire Council for the purposes set out in this report. Any reliance on this report by third parties shall be at that party's own risk. This report shall only be presented in full and may not be used to support any other objectives other than those set out in this report, except with permission of RPS. No other warranty, expressed or implied, is made as to the professional advice included in this report or any other services provided by us.

1.5.2 The use and reliance upon third party information during the compilation of this document has assumed this to be appropriate and correct but no warranty is given to that effect. While reasonable care and skill has been applied in review of this data no responsibility can be accepted by RPS for inaccuracies in the data supplied. Information obtained from third parties has not been independently verified by RPS, unless otherwise stated in the report.

1.5.3 The information contained within this report is valid at the date of the investigations referenced within this report. Site conditions, and hence the validity of the information contained within this report, will vary with time and the user needs to satisfy themselves of the current validity of the information during any subsequent use.

1.5.4 This report has been prepared reflecting the scope of works provided by NLC (Ref. LS-16-033) and RPS' submitted tender (Geotechnical and Geo-environmental Investigation and Assessment for Pather Farm Cemetery – Proposal, RPS, April 2019) and the updated proposal for Additional Site Data and Groundwater Pollutant Modelling Scenario Report (Proposal, RPS, July 2020).

2 DETAILED QUANTITATIVE RISK ASSESSMENT METHODOLOGY

2.1 Introduction

2.1.1 The Environment Agency's (EA) 'Remedial Targets Methodology' (Environment Agency, 2006a) and the accompanying '***Remedial Targets Worksheet v3.2***' (Environment Agency, 2013) and User Manual (Environment Agency, 2006b) presents a recommended methodology for deriving site specific remedial objectives for contaminated soils and/or groundwater to protect the aquatic environment. The methodology is based on a phased approach to risk assessment and management as set out in the EA guidance. The approach is underpinned by progressive data collection and analysis, structured decision making and cost-benefit assessment.

2.2 Risk Assessment Procedure

2.2.1 This 'Detailed Quantitative Risk Assessment' has been carried out using the '***Remedial Targets Worksheet v3.2***'. This Microsoft Excel-based Worksheet is based on a staged approach (referred to as ***Levels***) to determine risk based remedial targets for soil and groundwater. The staged approach is used to identify unacceptable risks of pollution to the water environment and facilitates discussion and establishment of remedial targets for the water environment. With each Level of assessment, additional attenuation processes are considered (such as dilution and dispersion) which affect the predicted contaminant concentrations along a pathway to a receptor (compliance point).

2.2.2 The assessment procedure described in this report involves the following steps, in general accordance with the Remedial Targets Methodology:

1. Determine the appropriate ***receptor*** to be considered in the model (e.g. the underlying Scottish Middle Coal Measures Formation – a moderately productive aquifer, or a hypothetical compliance point from the site).
2. Identify ***contaminants of concern*** that pose a potential risk to the identified receptor or compliance point.
3. Determine the appropriate ***target concentration*** to be applied at the compliance point, for each contaminant from published sources (e.g. Environmental Quality Standards-EQS, Drinking Water Standards-DWS).
4. Carry out risk assessment to derive a ***remedial target*** for each contaminant (starting at Level 2). Note that the remedial target for a Level 1 assessment is always equal to a published guideline value (e.g. EQS, DWS) and no allowance is made for either dilution or attenuation processes.
5. Compare the derived remedial target with representative contaminant concentration measured at the site.
6. Where contaminant concentrations at the site exceed the derived remedial target, repeat steps 4 and 5 above for the successive Levels of assessment.
7. Where the derived remedial target is not exceeded by contaminant concentrations recorded at the site, the remedial target is adopted as the acceptable contaminant threshold for the site and further assessment is not necessary.

2.3 Definitions

2.3.1 The following key parameter definitions, in general accordance with the Remedial Targets Methodology (Environment Agency, 2006a), have been used in this report.

- Compliance Point – refers to a point along the pathway where the target concentrations should not be exceeded as this would represent an unacceptable risk of harm to the receptor. This may be a receptor (e.g. an aquifer), a specified point within an aquifer nearer to the contamination source, or even the 'pore water' in the soil zone. Alternatively, this may be a hypothetical compliance point between the source and a receptor. A hypothetical compliance point located 250m downgradient of the site was agreed with SEPA. Correspondence between RPS and SEPA is presented in Appendix B.
- Target Concentration – is the concentration at the compliance point that should not be exceeded. It is normally based on relevant environmental standards or background water quality and remains constant at all levels of the assessment.
- Remedial Target – is the derived soil or groundwater concentration from the analysis, above which remediation is required. The remedial target concentration is site specific and will change with each level of assessment.
- Pore Water – is used to describe any free water (i.e. not adsorbed within the matrix of a soil or rock and incapable of participating in contaminant movement) contained within the primary pore spaces or within fissures either in the unsaturated or saturated zone.

2.4 Staged Assessment

2.4.1 A brief description of each Level of assessment included in the Remedial Targets Worksheet is given below. For each assessment, the pore water concentration determined for the soil zone is compared with the remedial target to determine the need for remedial action or further assessment.

Soil Assessment

2.4.2 Level 1 assessment output is always equal to the target concentration and no allowance is made for the processes that could reduce the contaminant concentrations between the source and receptor. This Level considers whether the concentrations in pore water in contaminated soils are sufficient to impact on the receptor when dilution, dispersion and attenuation along the pathway are ignored. The compliance point is the soil zone.

2.4.3 At Level 2, a Dilution Factor (DF) is calculated reflecting the ratio between groundwater flow below the site (the source area) and infiltration through the contaminated soil. The remedial target (for soil) is defined as the target concentration multiplied by the calculated DF and/or unsaturated zone attenuation factor (AFu). The compliance point is the groundwater beneath the source area.

2.4.4 Level 3 considers attenuation of the contaminant as it moves through the saturated zone. The remedial target (for soil) is defined as the Level 2 remedial target multiplied by a saturated zone Attenuation Factor (AFs). Attenuation Factor is the ratio of the contaminant concentration in groundwater below the source to the calculated concentration at the compliance point. The compliance point is a point down hydraulic gradient of the site, which may be an abstraction point, groundwater dependent surface water or an agreed hypothetical compliance point from the site (source zone). For this assessment, a hypothetical compliance point of 250m down gradient from the development site was agreed with SEPA.

Groundwater Assessment

2.4.5 A similar assessment approach is presented for contaminated groundwater. As the contaminants have already moved through the soil zone, the assessment for contaminated groundwater commences at Level 2.

2.4.6 Groundwater assessment considers natural attenuation processes (including degradation, retardation, dispersion and dilution) affecting the contaminant as it moves through the saturated zone to the receptor. The target concentration is multiplied by an attenuation factor to determine the remedial target at a given compliance point that is compared with groundwater concentrations from below the site.

2.5 Sub-Division of the Site for Purpose of DQRA

2.5.1 It is understood that the proposed cemetery use of the site will be divided into three Phases covering various parts of the site. It is proposed that Phase 1 lair interment area will comprise 976 burial lairs, while Phases 2 and 3 internment areas will comprise 640 and 1030 burial lairs, respectively.

2.5.2 In order to aid calculation of overall cumulative contamination loading from burial lairs, the site was divided into six separate zones, as outlined below.

- Zone 1 – Phase 1 lair internment area, located in the central part of the site
- Zone 2 – Phase 2 lair internment area, located in the south-eastern part of the site
- Zone 3 – Phase 3 (future) lair internment area 1, located in the northern part of the site
- Zone 4 – Phase 3 (future) lair internment area 2, located in the eastern part of the site
- Zone 5 – Phase 3 (future) lair internment area 3, located in the southern part of the site
- Zone 6 – No burial proposed in this area, located in the northern part of the site

2.5.3 The six zones of the site are shown on Drawing 4.

2.5.4 Site zones 1 to 6 occupy the following approximate areas.

Table 2.1 Approximate Areas of Site Zone 1 to 6

Site Zone	Burial Phase	Approximate Area (m^2)
Zone 1	Phase 1 burial area	10,791
Zone 2	Phase 2 burial area	17,477
Zone 3	Phase 3 burial area	3,236
Zone 4	Phase 3 burial area	11,018
Zone 5	Phase 3 burial area	10,064
Zone 6	No burial proposed	12,200

3 SUMMARY OF GROUND CONDITIONS

3.1.1 Detailed descriptions of the ground conditions encountered at the site during the RPS ground investigation are provided in the exploratory hole logs presented in Appendix C. However, a summary of the ground conditions at the site are provided below.

Topsoil Materials

3.1.2 Topsoil (0.2m to 0.5m thick) was encountered across the site. The stratum generally comprised dark brown slightly sandy slightly silty clay with rootlets.

Made Ground

3.1.3 Made Ground materials were encountered mainly in the northern part of the site (area previously occupied by Pather Farm buildings). The Made Ground in this area comprised granular materials (clayey sandy gravel) with inclusions of concrete, brick, clinker, sandstone, coal and localised ash. The stratum was encountered to variable depths between 0.3m and 1.0m below ground level (bgl).

3.1.4 Cohesive Made Ground comprising slightly sandy slightly gravelly clay with brick inclusions was encountered in TP30 (0.3m thick). Sandy gravelly clay with coal fragments was also encountered in boreholes BH1 to BH6 (0.3m to 0.5m thick). In BH10, the stratum comprised reworked clay with timber, bricks and coal fragments.

3.1.5 Localised Made Ground (slightly gravelly clay with brick fragments) were also noted in TP8 and TP12; these materials are considered to be associated with the old/disused ceramic pipes for field drainage encountered at these locations.

Superficial Deposits

3.1.6 Superficial deposits (Glacial Till) were encountered to a maximum depth of 5.45m bgl, and generally comprised slightly sandy slightly gravelly clay with localised boulders and sand layers.

Bedrock (Solid Geology)

3.1.7 Bedrock rockhead (predominantly mudstone and sandstone) was encountered across the site at shallow depths between 0.9m and 5.5m bgl. Rotary boreholes drilled into the bedrock to variable depths between 25m and 35m bgl indicated that the bedrock comprises layers of interbedded sandstone, mudstone and localised coal which were logged and identified by rock core recovery after drilling.

3.1.8 In the cable percussion boreholes, the upper weathered zone of bedrock was recovered predominantly as a gravel.

Summary of Ground Conditions in Each Zone of the Site

3.1.9 To aid in the modelling, the thickness of the ground conditions encountered in the exploratory holes in each of the six site zones have been summarised in the following table.

3.1.10 The exploratory holes in each site zone are presented below.

- Zone 1 – BH3, RC03, TP20, TP23, TP28, TP29 and TP41
- Zone 2 – BH6, BH9, RC02, TP24, TP35, TP36, TP42, TP43, TP47, TP48, TP51 and TP52
- Zone 3 – BH1 and TP3
- Zone 4 – TP16, TP21, TP31, TP37 and TP44
- Zone 5 – BH5, RC05, RC06, TP34, TP40, TP46, TP49 and TP50

- Zone 6 – BH7, BH8, BH10, RC01, TP1, TP2, TP6, TP7, TP13, TP14, TP15, TP18, TP19 and TP30

Table 3.1 Summary of Thicknesses of Ground Conditions in Site Zones 1 to 6

Ground Strata	Ground Strata Thicknesses, m (range)					
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Topsoil	0.1 to 0.34	0.1 to 0.3	0.5	0.25 to 0.4	0.1 to 0.3	0.3 to 0.4
Made Ground	0.3	0.2 to 0.3	0.5	None	0.3	0.3 to 1.0
Glacial Till (Clay)	0.65 to 2.9	1.9 to >3.3	1.6 to >1.6	1.55 to >2.05	>1.9 to 4.8 (***a layer of 4.8m thick sand in RC05***)	>0.7 to 5.05 (***localised sand layers, 0.4m to 2.7m thick***)
Bedrock	Encountered at depths ranging from 0.8 to 3.0m bgl	Encountered at depths ranging from 1.8 to 2.5m bgl	Encountered at 2.1m depth bgl	Encountered at 1.8m depth bgl	Encountered at depths ranging from 3.1 to 3.6m bgl	Encountered at depths ranging from 1.5 to 3.0m bgl

4 CONCEPTUAL SITE MODEL

4.1.1 The aim of the risk assessment of the site was to identify the potential for significant harm or pollution, or the significant possibility of this, as defined under Part IIA of the Environmental Protection Act 1990 and PAN33.

4.1.2 In general accordance with the statutory guidance provided in Scottish Executive Publication SE/2006/44 there are two steps in applying the definition of Contaminated Land to a site:

- A pollutant linkage needs to be present comprising a contaminant source, a pathway and a receptor; and
- This linkage is causing, or has the significant possibility of causing, significant harm or pollution to statutory receptors.

4.1.3 Reference should be made to the previous reports listed in section 1.4 for a detailed description of the environmental setting of the site.

4.2 Contaminants of Concern identified from Ground Investigation

4.2.1 A total of 29 No. of groundwater samples (obtained from four separate monitoring and sampling rounds carried out on 27 June 2019, 11 September 2019, 16 January 2020 and 28 September 2020), and 2 No. surface water samples from the stream adjacent to the eastern site boundary were scheduled for laboratory analysis based upon the potential contaminants of concern identified in the Phase 1 Desk Study Report Review (RPS, July 2019), and the parameters specified in the SEPA Guidance LUPS GU32. The following parameters were scheduled:

- Metals (As, Cd, Cr, Pb, Hg, Se, Cu, Ni, Zn) as total metals (Round 1) and dissolved/filtered metals (Rounds 2 to 4), phenol, cyanide, pH, sulphide, sulphate, speciated polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs), pathogens (total viable count at 22^{0}C, total viable count at 37^{0}C, Escherichia Coli, total coliforms), nitrate, chloride, electrical conductivity, ammoniacal nitrogen and formaldehyde.

4.2.2 The laboratory chemical test results are presented in Appendix D. A Tier 1 risk assessment of the groundwater test results was carried out as presented in Appendix A, using the Resource Protection Values (RPV), based on WAT-PS-10-01.

4.2.3 Groundwater samples collected from the first sampling round on 27 June 2019 recorded elevated concentrations of arsenic, cadmium, chromium, lead, selenium and nickel above the corresponding RPV, as presented in the following table.

Table 4.1 Summary of Elevated Groundwater Concentrations (Sampling Round 1)

Parameter	Units	Tier 1 Assessment Criteria (Drinking Water Standard, DWS)	Range of Elevated Concentrations	Borehole Locations
Arsenic	µg/l	10	34	BH2
Cadmium	µg/l	5	7.6	BH2
Chromium (total)	µg/l	50	53 to 660	BH2, BH4, BH5
Lead	µg/l	25	51 to 540	BH2, BH4, BH5
Selenium	µg/l	10	20 to 120	BH2, BH4, BH5
Nickel	µg/l	20	140 to 650	BH2, BH4, BH5

4.2.4 Groundwater samples collected from the second sampling round on 11 September 2019 did not record elevated determinant concentrations of metals. However, localised detectable concentrations of TPHs were recorded in a groundwater sample from borehole RC02, as summarised in the following table. These detectable concentrations of TPHs are considered to be associated with hydrocarbon odour noted from groundwater during sampling at this location. It should be noted that

the concentrations of TPHs recorded in soil samples across the site were either below laboratory detection limits or negligible (below the soil assessment criteria values).

4.2.5 Groundwater monitoring rounds did not observe any hydrocarbon sheen or olfactory evidence in rounds one, two or three, and the hydrocarbon odour in RC02 was recorded in monitoring visits four, five, six, seven and eight, then no evidence noted in groundwater monitoring rounds nine, ten and eleven.

Table 4.2 Detectable TPH Concentrations in Groundwater from RC02 (Sampling Round 2)

TPH	Units	Detectable Concentration in Sample of Groundwater from RC02[$]	Potentially Applicable WHO Water Quality Standards[#]	Remarks
TPH aliphatic C6-C8	mg/l	0.042	15	Not elevated
TPH aliphatic C8-C10	mg/l	1.1	0.3	Concentrations are elevated above the WHO guide value adopted
TPH aliphatic C10-C12	mg/l	2	0.3	
TPH aliphatic C12-C16	mg/l	7.2	0.3	
TPH aliphatic C16-C21	mg/l	12	0.3[&]	
TPH aliphatic C21-C35	mg/l	10	0.3[&]	
TPH aromatic C8-C10	mg/l	0.062	0.3	Not elevated

Notes:
[$] Hydrocarbon odour was noted from the groundwater sample during sampling.
[#] Although no RPV is available for TPHs (based on WAT-PS-10-01), potentially applicable water quality standards presented in CL:AIRE (2017), which refers to World Health Organisation (WHO) guide values, were used in the DQRA models.
[&] The value (0.3 mg/l) was used in the absence of a potentially applicable guide value.

4.2.6 Groundwater samples collected from the third sampling round on 16 January 2020 recorded an elevated concentration of arsenic, above the corresponding RPV, as presented in the following table.

Table 4.3 Summary of Elevated Groundwater Concentration (Sampling Round 3)

Parameter	Units	Assessment Criteria (Drinking Water Standard, DWS)	Elevated Concentration	Borehole Locations
Arsenic	µg/l	10	27.5	RC02

4.2.7 In addition, localised detectable concentrations of TPHs were recorded in a groundwater sample from borehole RC02, as summarised in the following table. During sampling, the groundwater sample from RC02 had a slight hydrocarbon odour and visible sheen.

Table 4.4 Detectable TPH Concentrations in Groundwater from RC02 (Sampling Round 3)

TPH	Units	Detectable Concentration in Sample of Groundwater from RC02[$]	Potentially Applicable WHO Water Quality Standards[#]	Remarks
TPH aliphatic C8-C10	mg/l	1.2	0.3	Concentrations are elevated above the WHO guide value adopted
TPH aliphatic C10-C12	mg/l	0.6	0.3	
TPH aliphatic C12-C16	mg/l	6.3	0.3	
TPH aliphatic C16-C21	mg/l	11	0.3[&]	
TPH aliphatic C21-C35	mg/l	6.4	0.3[&]	
TPH aromatic C12-C16	mg/l	0.26	0.3	Not elevated

Notes:
[$] Hydrocarbon odour was noted from the groundwater sample during sampling.

[#] Although no RPV is available for TPHs (based on WAT-PS-10-01), potentially applicable water quality standards presented in CL:AIRE (2017), which refers to World Health Organisation (WHO) guide values, were used in the DQRA models.
[&] The value (0.3 mg/l) was used in the absence of a potentially applicable guide value.

4.2.8 Groundwater samples collected from the fourth sampling round on 28 September 2020 recorded elevated concentrations lead and nickel above the corresponding RPV, as presented in the following table.

Table 4.5 Summary of Elevated Groundwater Concentrations (Sampling Round 4)

Parameter	Units	Assessment Criteria (Drinking Water Standard, DWS)	Range of Elevated Concentrations	Borehole Locations
Lead	µg/l	25	32 to 68	BH7, BH9
Nickel	µg/l	20	38 to 460	BH7, BH9

4.2.9 During sampling round 4, two surface water samples were collected from the stream adjacent to the eastern boundary of the site. No elevated determinant concentrations were recorded in these surface water samples.

4.2.10 Although the elevated concentrations presented in Tables 4.1 to Table 4.4 were identified in groundwater samples obtained from beneath the site, these concentrations were localised. No significant concentrations of these metals were recorded in soil and leachate test results; therefore, the localised metals in groundwater may be indicative of the background baseline water environment, not particularly associated with this site. The potential source of the elevated TPH identified in groundwater from borehole RC02 is not clear, based on the known environmental setting of the site.

4.2.11 It should be noted that these elevated metals and TPH in groundwater are not the primary contaminants of concern for a burial site, according to SEPA's Guidance on Assessing the Impacts of Cemeteries on Groundwater (LUPS GU32, version 4).

4.2.12 However, the elevated metals and TPH were included in the DQRA to predict their corresponding concentrations reaching a hypothetical compliance point located 250m away from the site.

4.3 Estimation of Cumulative Contaminant Loading from Burials

Potential groundwater pollutants from human burials

4.3.1 According to Environment Agency (2004)[1], potential groundwater pollutants from human burials include ammoniacal nitrogen, formaldehyde, mercury, pathogens, phosphorus and calcium. The potential groundwater pollutants are also listed in the current UK government online guidance[2] on "Cemeteries and burials: prevent groundwater pollution".

4.3.2 According to SEPA's Guidance LUPS GU32, ammoniacal nitrogen is the principal contaminant of concern to the water environment from burials. Risks from other contaminants such as metals, formaldehyde, and microbial pathogens should also be considered if a sensitive receptor is very close to the site (i.e., within the standoff distances presented in Box 1 of the SEPA guidance). One of the standoff distances is that the site should not be located within 50m from any watercourse. A

[1] Environment Agency (2004). Potential groundwater pollutants from cemeteries.

[2] https://www.gov.uk/guidance/cemeteries-and-burials-prevent-groundwater-pollution (Accessed 24 November 2020).

stream or drain is located beyond the eastern site boundary; and therefore, formaldehyde and mercury were also considered as potential contaminants of concern for the site.

4.3.3 The contaminant decay rates and timings presented in the following table were obtained from Environment Agency (2004). These are based on a human body weighing 70 kg.

Table 4.6 Contaminant Decay Rates and Timings

Contaminant	Mass per burial (g)	Available mass for release (g)	Release start year	Release end year	Kinetic release model	Release rate per burial (g y^{-1})
Calcium	1100	1100	10	100	Zero-order	12.22
Nitrogen	1800 + 500[a,d]	1400[c] + 500[a,d]	0	10	Zero-order	190
Nitrogen	400	400	10	20	Zero-order	40
Mercury	3	3	0	2600	Zero-order	1.12×10^{-3}
Phosphorus	500	500	10	100	Zero-order	5.55
Formaldehyde	180	180	0	0.25	As a single event	NA
Formaldehyde	500[d]	500[d]	0	10	Zero-order	50

Notes:
[a] assumed from coffin of mass 15kg
[c] assumes that of the 1,800g body total then 400g are present in collagen in bone etc and so degraded after skeletonisation and completely lost over the subsequent decade.
[d] relies on catalytic hydrolysis of resin ***in situ***.

4.3.4 In Table 4.6, it should be noted that the release of calcium and phosphorus from lairs start 10 years after burial has taken place. Therefore, calcium and phosphorus were not considered as priority substances for this site. Instead, ammonia (derived from nitrogen), mercury and formaldehyde were considered in this assessment, given that they are released into the soil/groundwater environment immediately following burial.

Burials in site zones 1 to 5

4.3.5 It is anticipated that the average annual rate will be 240 burials per year. Based on information provided by NLC, the proposed total number of burial lairs in site zones 1 to 5 are presented in the following table.

4.3.6 No burials are proposed in site zone 6 in the northern part of the site, where the new building has been proposed. Therefore, no contaminant loading from burials will be present in zone 6.

Table 4.7 Burial Lairs in Site Zones 1 to 5

Item	Site zone 1	Site zone 2	Site zone 3	Site zone 4	Site zone 5
Burial Phase	Phase 1	Phase 2	Phase 3	Phase 3	Phase 3
Total burial lairs	976	640	1030 (total for all areas under Phase 3). ***The individual total number of burial lairs in each of the Phase 3 areas has not been confirmed by NLC***		
Approximate number of years required to reach the burial capacity, at 240 burials / year	4.1	2.6	4.3 years (for all areas under Phase 3)		

Ammonia, mercury and formaldehyde from burials

4.3.7 The cumulative mass loading of nitrogen, mercury and formaldehyde from burials was estimated for the first 5 years of the site being used as a cemetery. The loading was predicted for site zones 1 and 2 with defined total burial liars of 976 and 640, respectively, as presented in the following table.

4.3.8 At the time of writing this report, the total numbers of lairs in site zones 3 to 5 had not been confirmed by NLC. Therefore, contamination loading in these zones could not be estimated.

Table 4.8 Predicted Contamination Loading from Burials in Site Zones 1 and 2

Contaminant	Available mass for release per burial (g)	Release rate* per burial (g)	Release start year (after burial)	Site Zone 1: total of 976 lairs at 240 burials per year					Cumulative mass for the first 5 years (g)
				Year 1 (240 lairs)	Year 2 (480 lairs)	Year 3 (720 lairs)	Year 4 (960 lairs)	Year 5 (976 lairs)	
Nitrogen	1900	190	0	45600	91200	136800	182400	185440	641440
Mercury	3	0.00112	0	0.2688	0.5376	0.8064	1.0752	1.0931	3.7811
Formaldehyde	180	Single event	0	43200	43200	43200	43200	2880	(***added below***)
Formaldehyde	500	50	0	12000	24000	36000	48000	48800	344480
Contaminant	**Available mass for release per burial (g)**	**Release rate* per burial (g)**	**Release start year (after burial)**	**Site Zone 2: total of 640 lairs at 240 burials per year**					**Cumulative mass for the first 5 years (g)**
				Year 1 (240 lairs)	**Year 2 (480 lairs)**	**Year 3 (640 lairs)**	**Year 4 (640 lairs)**	**Year 5 (640 lairs)**	
Nitrogen	1900	190	0	45600	91200	121600	121600	121600	501600
Mercury	3	0.00112	0	0.2688	0.5376	0.7168	0.7168	0.7168	2.9568
Formaldehyde	180	Single event	0	43200	43200	28800	N/A	N/A	(***added below***)
Formaldehyde	500	50	0	12000	24000	32000	32000	32000	247200

Notes:
* zero-order release rate

4.3.9 In order to derive the mass of ammonia from the predicted cumulative mass of nitrogen, the mass of nitrogen presented in Table 4.8 was multiplied by a factor of 1.21. Detailed calculations showing how the 1.21 factor was derived is presented in Appendix J.

4.3.10 Site zones 1 and 2 occupy areas of approximately 10,791m^2 and 17,477m^2, respectively. Assuming that 1m thick soil around a coffin will comprise a contamination source across each site zone, the estimated volume of soil that will comprise source of contamination will be 10,791m^3 (zone 1) and 17,477m^3 (zone 2). These estimated soil volumes were used to calculate soil and porewater concentrations as presented in the following table. Porewater concentrations were derived using the following equation[3].

[3] Environment Agency (2006). Remedial Targets Methodology. Hydrogeological Risk Assessment for Land Contamination.

$$Cp = \frac{Cs}{\left(Kd + \frac{\theta w + \theta a\ H}{\rho}\right)}$$

Where:

C_s = soil concentration (mg/kg)

C_p = porewater concentration (mg/l)

K_d = soil-water partition coefficient (l/kg) (***K_d can also be estimated by K_{oc} x f_{oc} for non-polar organic chemicals***).

θ_w = water filled soil porosity (fraction)

θ_a = air filled soil porosity (fraction)

ρ = bulk soil density (g/cm^3)

H = Henry's Law constant (dimensionless)

Table 4.9 Predicted Soil and Porewater Contaminant Concentrations in Site Zones 1 and 2

Contaminant	Cumulative mass (g)	Estimated Concentration in Soil (mg/kg)#	Site Zone 1: Estimating porewater concentration (C_p) (mg/l)					
			H **(dimensionless)+**	***ρ*** **(g/cm^3)+**	***θ_w*** **(fraction)+**	***θ_a*** **(fraction)+**	***K_d*** **(l/kg)+**	***C_p*** **(mg/l)**
Ammonia	776142*	59.94	0.000309	1.2	0.37	0.16	0.4	84.6
Mercury	3.7811	0.00029	0.000000516	1.2	0.37	0.16	0.000099	0.00013
Formaldehyde	344480	26.60	0.0000138	1.2	0.37	0.16	12.21	15.55
Contaminant	**Cumulative mass (g)**	**Estimated Concentration in Soil (mg/kg) #**	**Site Zone 2: Estimating porewater concentration (C_p) (mg/l)**					
			H **(dimensionless)+**	***ρ*** **(g/cm^3)+**	***θ_w*** **(fraction)+**	***θ_a*** **(fraction)+**	***K_d*** **(l/kg)+**	***C_p*** **(mg/l)**
Ammonia	606936*	28.94	0.000309	1.2	0.37	0.16	0.4	40.85
Mercury	2.9568	0.00014	0.000000516	1.2	0.37	0.16	0.000099	0.000061
Formaldehyde	247200	11.79	0.0000138	1.2	0.37	0.16	12.21	6.89

Notes:
* mass of nitrogen x 1.21.
# bulk density of soil used in the calculation is 1.2 g/cm^3 (CLEA Software); this equals 1200 kg/m^3, which allowed for estimation the mass of soil (kg) from the assumed volume of soil comprising source of contamination as described in the preceding page. Soil mass (kg) was used in calculating estimated soil concentration (mg/kg).
+ same as (or derived from) values used in the model (see the model worksheets in Appendix H).

4.3.11 The estimated contaminant concentrations in porewater were used in the DQRA models.

Microbial Pathogen loading from burials

4.3.12 According to the Environment Agency (2004), there are three conceivable scenarios for pathogen escape from a buried corpse.

- release of normal body flora (for example faecal organisations from the gut, skin or mucosal membranes);
- release of existing pathogens from infections present at the time of death; and
- release of pathogens which invade the body after burial.

4.3.13 However, there is a general lack of literature data on microbial and pathogen loading from cemeteries.

4.4 Summary of Contaminants of Concern

4.4.1 For purposes of this assessment, the identified potential contaminants of concern are:

- Metals (arsenic, cadmium, chromium, lead, selenium, nickel) which recorded elevated concentrations in groundwater.
- TPHs (aliphatic C8-C10, aliphatic C10-C12, aliphatic C12-C16, aliphatic C16-C21 and aliphatic C21-C35). Although no RPV is available for TPHs (based on WAT-PS-10-01), these detectable TPHs were included in the assessment in order to determine whether the recorded TPH concentrations would exceed their respective remedial targets calculated by the model, based on the agreed hypothetical compliance point. Given that the DQRA model requires a '***target concentration***' (i.e., water quality standard) to derive a remedial target, potentially applicable water quality standards presented in CL:AIRE (2017) were used in the models.
- Predicted cumulative contamination (formaldehyde, ammonia and mercury) loading from burials.

4.5 Pathways

4.5.1 Based on the ground conditions summarised in the preceding section 3, the following potential pathways have been identified through which contamination within the underlying soil materials and/or groundwater could reach a potential receptor.

- Made Ground materials encountered in the northern part of the site (to depths between 0.3m and 1.0m bgl) comprised clayey sandy gravel with inclusions of concrete, brick, clinker, sandstone, coal and localised ash. Because these Made Ground materials are predominantly granular, they provide a potential pathway for contaminant/leachate transport. However, laboratory analysis results on soil leachate samples (from the same area of the site) generally indicated negligible/low leachability of the determinants analysed.
- The superficial deposits (Glacial Till) underlying the site include localised granular layers (i.e., sand), which could provide preferential pathway for migration of contaminants in groundwater.
- The weathered bedrock (recovered predominantly as gravel in cable percussion boreholes) may provide preferential pathway for migration of contaminants in groundwater, due to the granular / fractured condition of the bedrock.

4.6 Receptors

4.6.1 The underlying bedrock geology (a moderately productive aquifer) was considered a potential receptor. However, the no significant impact to the aquifer was anticipated from the identified contaminants of concern, given that the aquifer is generally overlain by low permeability glacial till which would minimise vertical migration of potential contamination into the aquifer. Any potential

contaminant migrations pathways within the granular layers within the Glacial Till would be localised and therefore would have minimal impact on the aquifer.

4.6.2 The Gowkthrapple Burn is located approximately 200m south-west of the site. Even though the hydraulic gradient of the site is generally orientated from a north-east to south-west direction (as described further in section 5.2), the Burn is not considered a sensitive surface water receptor because it is not located within 50m of the site in accordance with SEPA's Guidance LUPS GU32.

4.6.3 For purposes of this risk assessment, a hypothetical compliance point (250m away from the site / source zone, and down gradient of the site) has been used in the model, as agreed with SEPA.

4.7 Conceptual Site Model Summary

4.7.1 In reflection of the Tier 1 risk assessment presented in Appendix A, and the predicted contamination cumulative loading from burials, the potential source-pathway-receptor linkage identified at the site is summarised in the following table.

Table 4.10 Source-Pathway-Receptor Linkage Assessment

Source	The Water Environment *Migration of groundwater / surface water pathway*
Measured elevated concentrations of selected metals (As, Cd, Cr, Pb, Se, Ni) in groundwater. Detected TPHs in groundwater from RC02.	☒
Predicted cumulative contamination (formaldehyde, ammonia and mercury) loading from burials	☒

4.7.2 The elevated metals and the TPHs detected in groundwater were considered further in this DQRA. In addition, the predicted cumulative contamination loading from burials were included in this assessment.

4.8 Results of Microbial Pathogens and Other Parameters from Ground Investigation

4.8.1 Other principal contaminants of concern to the water environment from burials, as specified in SEPA's Guidance LUPS GU32, include ammoniacal nitrogen, formaldehyde and microbial pathogens. The recorded concentrations of these substances and pH, electrical conductivity, chloride and nitrate are summarised in the following tables. Full laboratory test results are presented in Appendix D.

Table 4.11 Groundwater Baseline Conditions – Pathogens and Other Parameters

Parameter	Groundwater Test results (Sampling Rounds 1 to 4)		
	Minimum	Maximum	Remarks
Microbial Pathogens			
Total viable count at 22^{0}C (cfu/ml)	670	>15000	No RPV is available for these pathogens, based on WAT-PS-10-01
Total viable count at 37^{0}C (cfu/ml)	37	13750	
Escherichia Coli (MPN or cfu/100ml)	None detected	>201	
Total coliforms (MPN or cfu/100ml)	29	>201	
Other Parameters			
pH	7.0	7.7	pH values recorded indicate neutral conditions in groundwater
Chloride (mg/l)	3.3	51	Below chloride RPV of 250 mg/l

Nitrate (mg/l)	<0.5	33.6	Below nitrate RPV of 50 mg/l
Ammoniacal nitrogen (mg/l)	<0.015	3.3	Localised exceedance of RPV for ammonia (0.5mg/l) in groundwater samples from RC01, RC04 and BH4
Electrical conductivity (µS/cm)	350	1100	No RPV is available, based on WAT-PS-10-01
Formaldehyde (mg/l)	<0.005	<0.5	Formaldehyde was not detected

Table 4.12 Surface Water Baseline Conditions – Pathogens and Other Parameters

Parameter	Surface Water Test results (Sampling Round 4)		
	SW1	SW2	Remarks
Microbial Pathogens			
Total viable count at 22^{0}C (cfu/ml)	>15000	3645	
Total viable count at 37^{0}C (cfu/ml)	2025	137	
Escherichia Coli (cfu/100ml)	>100	23	
Total coliforms (cfu/100ml)	>100	35	
Other Parameters			
pH	8.0	8.0	pH values recorded indicate neutral conditions in surface water
Chloride (mg/l)	19	19	
Nitrate (mg/l)	12.9	11.7	
Ammoniacal nitrogen (mg/l)	0.26	0.59	Although this is not groundwater, SW2 test result marginally exceeds RPV for ammonia (0.5 mg/l)
Electrical conductivity (µS/cm)	680	620	
Formaldehyde (mg/l)	<0.05	<0.05	Formaldehyde was not detected

4.8.2 Microbial pathogens and the other parameters (apart from ammonia) presented in Tables 4.11 and 4.12 were not included in the DQRA, due to the following considerations:

- No elevated concentrations of chloride and nitrate were recorded above their respective RPVs; therefore, chloride and nitrate are not considered to present significant COCs;
- Formaldehyde concentrations were non-detectable and do not present a COC;
- Microbial pathogens do not have physico-chemical parameters required for contaminant fate and transport modelling as part of DQRA; and
- Electrical conductivity and pH are groundwater quality parameters that do not require inclusion in the DQRA.

4.8.3 The measured concentrations of ammonia were assessed further in this DQRA.

4.8.4 It is considered that the concentrations of microbial pathogens and other parameters in Tables 4.11 and 4.12 indicate the baseline conditions in groundwater collected from beneath the site.

5 DETAILED QUANTITATIVE RISK ASSESSMENT MODELS

5.1 Model Input Parameters

5.1.1 The input parameters used in this risk assessment are summarised in the Tables D1 and D2 presented in Appendix E. The tables also indicate the corresponding data sources and the relevant justifications / assumptions used. Where no information is available, conservative input values that are considered protective of the environment have been used in the models.

5.1.2 In addition, model input parameters and assumptions that are specific to site zones 1 and 2 are presented in Table D3 in Appendix E.

5.2 Groundwater Levels

5.2.1 Groundwater levels were monitored in a total of 12 No. wells across the site from June 2019 to June 2020. Groundwater levels were monitored for a period of 12 months (on a monthly basis) during the initial phase of ground investigation, and four additional rounds of groundwater levels were obtained fortnightly during the second phase of ground investigation from September to October 2020. Borehole logs, which show details of monitoring well installations are presented in Appendix C. The groundwater levels are presented in the following table, in m bgl and in m Above Ordnance Datum (AOD). Groundwater monitoring datasheets are presented in Appendix F.

5.2.2 Five groundwater level contour plots were prepared, as presented in Drawings 5a to 5e. The contour plots were prepared using average groundwater level from 3 to 4 readings as shown below:

- ***Contour plot 1 – average groundwater level for 3 readings from June to August 2019 (Summer 2019);***
- ***Contour plot 2 – average groundwater level for 3 readings from September to November 2019 (Autumn 2019);***
- ***Contour plot 3 – average groundwater level for 3 readings from December 2019 to February 2020 (Winter 2019/2020);***
- ***Contour plot 4 – average groundwater level for 3 readings from March to June 2020 (Spring 2020); and***
- ***Contour plot 5 – average groundwater level for 4 readings from September to October 2020 (Autumn 2020).***

5.2.3 Based on the groundwater level contour plots, the approximate flow direction of the shallow groundwater beneath the site is generally from northeast to southwest.

5.2.4 This implies that the surface water stream located adjacent to the eastern boundary of the site is upstream of the site. Therefore, the stream is not considered a plausible receptor.

Table 5.1 Groundwater Levels

Monitoring Round (Date)	Groundwater Levels in Monitoring Wells, m BGL – measured from surface (Corrected groundwater levels in m AOD; accuracy +/- 30mm)											
	BH1	BH2	BH4	BH5	RC01	RC02*	RC04	RC06	BH7	BH8	BH9	BH10
27/06/2019	Dry	2.02 (133.65)	2.71 (127.27)	4.52 (129.88)	No data. Rotary boreholes had not been drilled.				Boreholes BH7, BH8, BH9 and BH10 were drilled during the supplementary phase of ground investigation in September 2020			
24/07/2019	Dry	1.97 (133.70)	1.06 (128.92)	3.71 (130.69)								
21/08/2019	1.80 (137.99)	1.56 (134.11)	#	3.02 (131.38)	4.13 (136.40)	18.59 (124.20)	1.69 (129.55)	5.44 (132.84)				
11/09/2019	2.27 (137.52)	1.01 (134.66)	0.46 (129.52)	2.09 (132.31)	3.82 (136.71)	17.95 (124.84)	1.38 (129.86)	5.44 (132.84)				
22/10/2019	1.80 (137.99)	1.56 (134.11)	#	3.02 (131.38)	4.13 (136.40)	18.59 (124.20)	1.69 (129.55)	5.44 (132.84)				
26/11/2019	1.59 (138.20)	1.57 (134.10)	0.77 (129.21)	2.01 (132.39)	4.90 (135.63)	19.85 (122.94)	1.16 (130.08)	4.75 (133.53)				
17/12/2019	1.19 (138.60)	0.57 (135.10)	0.52 (129.46)	0.95 (133.45)	4.13 (136.40)	20.08 (122.71)	0.81 (130.43)	4.15 (134.13)				
16/01/2020	1.21 (138.58)	0.68 (134.99)	0.53 (129.45)	1.00 (133.40)	3.33 (137.20)	18.90 (123.89)	0.83 (130.41)	3.89 (134.39)				
19/02/2020	1.17 (138.62)	0.44 (135.23)	0.48 (129.50)	0.95 (133.45)	3.49 (137.04)	20.54 (122.25)	0.80 (130.44)	3.99 (134.29)				
18/03/2020	1.42 (138.37)	0.46 (135.21)	0.53 (129.45)	0.89 (133.51)	3.11 (137.42)	20.55 (122.24)	0.92 (130.32)	3.78 (134.50)				
29/05/2020	2.25 (137.54)	1.96 (133.71)	1.08 (128.90)	2.67 (131.73)	3.30 (137.23)	21.10 (121.69)	1.85 (129.39)	5.60 (132.68)				
30/06/2020	2.25 (137.54)	2.27 (133.40)	1.10 (128.88)	1.10 (133.30)	4.00 (136.53)	20.60 (122.19)	1.90 (129.34)	5.60 (132.68)				

Monitoring Round (Date)	Groundwater Levels in Monitoring Wells, m BGL – measured from surface (Corrected groundwater levels in m AOD; accuracy +/- 30mm)											
	BH1	BH2	BH4	BH5	RC01	RC02*	RC04	RC06	BH7	BH8	BH9	BH10
11/09/2020	1.79 (138.00)	0.86 (134.81)	#	1.25 (133.15)	3.47 (137.06)	#	1.12 (130.12)	#	2.20 (139.09)	2.94 (137.59)	2.15 (138.79)	1.70 (139.52)
28/09/2020	1.90 (137.89)	1.41 (134.26)	0.80 (129.18)	1.98 (132.42)	3.58 (136.95)	#	1.35 (129.89)	#	2.49 (138.80)	3.15 (137.38)	3.01 (137.93)	1.67 (139.55)
09/10/2020	1.59 (138.20)	0.91 (134.76)	0.58 (129.40)	1.41 (132.99)	3.58 (136.95)	#	1.71 (129.53)	#	2.59 (138.70)	3.07 (137.46)	2.76 (138.18)	1.74 (139.48)
27/10/2020	1.50 (138.29)	0.68 (134.99)	0.48 (129.50)	1.00 (133.40)	3.33 (137.20)	#	1.03 (130.21)	#	2.34 (138.95)	2.78 (137.75)	2.17 (138.77)	1.55 (139.67)

Notes

Borehole was not located due to access / possible vandalism of borehole cover hence borehole not located under thick grass cover.

* Groundwater in RC02 is considered a deeper groundwater body within bedrock, separate from the shallow groundwater recorded in the other wells.

5.2.5 Hydraulic gradients used in the DQRA models were calculated from the measured groundwater levels; a summary of calculated hydraulic gradients is presented in the following table, while the detailed calculations are included in Appendix G.

Table 5.2 Summary of Calculated Hydraulic Gradients

Monitoring Round	Monitoring Date	Maximum Hydraulic Gradient	Monitoring Round	Monitoring Date	Maximum Hydraulic Gradient
1	26/06/2019	0.0399	9	19/02/2020	0.0306
2	24/07/2019	0.0299	10	18/03/2020	0.0299
3	21/08/2019	0.0310	11	29/05/2020	0.0290
4	11/09/2019	0.0294	12	30/06/2020	0.0291
5	22/10/2019	0.0310	13	11/09/2020	0.0610
6	26/11/2019	0.0302	14	28/09/2020	0.0476
7	17/12/2019	0.0307	15	09/10/2020	0.0462
8	16/01/2020	0.0306	16	27/10/2020	0.0466

5.2.6 The maximum hydraulic gradients calculated for each groundwater monitoring round ranged from 0.029 (round 11) to 0.061 (round 13), with an average of approximately 0.036.

6 MODEL OUTPUT / RESULTS

6.1 Predicted Concentrations for the Contaminants identified from RPS' Ground Investigation

6.1.1 The 'Remedial Targets Worksheets' showing the model input parameters and the calculated results are included in Appendix H. For ease of reference, summarised below are the predicted concentrations (for the contaminants of concern identified at the site during the ground investigation), at a hypothetical compliance point located 250m away from the site. Full model results are included in the worksheets (Appendix H).

Table 6.1 Predicted contaminant concentrations at a compliance point 250m away

Determinant	Maximum Recorded Concentration in Groundwater (MRC) mg/l	Tier 1 Assessment Threshold Value (RPV) (DWS) mg/l	Predicted Concentration in Groundwater at a Compliance Point 250m away (GCP) (mg/l)	Does GCP exceed RPV? Yes (✓) No (×)
Arsenic	0.034	0.01	3.37×10^{-05}	×
Cadmium	0.0076	0.005	7.53×10^{-06}	×
Chromium (total)	0.66	0.05	6.54×10^{-05}	×
Lead	0.54	0.025	5.35×10^{-04}	×
Selenium	0.12	0.01	1.19×10^{-04}	×
Nickel	0.65	0.02	6.44×10^{-04}	×
TPH aliphatic C8-C10	1.2	0.3	1.19×10^{-03}	×
TPH aliphatic C10-C12	2	0.3	1.98×10^{-03}	×
TPH aliphatic C12-C16	7.2	0.3	7.13×10^{-03}	×
TPH aliphatic C16-C21	12	0.3#	1.19×10^{-02}	×
TPH aliphatic C21-C35	10	0.3#	9.90×10^{-03}	×
Ammonia	3.3	0.5	3.61×10^{-04}	×

Notes

Although no RPV is available for TPHs (based on WAT-PS-10-01), potentially applicable water quality standards presented in CL:AIRE (2017), which refers to World Health Organisation (WHO) guide values, were used in the DQRA models. The value (0.3 mg/l) was used in the absence of a potentially applicable guide value.

6.1.2 The predicted concentrations in groundwater at the compliance point (250m away, downgradient of the groundwater flow) are extremely low compared to the corresponding Tier 1 assessment threshold values.

Sensitivity Analysis

6.1.3 A sensitivity analysis was carried out as part of the risk assessment to assess which conceptualised parameters had the greatest influence on the derived remedial targets. This allowed the most sensitive parameters to be identified and a reasoned judgement to be made on whether further data to better define the parameter was needed. In addition, it provides greater confidence attached to the decisions made based on the derived remedial targets.

6.1.4 The sensitivity analysis has been undertaken by varying the conceptualised model input parameter values used in Level 3 groundwater risk assessment stage. These input parameters are:

- Width of plume in aquifer at source (perpendicular to flow) (***Sz***);
- Plume thickness at source (***Sy***);

- Saturated aquifer thickness (***da***); and
- Hydraulic conductivity of aquifer in which dilution occurs (***k***).

6.1.5 The derived remedial target output variations arising from the sensitivity analysis are summarised in the following table.

Table 6.2 Sensitivity analysis output

Results of Sensitivity Analysis carried out for Selected Input Parameters					
Illustration of the influence of varying the '*width of plume in aquifer at source (perpendicular to flow) (Sz)*' on the predicted concentrations					
Predicted Concentration in Groundwater at a Compliance Point 250m away (mg/l)	Determinant (Tier 1 assessment threshold value)	Width of plume in aquifer at source, ***Sz*** (m)			
		1.0$	+25% change	+50% change	Remarks
	Arsenic (0.01mg/l)	3.37E-05	4.21E-05	5.05E-05	Predicted concentrations are below the corresponding Tier 1 assessment threshold values, based on up to +50% change in parameter value
	Cadmium (0.005mg/l)	7.53E-06	9.41E-06	1.13E-05	
	Chromium (0.05mg/l)	6.54E-05	8.17E-05	9.80E-05	
	Lead (0.025mg/l)	5.35E-04	6.68E-04	8.02E-04	
	Selenium (0.01mg/l)	1.19E-04	1.49E-04	1.78E-04	
	Nickel (0.02mg/l)	6.44E-04	8.05E-04	9.65E-04	
	TPH aliphatic C8-C10 (0.3mg/l)	1.19E-03	1.49E-03	1.78E-03	
	TPH aliphatic C10-C12 (0.3mg/l)	1.98E-03	2.48E-03	2.97E-03	
	TPH aliphatic C12-C16 (0.3mg/l)	7.13E-03	8.91E-03	1.07E-02	
	TPH aliphatic C16-C21 (0.3mg/l)	1.19E-02	1.49E-02	1.78E-02	
	TPH aliphatic C21-C35 (0.3mg/l)	9.90E-03	1.24E-02	1.49E-02	
	Ammonia (0.5mg/l)	3.61E-04	4.51E-04	5.41E-04	
Illustration of the influence of varying the '*plume thickness at source (Sy)*' on the predicted concentrations					
Predicted Concentration in Groundwater at a Compliance Point 250m away (mg/l)	Determinant (Tier 1 assessment threshold value)	Plume thickness at source, ***Sy*** (m)			
		1.23$	+25% change	+50% change	Remarks
	Arsenic (0.01mg/l)	3.37E-05	4.09E-05	5.04E-05	Predicted concentrations are below the corresponding Tier 1 assessment threshold values, based on up to +50% change in parameter value
	Cadmium (0.005mg/l)	7.53E-06	9.15E-06	1.13E-05	
	Chromium (0.05mg/l)	6.54E-05	7.95E-05	9.79E-05	
	Lead (0.025mg/l)	5.35E-04	6.50E-04	8.01E-04	
	Selenium (0.01mg/l)	1.19E-04	1.45E-04	1.78E-04	
	Nickel (0.02mg/l)	6.44E-04	7.83E-04	9.64E-04	
	TPH aliphatic C8-C10 (0.3mg/l)	1.19E-03	1.45E-03	1.78E-03	
	TPH aliphatic C10-C12 (0.3mg/l)	1.98E-03	2.41E-03	2.97E-03	
	TPH aliphatic C12-C16 (0.3mg/l)	7.13E-03	8.67E-03	1.07E-02	
	TPH aliphatic C16-C21 (0.3mg/l)	1.19E-02	1.45E-02	1.78E-02	
	TPH aliphatic C21-C35 (0.3mg/l)	9.90E-03	1.20E-02	1.48E-03	
	Ammonia (0.5mg/l)	3.61E-04	4.39E-04	5.41E-04	

Results of Sensitivity Analysis carried out for Selected Input Parameters					
Illustration of the influence of varying the '*saturated aquifer thickness (da)*' on the predicted concentrations					
Predicted Concentration in Groundwater at a Compliance Point 250m away (mg/l)	Determinant (Tier 1 assessment threshold value)	Saturated aquifer thickness, ***da*** (m)			
		6.0$	+25% change	+50% change	Remarks
	Arsenic (0.01mg/l)	3.37E-05	3.37E-05	3.37E-05	Changes in parameter values have no impact on the predicted concentrations at compliance point
	Cadmium (0.005mg/l)	7.53E-06	7.53E-06	7.53E-06	
	Chromium (0.05mg/l)	6.54E-05	6.54E-05	6.54E-05	
	Lead (0.025mg/l)	5.35E-04	5.35E-04	5.35E-04	
	Selenium (0.01mg/l)	1.19E-04	1.19E-04	1.19E-04	
	Nickel (0.02mg/l)	6.44E-04	6.44E-04	6.44E-04	
	TPH aliphatic C8-C10 (0.3mg/l)	1.19E-03	1.19E-03	1.19E-03	
	TPH aliphatic C10-C12 (0.3mg/l)	1.98E-03	1.98E-03	1.98E-03	
	TPH aliphatic C12-C16 (0.3mg/l)	7.13E-03	7.13E-03	7.13E-03	
	TPH aliphatic C16-C21 (0.3mg/l)	1.19E-02	1.19E-02	1.19E-02	
	TPH aliphatic C21-C35 (0.3mg/l)	9.90E-03	9.90E-03	9.90E-03	
	Ammonia (0.5mg/l)	3.61E-04	3.61E-04	3.61E-04	
Illustration of the influence of varying the '*hydraulic conductivity of aquifer in which dilution occurs (k)*' on the predicted concentrations					
Predicted Concentration in Groundwater at a Compliance Point 250m away (mg/l)	Determinant (Tier 1 assessment threshold value)	Hydraulic conductivity of aquifer, ***k*** (m/d)			
		0.26$	+25% change	+50% change	Remarks
	Arsenic (0.01mg/l)	3.37E-05	3.37E-05	3.37E-05	Changes in parameter values have no significant impact on the predicted concentrations at compliance point
	Cadmium (0.005mg/l)	7.53E-06	7.53E-06	7.53E-06	
	Chromium (0.05mg/l)	6.54E-05	6.54E-05	6.54E-05	
	Lead (0.025mg/l)	5.35E-04	5.35E-04	5.35E-04	
	Selenium (0.01mg/l)	1.19E-04	1.19E-04	1.19E-04	
	Nickel (0.02mg/l)	6.44E-04	6.44E-04	6.44E-04	
	TPH aliphatic C8-C10 (0.3mg/l)	1.19E-03	1.19E-03	1.19E-03	
	TPH aliphatic C10-C12 (0.3mg/l)	1.98E-03	1.98E-03	1.98E-03	
	TPH aliphatic C12-C16 (0.3mg/l)	7.13E-03	7.13E-03	7.13E-03	
	TPH aliphatic C16-C21 (0.3mg/l)	1.19E-02	1.19E-02	1.19E-02	
	TPH aliphatic C21-C35 (0.3mg/l)	9.90E-03	9.90E-03	9.90E-03	
	Ammonia (0.5mg/l)	3.61E-04	5.43E-04	7.17E-04	
Note: $ Selected value used in the initial model calculations (as presented in Appendix E)					

6.1.6 The sensitivity analysis output indicates that the derived remedial targets are not significantly affected by changes in the input parameter values (*Sz*, *Sy*, *da* and *k*). The conceptualised input values for 'width of plume in aquifer at source (perpendicular to flow)', 'plume thickness at source', 'saturated aquifer thickness' and 'hydraulic conductivity of aquifer' used in the model are therefore considered to be reasonably representative of the site conditions.

6.2 Estimated Concentrations of Ammonia, Mercury and Formaldehyde from Burial Lairs at Compliance Point

6.2.1 The estimated cumulative contaminant loading of ammonia, mercury and formaldehyde in burial zones 1 and 2 were used in the DQRA to predict the corresponding concentrations at a hypothetical compliance point located 250m away from the site.

6.2.2 The predicted concentrations at compliance point are presented in the following table. The 'Remedial Targets Worksheets' showing the model input parameters and the calculated results are included in Appendix H.

Table 6.3 Estimated concentrations of ammonia, mercury and formaldehyde at compliance point 250m away (site zones 1 and 2)

Determinant	Estimated Concentration in Pore-water[1] (PWC) mg/l	Tier 1 Assessment Threshold Value (RPV) (DWS) mg/l	Predicted Concentration in Groundwater at a Compliance Point 250m away (GCP) (mg/l)	Does GCP exceed RPV? Yes (✓) No (×)
Burial zone 1				
Ammonia (zone 1)	84.6	0.5	0.148	×
Mercury (zone 1)	0.00013	0.001	2.06×10^{-06}	×
Formaldehyde (zone 1)	15.55	0.005	9.76×10^{-78}	×
Burial zone 2				
Ammonia (zone 2)	40.85	0.5	0.0716	×
Mercury (zone 2)	0.000061	0.00007	9.68×10^{-07}	×
Formaldehyde (zone 2)	6.89	0.005	4.32×10^{-78}	×

Notes
[1] Pore-water concentration was determined from theoretical calculations based on soil/water partitioning coefficient.

6.2.3 The predicted concentrations of ammonia, mercury and formaldehyde in groundwater at the compliance point (250m away, downgradient of the groundwater flow) are extremely low compared to the corresponding estimated pore-water concentrations derived from burial lairs.

Sensitivity Analysis

6.2.4 A sensitivity analysis was carried out to assess whether the following key conceptualised parameters have any significant influence on the predicted groundwater concentrations of ammonia, mercury and formaldehyde at a compliance point located 250m away (and downgradient of the site).

- Width of plume in aquifer at source (perpendicular to flow) (***Sz***);
- Plume thickness at source (***Sy***);

6.2.5 The variations in groundwater concentrations at compliance point arising from the sensitivity analysis are summarised in the following table. Data for site zone 1 data were used in this assessment.

Table 6.4 Sensitivity analysis output for ammonia, mercury and formaldehyde

Results of Sensitivity Analysis carried out for Selected Input Parameters					
Illustration of the influence of varying the '*width of plume in aquifer at source (perpendicular to flow) (Sz)*' on the calculated groundwater concentrations					
	Determinant (Tier 1 assessment threshold value – Drinking Water Standard)	Width of plume in aquifer at source, Sz (m)			
		20$	+25% change	+50% change	Remarks
Predicted concentration (mg/l) in groundwater at a compliance point 250m away	Ammonia, zone 1 (0.5 mg/l)	0.148	0.184	0.219	Predicted concentrations are below the corresponding Tier 1 threshold values, based on up to +50% change in parameter value
	Mercury, zone 1 (0.001 mg/l) – DWS threshold	2.06×10^{-06}	2.56×10^{-06}	3.04×10^{-06}	
	Formaldehyde, zone 1 (0.005 mg/l)	9.76×10^{-78}	1.21×10^{-77}	1.44×10^{-77}	
Illustration of the influence of varying the '*plume thickness at source (Sy)*' on the calculated groundwater concentrations					
	Determinant (Tier 1 assessment threshold value)	Plume thickness at source, Sy (m)			
		1.0$	+25% change	+50% change	Remarks
Predicted concentration (mg/l) in groundwater at a compliance point 250m away	Ammonia, zone 1 (0.5 mg/l)	0.148	0.185	0.222	Predicted concentrations are below the corresponding Tier 1 threshold values, based on up to +50% change in parameter value
	Mercury, zone 1 (0.001 mg/l) – DWS threshold	2.06×10^{-06}	2.58×10^{-06}	3.09×10^{-06}	
	Formaldehyde, zone 1 (0.005 mg/l)	9.76×10^{-78}	1.22×10^{-77}	1.46×10^{-77}	
Note: $ Selected value used in the initial model calculations (as presented in Appendix E)					

6.2.6 The sensitivity analysis output indicates that the predicted concentrations in groundwater at a compliance point located 250m away are not significantly affected by changes in the input parameter values (*Sz* and *Sy*).

6.2.7 As presented in Tables 6.3 and 6.4, the estimated concentrations of ammonia, mercury and formaldehyde in porewater do not give rise to significant concentrations at a compliance point located 250m away (along the groundwater flow path).

7 UPDATED CONCEPTUAL SITE MODEL

7.1 Potential Risk from Contaminant Concentrations from Ground Investigation

7.1.1 Although elevated concentrations of selected metals (As, Cd, Cr, Pb, Se, Ni), ammonia and TPH were recorded in groundwater samples obtained from beneath the site, this DQRA has demonstrated that these concentrations do not present a significant risk to the water environment, based on a hypothetical compliance point located 250m downgradient of the site (as agreed with SEPA).

7.1.2 An updated Conceptual Site Model for the site is presented as Drawing 6.

7.2 Potential Risk from Estimated Contamination Loading from Burials

7.2.1 Potential contamination loading from burials (site zones 1 and 2) was estimated for ammonia, mercury and formaldehyde. The mass loading for these contaminants were used to estimate the corresponding porewater concentrations, from theoretical calculations based on soil/water partitioning coefficients.

7.2.2 The estimated porewater concentrations were used in the DQRA models. The outcome of the DQRA has indicated that the estimated concentrations of ammonia, mercury and formaldehyde in porewater do not give rise to significant corresponding concentrations at a hypothetical compliance point located 250m away (along the groundwater flow path).

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 General

8.1.1 This DQRA of the water environment was carried out using '***Remedial Targets Worksheet v3.2***', which is based on a staged approach (referred to as ***Levels***) to determine risk based remedial targets for soil and groundwater. With each Level of assessment, additional attenuation processes are considered (such as dilution and dispersion) which affect the predicted contaminant concentrations along a pathway to a receptor (compliance point).

8.1.2 The contaminants that were identified at the site comprised selected metals (As, Cd, Cr, Pb, Se, Ni), localised TPHs and ammonia. The metals and ammonia were selected as contaminants of concern because their concentrations exceeded the corresponding RPV (i.e., Drinking Water Standards). Although no specific RPV is available for TPHs (based on WAT-PS-10-01), the locally detected TPHs were included in the DQRA in order to determine whether the recorded TPH concentrations would exceed the remedial targets calculated based on potentially applicable RPV presented in CL:AIRE (2017), i.e., WHO guide values.

8.1.3 Potential pollutant pathways which may provide preferential pathways for contaminant/leachate transport were considered to include the underlying Made Ground, superficial deposits (Glacial Till) and weathered bedrock.

8.1.4 For purposes of this risk assessment, a hypothetical groundwater receptor (compliance point) located 250m downgradient (along the groundwater flow path) of the site was considered, as agreed with SEPA.

8.2 Water Environment Risk Assessment

Contaminants identified from RPS' Ground Investigation

8.2.1 The predicted concentrations in groundwater at a hypothetical compliance point (250m away, downgradient of the groundwater flow) are extremely low compared to the corresponding Tier 1 assessment threshold values (RPV). Therefore, the recorded concentrations of contaminants of concern are not considered to pose a significant risk to a hypothetical compliance point located 250m from the site.

8.2.2 A sensitivity analysis has been undertaken by varying the conceptualised model input parameter values used in the risk assessment models ('width of plume in aquifer at source (perpendicular to flow)', 'plume thickness at source', 'saturated aquifer thickness' and 'hydraulic conductivity of aquifer'). The sensitivity analysis output indicates that the derived remedial targets are not significantly affected by changes in values of the conceptualised input parameters. Therefore, the values of the conceptualised input parameters used in the models are considered reasonably representative of the site conditions.

Potential Contaminants of Concern from Burials

8.2.3 The site was divided into six separate zones to enable calculation of overall cumulative contamination loading from burial lairs. Burials are proposed in site zones 1 to 5. At the time of writing this report, the total numbers of lairs in site zones 3 to 5 had not been confirmed by NLC. Therefore, contamination loading could only be estimated for site zones 1 and 2.

8.2.4 Potential contamination loading from burials (site zones 1 and 2) was estimated for ammonia, mercury and formaldehyde. The mass loading for these contaminants were used to estimate the corresponding porewater concentrations, from theoretical calculations based on soil/water partitioning coefficients.

8.2.5 The estimated porewater concentrations were used in the DQRA models. The outcome of the DQRA has indicated that the estimated concentrations of ammonia, mercury and formaldehyde in porewater do not give rise to significant concentrations at a hypothetical compliance point located 250m away (along the groundwater flow path).

8.3 Microbial Pathogens

8.3.1 Given that microbial pathogens do not have physico-chemical parameters that are required for contaminant fate and transport modelling, pathogen loading from burials could not be assessed in this DQRA. Therefore, if deemed necessary, consideration should be given to additional periodic groundwater quality monitoring for pathogens once burials have started at the site. This should be discussed and agreed with the SEPA.

8.3.2 The pathogen data presented in this report should be used as a baseline for comparison with any future microbial pathogen concentrations obtained from the site.

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DRAWINGS

Drawing 1 Site Location Plan

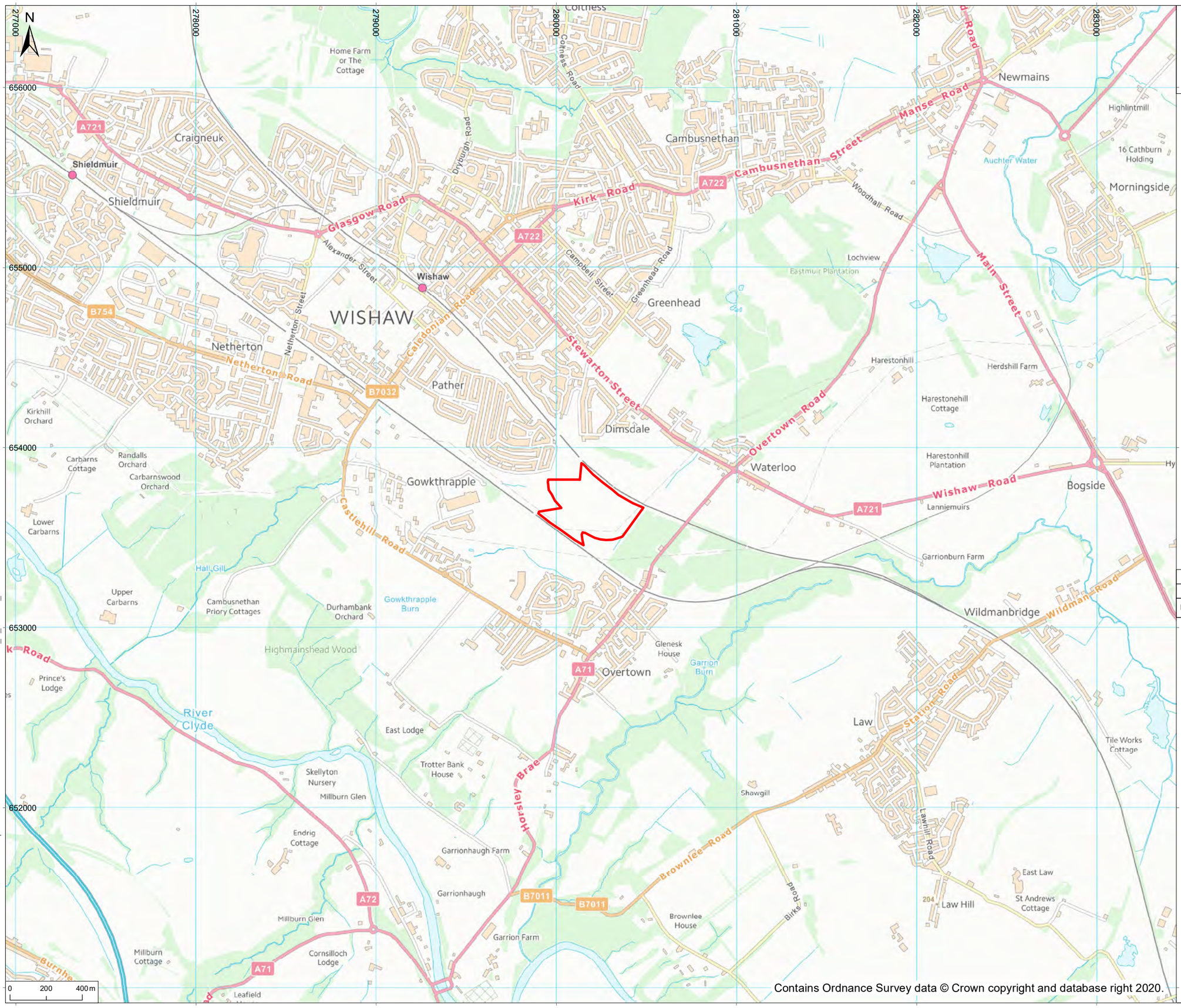
Drawing 2 Proposed Site Masterplan (NLC Drawing No. LS-19-025-002)

Drawing 3 Exploratory Hole Location Plan

Drawing 4 Site Zoning Plan

Drawing 5 Groundwater Level Contours

Drawing 6 Updated Conceptual Site Model



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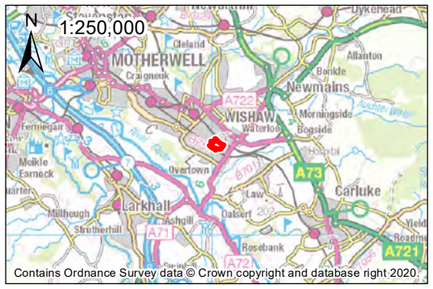
Legend

Site boundary



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Client: North Lanarkshire Council

Project: Pather Farm Cemetery

Title: Site Location Plan

Status	Drawn By	PM/Checked By
FINAL	KAG	JG
Project Number	**Scale @ A3**	**Date Created**
JFR9276	1:20,000	DEC 2020

Drawing Number	Rev
1	-

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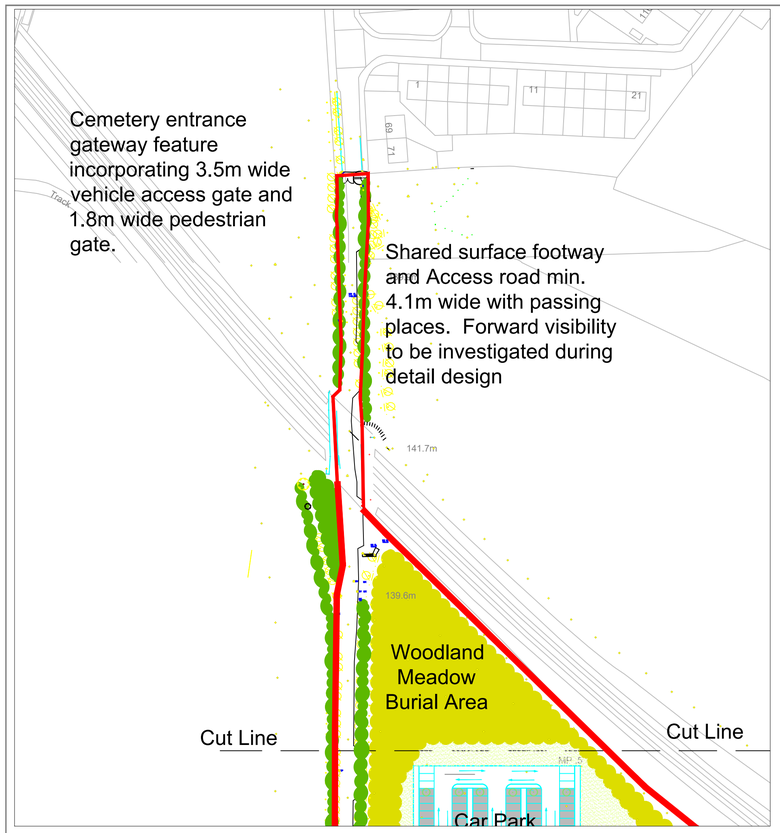

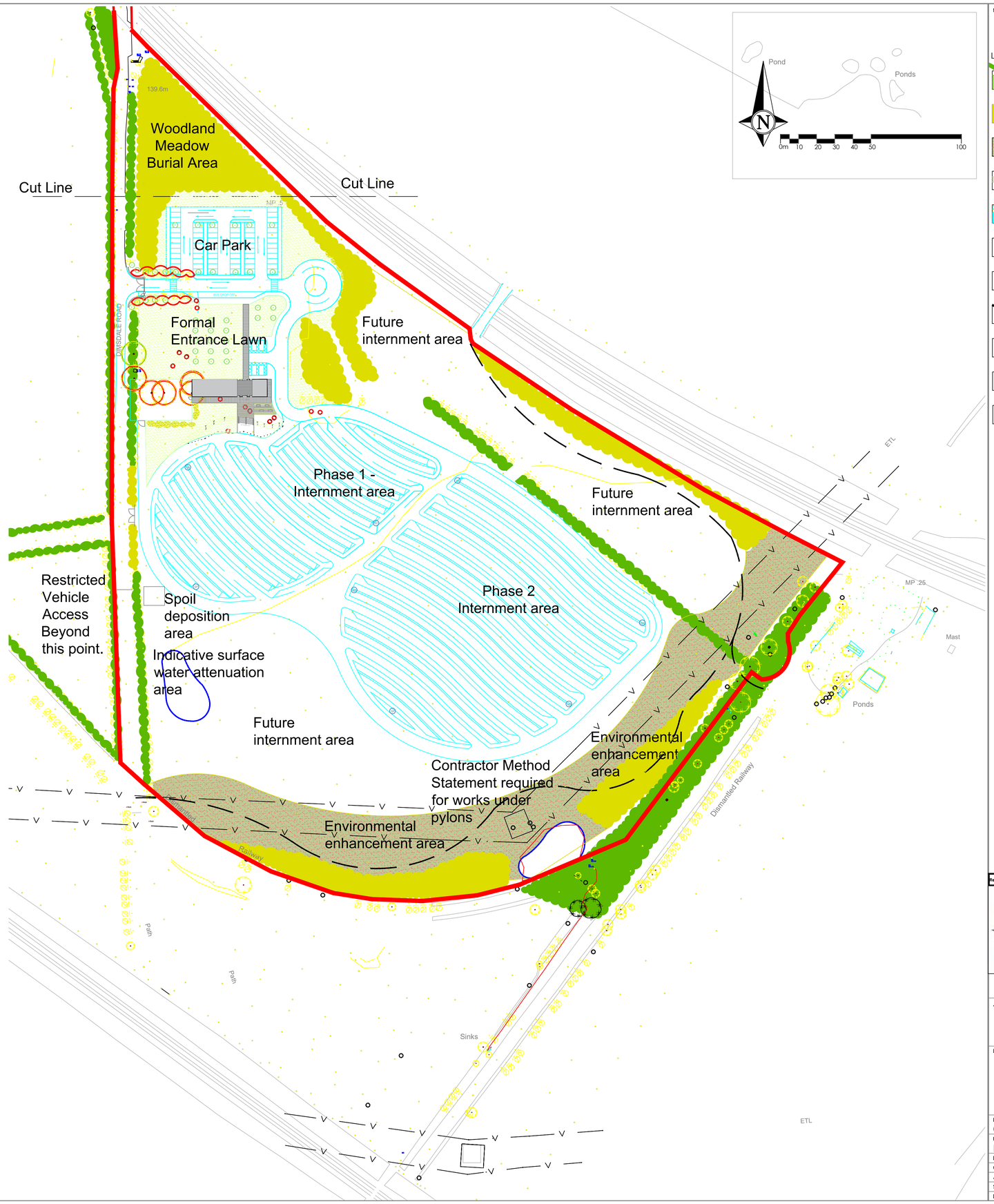

Notes :-

LEGEND

- Existing retained vegetation
- Mix A -Proposed woodland / planting
- Mix B- Proposed environmental enhancement area
- Mix C Perennial Planting
- Proposed phase 1 lair internment area
- SP Proposed location for stand pipe
- Concept drainage layout
- Informal pedestrian access
- Suggested Trees for Removal
- New Specimen Tree Planting
- SP New Water Stand Pipe Loca

Revision	Date	By	Details

North Lanarkshire Council

Tel: 01236 632811
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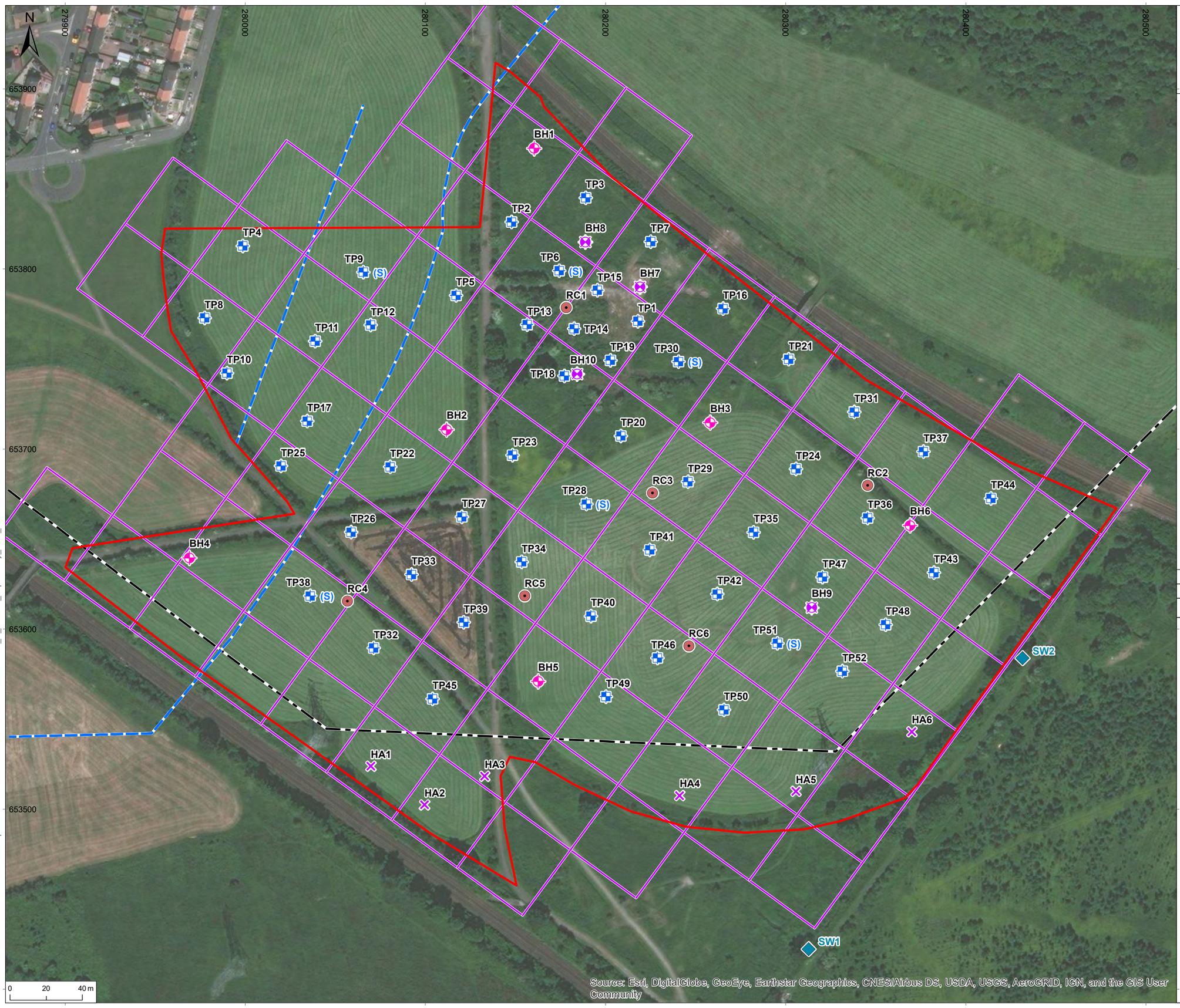
Job Title
PATHER CEMETERY PLANNING

Drawing Title
SITE MASTERPLAN

Drawing No 002	Revision
File No LS-19-025	
Drawn by AB	Date : JAN 2020
Checked by RT	Date : JAN 2020
Approved by AMcN	Date :
Scale/s 1:1000 @A1	Original Drawing Size: 841P(A4)(A1)
Drawing Status: Draft X Tender	Contract As built



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Legend

- Site boundary
- Sampling grid (45 m)

Site investigation locations

- Cable percussive borehole - 2020 (4 No.)
- Cable percussive borehole (6 No.)
- Rotary borehole (6 No.)
- Trial pit (52 No.)
- (S) Soakaway test (6 No.)
- Hand Auger (6 No.)
- Surface water samples (2 No.)

Utility

- 400 kV OHL
- Water pipeline

Rev	Description	By	CB	Date

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Client: North Lanarkshire Council

Project: Pather Farm Cemetery

Title: Exploratory Hole Location Plan

Status	Drawn By	PM/Checked By
FINAL	KAG	ED
Project Number	**Scale @ A3**	**Date Created**
JFR9276	1:2,000	DEC 2020

Drawing Number	Rev
3	-

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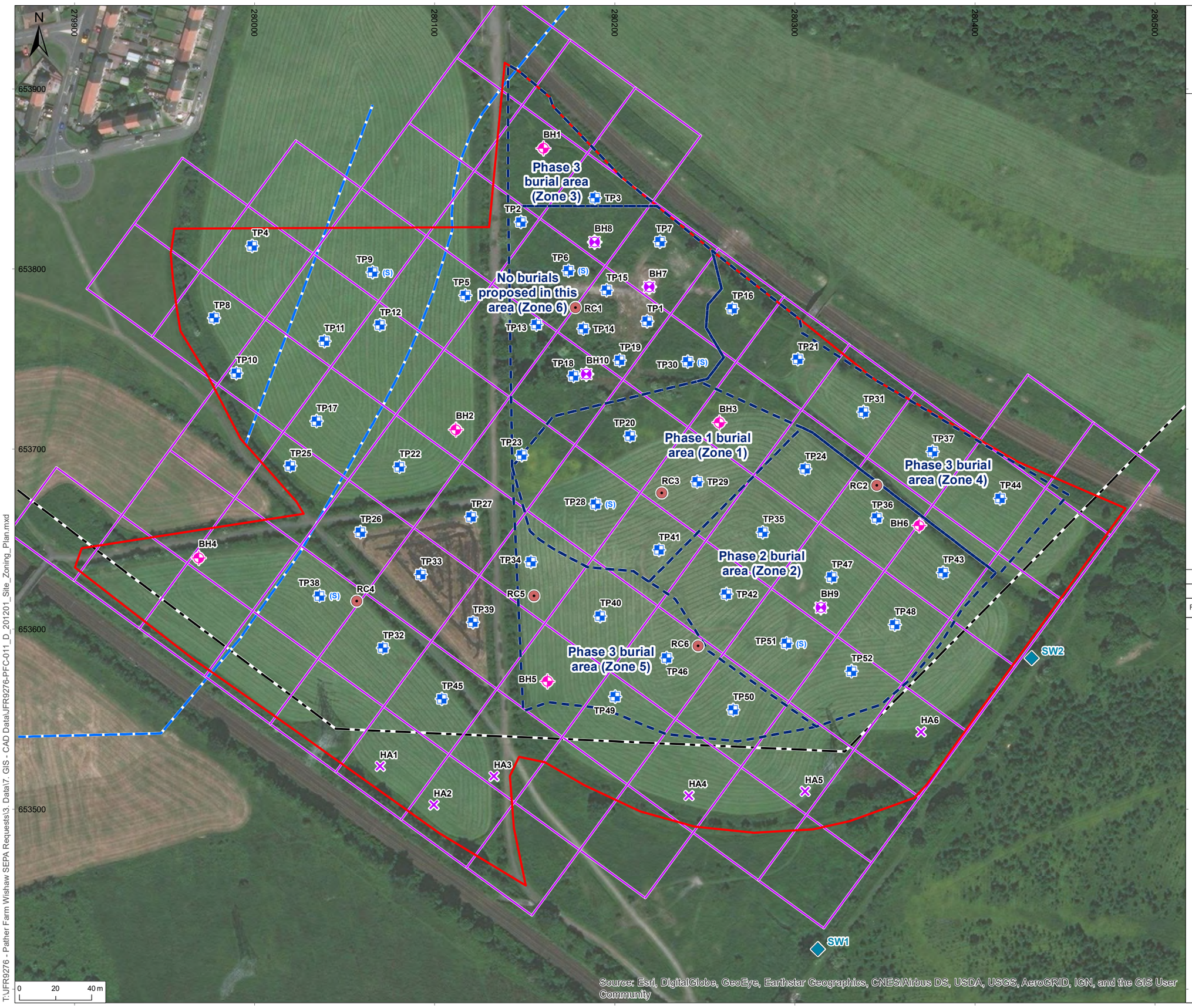

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Legend

- Site boundary
- Zones 1-6
- Sampling grid (45 m)

Site investigation locations

- Cable percussive borehole - 2020 (4 No.)
- Cable percussive borehole (6 No.)
- Rotary borehole (6 No.)
- Trial pit (52 No.)
- (S) Soakaway test (6 No.)
- Hand Auger (6 No.)
- Surface water samples (2 No.)

Utility

- 400 kV OHL
- Water pipeline

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Project: Pather Farm Cemetery

Title: Site Zoning Plan

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Drawing Number	Rev
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Legend

- Site boundary
- Sampling grid (45 m)

Average shallow groundwater levels (mAOD)

- Cable percussive borehole
- Rotary borehole
- Interpolated groundwater contours (mAOD) at 1m intervals (indicative only)

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Client: North Lanarkshire Council

Project: Pather Farm Cemetery

Title: Average Groundwater Level (Rounds 1 to 3: Summer 2019)

Status	Drawn By	PM/Checked By
FINAL	KAG	ED
Project Number	**Scale @ A3**	**Date Created**
JFR9276	1:2,000	DEC 2020

Drawing Number	Rev
5a	**-**

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