6.0 WATER

6.1 Introduction

This chapter of the remedial EIAR (rEIAR) provides an assessment of the hydrological (surface water) and hydrogeological (groundwater) aspects of the Windmill Hill Quarry (the ‘Site’) in support of an application for Substitute Consent for the existing quarry.

6.1.1 Technical Scope

The technical scope of this assessment is to consider the potential impacts and effects that changes in activities at the Site (as detailed in Chapter 2.0, Project Description) may have had on the water environment throughout the review period (see Section 6.1.2). The assessment considers the potential sources of change resulting from varying activities at the Site on hydrological and hydrogeological receptors. It considers water levels, flow regimes, water resources and uses, water quality, flood risk and water management.

The potential effects of secondary changes in the water environment on land, people, ecology (including water dependent habitats or ecological receptors) and infrastructure are considered further in the following chapters of the rEIAR:

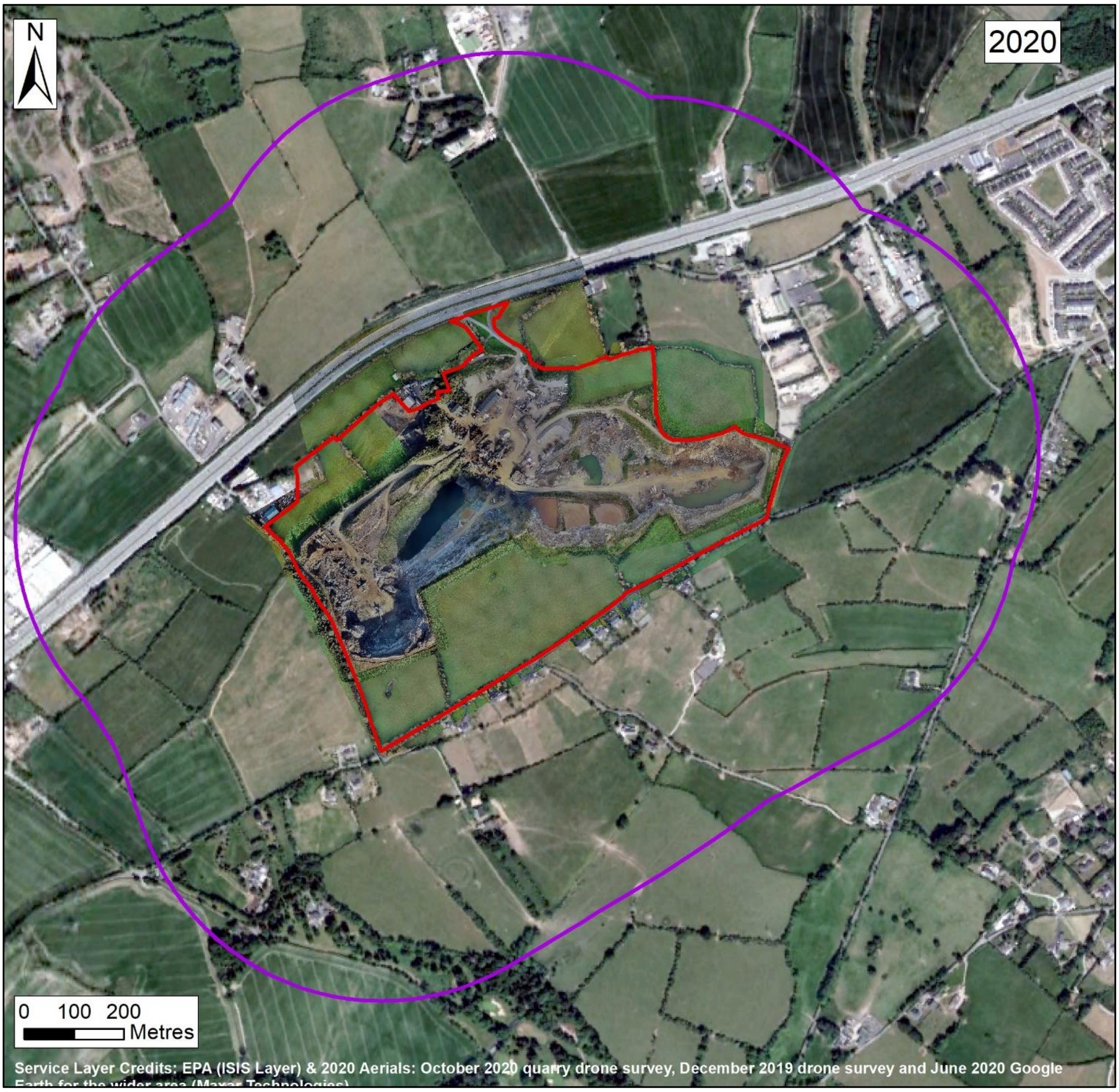
- Chapter 3.0 – Populations and Human Health;
- Chapter 4.0 – Ecology and Biodiversity;
- Chapter 12.0 – Material Assets; and
- Chapter 13.0 – Interactions.

This chapter also addresses the potential secondary effects of changes in land quality on water quality. As such, it draws on the assessment presented in the Land, Soils and Geology section of this report (Chapter 5.0).

6.1.2 Geographical and Temporal Scope

The temporal scope of the assessment covers the period of February 1990 (‘baseline conditions’) to the present day (‘current conditions’). This timeframe of 1990 to 2021 is subsequently referred to as the ‘review period’. The assessment establishes what the baseline water environment conditions were for the Site and then assesses what impacts may have occurred due to subsequent activities at the Site during the review period.

The geographical study area for the assessment covers the area within the Site boundary and a buffer zone that nominally extends to 0.5 kilometres (km) from the boundary (Figure 6.1). However, where deemed appropriate, the buffer zone is increased to allow for identification of downstream or downgradient hydraulic connectivity with off-site water features or users that may have been affected by changes associated with the Site activities.



Service Layer Credits: EPA (ISIS Layer) & 2020 Aerials: October 2020 quarry drone survey, December 2019 drone survey and June 2020 Google Earth for the wider area (Maxar Technologies)

Figure 6.1: Site Boundary (red) and 500 m Buffer Zone (purple).

6.2 Legislative and Policy Context

This section addresses the legislation and guidance that has been considered when preparing this chapter, and key policy context relevant to the water environment that has guided the focus of the assessment. The overarching EIA legislation under which this assessment is required is addressed separately in Chapter 1.0.

6.2.1 Legislation and Guidance

In addition to the Regulations that underpin the Environmental Impact Assessment (EIA) process (see Chapter 1.0, Introduction), this assessment has been made with cognisance to relevant guidance, advice and legislation relating to the water environment, which have been used to steer the focus of the baseline information collection, the categorisation of receptor sensitivities, and the mitigation measures that have been included.

- The Local Government (Water Pollution) Act 1977 (as amended) and associated Statutory Instrument Regulations made under that Act outline the general prohibition of entry of polluting matter to water, the requirement to licence both trade and sewage effluent discharges, licencing of water abstractions, controlling discharges to aquifers, and notification of accidental damages.

- The European Union (EU) Water Framework Directive (WFD) (2000/60/EC) is the European legislation that establishes a framework for the protection of groundwater and surface water, including the establishment of river basin districts, the requirement to prevent further deterioration by preventing or limiting inputs of pollutants into groundwater, reducing pollution and promoting sustainable water use. The Groundwater Daughter Directive (GWDD) (2006/118/EC) sits beneath the WFD and relates to water protection and management. It establishes measures to prevent and control groundwater pollution, including criteria for assessing good chemical status and identifying trends.

- The WFD and GWDD have been transposed into Irish law by means of many Regulations. These Regulations cover governance, the shape of the WFD characterisation, monitoring and status assessment programmes in terms of assigning responsibilities for the monitoring of different water categories, determining the quality elements and undertaking the characterisation and classification assessments. They include, but are not limited to, the following:

  - European Communities (Water Policy) Regulations 2003 and its subsequent amendments;
  - European Communities Environmental Objectives (Surface Waters) Regulations, 2009 and its subsequent amendments;
  - European Communities Environmental Objectives (Groundwater) Regulations, 2010 and its subsequent amendments; and
  - European Communities (Technical Specifications for the Chemical Analysis and Monitoring of Water Status) Regulations 2011.

  Many of these regulations contain threshold values or environmental quality standards which, when exceeded, can reflect a degradation in water quality. A degradation in water quality can be reflective of negative effects caused by the development, but it should be noted that a poor water quality can be naturally occurring due to the environmental setting.

- The EU Directive on the Assessment and Management of Flood Risks (2007/60/EC) is transposed into Irish law by the European Communities (Assessment and Management of Flood Risks) Regulations 2010 and its subsequent amendment. The aim of the legislation is to reduce the adverse consequences of flooding on human health and the environment, and it outlines the requirements for flood risk assessments to be completed as part of the planning process.

Guidance relating to the EIA process that has been used to guide the assessment of potential impacts to the water environment and the identification of relevant mitigation includes:

- Environmental Protection Agency Ireland (EPA) Advice Notes for Preparing Environmental Impact Statements (Draft, September 2015).
- EPA Guidelines on the Information to be Contained in Environmental Impact Assessment Reports, Environmental Protection Agency (Draft, August 2017).
- Department of Housing, Planning and Local Government Guidelines for Planning Authorities and An Bord Pleanala on carrying out Environmental Impact Assessment (August 2018).

- Land contamination risk management[1] (LCRM) (October 2020), formerly Contaminated Land Report (CLR) 11 Model Procedures for the Management of Contaminated Land (2004), which presents guidance on the management of land contamination and the risk assessment needed to estimate its severity. The guidance details the concept of source-pathway-receptor linkages and the use of generic assessment criteria that are used in this assessment.
- National Roads Authority (NRA) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2009) in relation to aspects to be considered and assessment approach (including relative receptor importance and cross discipline interactions).
- NRA Guidelines for the Creation, Implementation and Maintenance of an Environmental Operating Plan (2007) in relation to impact mitigation.
- Institute of Geologists of Ireland (IGI) Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (2013)
- CIRIA C532: Control of water pollution from construction sites. Guidance for consultants and contractors (2001).
- CIRIA C741: Environmental Good Practice on Site (2015, Fourth Edition) in relation to source of impact and mitigation.
- CIRIA C750: Groundwater control – design and practice (2016, Second Edition).
- Scottish and Northern Irish Pollution Prevention Guidelines (PPGs) and Guidance for Pollution Prevention (GPPs) – these, although not Irish guidance, provide environmental good practice guidance for activities such as oil and chemical storage, works in or near water, works on construction sites, and dealing with spills and pollution incidents.

6.2.2 National and Local Policy

The National Planning Framework (Project Ireland 2040) includes National Policy Objective 60 to “Conserve and enhance the rich qualities of natural and cultural heritage of Ireland in a manner appropriate to their significance”.

At a national level, the River Basin Management Plan (RBMP) for Ireland 2018-2021 (Department of Housing, Planning and Local Government, 2018) outlines the measures that will be taken to improve the water quality in Ireland’s groundwater and surface water. This plan focuses on the following priorities:

- Ensuring compliance with relevant EU legislation;
- Preventing deterioration;
- Meeting the objectives for designated protected areas;
- Protecting high-status waters; and,
- Implementing targeted actions and pilot schemes in focused sub-catchments aimed at targeting water bodies close to meeting their objectives and addressing more complex issues that will build knowledge for the next cycle in the RBMP.

There is currently no local plan for Rathcoole, however the South Dublin County Council Development Plan 2016-2022 incorporated the relevant policies and objectives for the area. The area is included in Zoning

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[1] https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm, accessed January 2021.

Objective 'Ru' of the South Dublin County Council Development Plan 2016-2022 which has the description *'to protect and improve rural amenity and to provide for the development of agriculture'.* Specific policies relating to the protection of the water environment and management of surface water and groundwater include the following:

- IE2 Objective 1: To maintain, improve and enhance the environmental and ecological quality of our surface waters and groundwater by implementing the programme of measures set out in the Eastern River Basin District River Basin Management Plan.
- IE2 Objective 2: To protect the regionally and locally important aquifers within the County from risk of pollution and ensure the satisfactory implementation of the South Dublin Groundwater Protection Scheme 2011, and groundwater source protection zones, where data has been made available by the Geological Survey of Ireland.
- IE2 Objective 10: To require adequate and appropriate investigations to be carried out into the nature and extent of any soil and groundwater contamination and the risks associated with site development work, in particular for brownfield development.

6.3 Assessment Methodology and Significance Criteria

This section presents the method used to assess the impacts and effects of activities at the Site during the review period on the water environment, and to identify potential secondary effects from changes to the water environment. It establishes the stages of the assessment, and the qualitative criteria used to assess impact magnitude and determine the level of effect significance.

6.3.1 Sources of Information

The assessment has been carried out using the following sources of information:

- Site walkovers of the Site and inspection of the surrounding area in 2020 and 2021;
- Field monitoring and sampling campaigns carried out in 2020 and 2021;
- Field survey of the off-site drainage system in 2021;
- Correspondence with the Applicant/Site Owner and Site staff;
- Desktop reviews of previous impact assessments by Byrne Environmental (2013a; 2015) and Viridus Consulting (2020);
- Desktop reviews of literature and publicly available information (including interactive mapping services);
- Review of historic surface water monitoring information provided by the EPA;
- Review of historic planning applications for the Site and surrounding area; and
- Review of available aerials imagery (1991, 1994, 1995, 2000, 2004, 2012, 2016 and 2020).

A full list of references are provided in Section 6.15.

6.3.2 Qualitative Assessment Method

The assessment of potential effects has been undertaken using the qualitative assessment method outlined below. The assessment is supported by the available baseline condition information, historical records of Site activities, previous hydrological and hydrogeological studies, historical monitoring data and recent monitoring and survey data collected to supplement the historical dataset. The assessment follows a staged approach. A summary of the stages involved is included below:

1) Confirm 1990 baseline and subsequent conditions – determine the 1990 baseline conditions and identify any changes throughout the review period. Develop conceptual site model by consideration of available records and data sets, site reports and published information.
2) Confirm the key receptors and their value/importance.
3) Qualitatively characterise the magnitude of impacts on the receptors – describe what potential changes may have occurred to each receptor as a result of the Site activities during the review period, identify source-pathway receptor linkages, and assign the magnitudes of impact. This stage takes into account embedded design mitigation, good practice in construction environment management and pollution prevention.
4) Determine the initial effect significance of each potential impact on each sensitive receptor.
5) Consider the need for remedial measures if it is considered necessary to reduce the initial magnitude of the impact and associated effect significance further.
6) Assess the residual impact magnitude and residual effect significance after all remedial measures are applied.
7) Identify any monitoring that may be required to measure the success of the remedial measures.

Stages 1 and 2 have been completed using available information specific to the Site, published literature and guidance, historical records, datasets and studies and additional monitoring data collected specifically to support this rEIAR chapter. For the identification of receptor value/importance that completes Stage 2, and for the description of impact magnitude (Stage 3), a common framework of assessment criteria and terminology has been used based on the EPA's draft 2017 Guidelines on the Information to be Contained in EIARs and adapted based on the additional guidance outlined in Section 6.2.1, such as those by the NRA and IGI. The descriptions for value (sensitivity) of receptors are provided in Table 6.1 and the descriptions for magnitude of impact are provided in Table 6.2.

The potential for an impact to have occurred at a receptor has been determined using the understanding of the baseline environment and its properties and consideration of whether there is a feasible linkage between a source of impact and each receptor (i.e. a conceptual site model). This follows the method of preliminary risk assessment that is widely presented in some of the guidance documents listed in Section 6.2.1, such as the LCRM guidance.

Table 6.1: Environmental Value (Sensitivity) and Descriptions.

Value (sensitivity) of receptor / resource	Typical description
High	High importance and rarity, national scale, and limited potential for substitution. For example: Global/European/National designation - or supports an internationally important feature. WFD river designation of 'High' and in hydraulic connectivity with the Site. Human health receptors. Regionally important aquifer with multiple wellfields. Inner source protection area for a regional resource. Regionally important potable water source supplying >2500 homes (surface water or aquifer).

Value (sensitivity) of receptor / resource	Typical description
	Floodplain protecting more than 50 residential or commercial properties or nationally important infrastructure (e.g. motorways/national roads) from flooding.
Medium	Medium or high importance and rarity, regional scale, limited potential for substitution. For example: Regionally important sites. Regionally important aquifer. WFD river designation of ‘Good’ or ‘Moderate’” and in hydraulic connectivity with the Site. Outer source protection area for a regional resource. Locally important potable water source supplying >1000 homes (surface water or aquifer). Floodplain protecting between 6 and 50 residential or commercial properties or regionally important infrastructure (e.g. regional roads) from flooding.
Low	Low or medium importance and rarity, local scale. For example: Locally important aquifer. WFD river designation of ‘Poor’ or ‘Bad’ and in hydraulic connectivity with the Site. Outer source protection area for a local resource. Local potable water source supplying >50 homes (surface water or aquifer). Floodplain protecting between 2 and 5 residential or commercial properties or locally important infrastructure (e.g. local roads) from flooding.
Negligible	Very low importance and rarity, local scale. Environmental equilibrium is stable and is resilient to impacts that are greater than natural fluctuations, without detriment to its present character. Poorly productive aquifer. Any WFD river quality designation not in hydraulic connectivity with the Site. Local potable water source supplying <50 homes (surface water or aquifer). Floodplain protecting up to 1 residential or commercial properties from flooding.

Table 6.2: Magnitude of Impact and Typical Descriptions.

Magnitude of impact (change)		Typical description
High	Adverse	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements. Significant harm to human health - death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Significant harm to buildings/infrastructure/plant - Structural failure, substantial damage or substantial interference with any right of occupation. Significant pollution of the water environment, which is defined by: ■ A breach of, or failure to meet, any statutory quality standard for the water environment at an appropriate pollution assessment point.

Magnitude of impact (change)		Typical description
		■ A breach of, or a failure to meet, any operational standard adopted by EPA for the protection of the water environment. ■ Pollution results in an increase in treatment required for an existing drinking water supply. ■ Pollution results in an increased level of treatment required of water abstracted for industrial purposes. ■ Pollution results in deterioration in the status of a water body, failure to meet good status objectives defined by the Water Framework Directive, or failure of a protected drinking water area to meet its objectives as defined by the Water Framework Directive. ■ There is a significant and sustained upwards trend in concentration of pollutants in groundwater being affected by the land in question. There is a material and adverse impact on the economic, social and/or amenity use associated with a particular water environment.
	Beneficial	Large scale or major improvement of resource quality; extensive restoration; major improvement of attribute quality.
Medium	Adverse	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements.
	Beneficial	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Low	Adverse	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.
	Beneficial	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	Adverse	Very minor loss or alteration to one or more characteristics, features or elements.
	Beneficial	Very minor benefit to or positive addition of one or more characteristics, features or elements.

The assessment of magnitude of impact considers whether the change that causes the impact is positive or negative, and whether the impact is direct or indirect, short- medium- or long-term, temporary or permanent, and if it is reversible.

For the purposes of this assessment, a direct impact is one that occurs as a direct result of the Development and is likely to occur at or near the Development itself. Indirect impacts (or secondary/tertiary impacts) are those where a direct impact on one receptor has another knock-on impact on one or more other related receptor(s) (e.g. the Development results in a change in groundwater quality, which then has an indirect impact on surface water quality and/or users of the water, such as human health or ecology). Indirect impacts can occur within the study areas or away from the Development.

For the purposes of this assessment, the following definitions of duration have been used:

- Temporary – effect likely to last less than 1 year without intervention;
- Short term – effect likely to last 1 to 7 years without intervention;
- Medium term – effect likely to last 7 to 15 years without intervention;
- Long term – effect likely to last 15 to 60 years without intervention; and
- Permanent – effect likely to last over 60 years without intervention.

An irreversible impact is defined as a change to the baseline that would not reverse itself naturally. Such impacts are usually long-term or permanent and irreversible, such as changes to the groundwater flow regimes caused by changes to the properties of the subsurface.

A reversible impact is defined as a change to the baseline conditions that would reverse naturally once the source of the impact is exhausted, removed or has stopped. For example, impacts to groundwater quality from contamination may only last as long as the source of the impacts is present. If it is removed, groundwater quality may naturally improve or could be remediated.

6.3.3 Significance Criteria

The approach followed to derive effects significance from receptor value and magnitude of impacts (Stage 4) is shown in Table 6.3. Where Table 6.3 includes two significance categories, supporting evidence is provided in the topic chapters if a single significance category is reported. A description of the significance categories used is provided in Table 6.4.

Table 6.3: Significance Matrix.

	Magnitude of Impact (Degree of Change)				
		Negligible	Low	Medium	High
Environmental value (Sensitivity)	High	Slight	Slight or moderate	Moderate or large	Profound
	Medium	Imperceptible or slight	Slight or moderate	Moderate	Large or profound
	Low	Imperceptible	Slight	Slight	Slight or moderate
	Negligible	Imperceptible	Imperceptible or slight	Imperceptible or slight	Slight

Table 6.4: Significance Categories and Typical Descriptions.

Significance Category	Typical Description
Profound	An effect which obliterates sensitive characteristics.
Large	An effect which, by its character, magnitude, duration or intensity alters a significant proportion of a sensitive aspect of the environment.
Moderate	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.

Significance Category	Typical Description
Slight	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
Imperceptible	An effect capable of measurement but without significant consequences.

Following the assessment of the level of effect significance, remedial measures are presented that will be used to further avoid, prevent or reduce the magnitude of the potential impact (Stage 5). If necessary, the significance of the effect taking into account the remedial measures is then assessed (Stage 6) to give the residual effect significance. Any monitoring that will be required to measure the success of the remedial measures is also presented in Section 6.10 (Stage 7).

Residual effects of ‘large’ or ‘profound’ significance are considered to be ‘significant’ for the purposes of this assessment.

The effects of the Development are also considered cumulatively with those that could foreseeably have resulted from other known developments that have occurred in the assessment study area (see Section 6.11 and Chapter 13.0, Interactions).

6.4 Baseline and Subsequent Conditions (1990 to 2021)

This Section presents a summary of the baseline (1990) and subsequent conditions (up to April 2021) for the water environment (hydrology, hydrogeology and flooding). Detailed information about land use, soils and geology and ground conditions at the Site is included in Chapter 5.0, Land, Soils and Geology.

6.4.1 Site Setting

The Site is located on the hillside at Windmill Hill, Rathcoole, County Dublin. Windmill Hill, located immediately south of the Site, is located at a topographical highpoint of ca. 219 mAOD. Quarrying activities have been permitted at the Site since 1968. Aerial photographs which show the quarry and the surrounding land use during the review period are presented in Figures 5.2 to 5.8 of Chapter 5.0, Land, Soils and Geology. Access to the Site is via the N/M7 dual carriageway, which is located north of the Site and connected to the Site entrance. The N/M7 has been present throughout the review period.

The land surrounding the Site in 1990 was predominantly used for agricultural pasture and it is likely that the Site was also used for agricultural purposes prior to the commencement of any quarrying activities. Some commercial and single-house residential properties were also located in the immediately surrounding area (as outlined in Figures 3.3 to 3.9 of Chapter 3.0, Population and Human Health). Since 1990, there has been little change to the surrounding land use, with only a small number of new single-house residential and commercial properties through the review period (see Chapter 3.0).

Regionally, the nearest town is Rathcoole which is located approximately 800 m to the northeast of the Site. Beyond this there are several other small towns and suburbs of Dublin. Other notable land uses in the regional vicinity of the Site are Greenogue Business Park and Casement Aerodrome located further to the northeast of the Site (approximately 2.6 km and 3.5 km respectively).

6.4.2 Site Layout

A detailed description of the Site layout and infrastructure is presented in Chapter 2.0 (Project Description), with only key information relevant to the water environment detailed below.

In 1990, the worked area of the Site was ca. 10.1 hectares (ha) with minimal infrastructure consisting of storage areas and plant used for the extraction and crushing and screening of material.

In 2021 the Site is comprised of three main areas: a northern area with buildings, parking and storage areas (including a fuel storage and refuelling area); a central plant area with a concrete plant (not active), asphalt plant, water treatment plant and plant used for the screening, washing and bagging of excavated material; and a southern area where material is subject to extraction.

Since 1990, whilst the configuration and number of buildings or plant may have been subject to changes over time, the northern and central areas of the Site did not change substantially in spatial footprint. The southern extraction area has however increased in footprint and varied in depth over time. It can be seen from aerial imagery (Figures 3.3 to 3.9 of Chapter 3.0, Population and Human Health) that the excavated area first expanded only in a south-western direction until some point in time between 1995 and 2000 when quarrying activities were also expanded in a south-eastern direction. Machinery and blasting have been used at the Site throughout the review period for the excavation of rock.

The lowest quarry floor elevation was reported as ca. 120 mAOD in 2013 (J. Cross, 2013) in the western pit area. As a result of the dynamic Site layout in extraction areas, the presence, location, elevation and shape of ponded water in the excavation areas have also changed over time (see Section 6.4.7.2).

In 2021, the Site covers an area of ca. 46.14 ha, with ca. 28.8 ha classed as a working area. The northern and central plant area are ca. 5 ha in size. The extraction activities at the Site are in two distinct areas: the east quarry and west quarry with ponding of water observed at the base of each pit. There are silt settlement ponds located in the southern area between the western and eastern pits.

6.4.3 Site Topography

The Site is situated on the northern flank of Windmill Hill, which reaches a peak of ca. 219 mAOD close to the southern boundary of the Site and is elevated in comparison to land to the northwest of the Site. The peak of Windmill Hill forms a topographical divide, with the ground surface sloping radially away from this peak (e.g. south flank slopes towards the south).

In general, the topography at the Site boundary is higher in the south, peaking at around 210 mAOD along the southern boundary and sloping to the north to a minimum elevation of ca. 142 mAOD at the Site entrance. Drawings showing the topography within the Site in 1990 and 2021 are presented on Substitute Consent Planning Application Drawing No. 03a and 04a. These drawings show that the central and northern areas of the Site have remained at an elevation of ca. 158-160 mAOD throughout the review period, whilst the southern area has changed as further extraction of rock material has been carried out.

The areas subject to active quarrying since 1990 are presented in cross-sections comparing the 2021 topography to that of 1990 (Substitute Consent Planning Application Drawing No. 05). The topography of these areas of the Site has been reduced from ca. 200 mAOD in 1990 to a level of ca. 150 mAOD in the North-South transect showing the excavation in the west pit. The West-East transect shows a similar picture with decreasing topography levels to ca. 150 mAOD in the west pit, and ca. 160-170 mAOD in the east pit since 1990.

6.4.4 Site Water Requirements and Management

Details of Site water requirements and water management in 1990 are limited. For the purpose of this assessment, it is assumed based on aerial photography and known infrastructure that in 1990:

- Any welfare and process water requirements for Site activities were met either by abstraction wells located in the northern or central areas or by rainfall runoff collected at topographical low-points of the Site;
- Any abstraction boreholes used at the time have been subsequently lost and replaced by the current abstraction infrastructure;
- Wheel washes were installed and located near the current weighbridge; and

- Wastewater management requirements at the Site were subject to a holding tank configuration similar to what is currently installed at the Site.

The Applicant reports that bottled water has been used for on-site supply of drinking water throughout the review period.

Previous studies for the Site in 2013, 2015 and 2018 (Byrne Environmental, 2013a; Byrne Environmental, 2015; Viridus Consulting, 2020) report that groundwater was used to meet the water requirements of the Site. There were four groundwater wells within the quarry area reported in the previous studies (see Section 6.4.7.2). The previous studies in 2013 and 2015 (Byrne Environmental, 2013a; 2015) identified the following details regarding Site water management:

- Water was required for the aggregate washing plant, wheel wash facilities and office facilities;
- The wheel wash facility near the weighbridge was a static system which sprayed high pressured water as the vehicles passed through. The system used a water storage recycling tank allowing for minimum usage of water. It was estimated that ca. 2 m^3/day water was used in this system. This was topped up as necessary from the on-site water supply;
- Occasionally washed aggregate was required (generally in the summer months). A washing plant was used which had two internal water recycling tanks, allowing for the recirculation of water in the system (ca. 2 m^3/day used). This wash plant was fed by a groundwater source on the Site;
- Water at the office building was supplied by a groundwater supply well which was situated adjacent to the office building. A storage tank of 500 litres (L) was located on the roof space of the office building and pumped via an underground pipeline. Water usage was considered to be similar to domestic usage; and

A summary of the 2021 Site water requirements and management scheme, as derived from walkovers carried out in 2020 and 2021, is shown in Figure 6.2 and Figure 6.3. An on-site well supplies water to the office buildings for toilet flushing and handwashing, and is also used to supply the four wheel wash facilities located at the weighbridge area. The 2021 wheel wash facilities are in line with those described in 2013 and 2015.

An operational water supply is also required at the Site for use in the washing plant. The concrete plant is noted to not yet be in use and therefore no water has been required through the review period for concrete batching. Operational water is pumped from the pond in the western pit area for use in the central plant area. Overflow from the water tank is returned to the flooded pit area. Following periods of prolonged rainfall water is discharged from the pond to a culvert located adjacent to the Site entrance.

A drainage survey of the culvert used for periodic discharge was carried out in 2021 and identified a piped flow path north towards the N/M7 dual carriageway, where it joins the road’s drainage system. The discharge culvert is not connected to the Irish Water public supply mains which runs adjacent to the Site boundary near the entrance (see Section 6.4.10 for further information regarding the water mains).

Welfare wastewater is discharged to a holding tank in the northern area of the Site, and is periodically emptied by a contractor.

Operational water generated from the washing plant is pumped to a water treatment tank, where flocculant is added. The flocculant used is Pollygold A260 (supplied by Abbey Water Limited in Cork) with ca. 15 kilograms being used per day. The silt ladened water is then transferred to either the silt press or the contained silt ponds, these are shown on Figure 6.3. In the silt ponds, the silt settles from the water and the water is either allowed to evaporate or discharge to ground. It is expected that the settlement of silt in these ponds will limit the amount of water infiltration to ground.

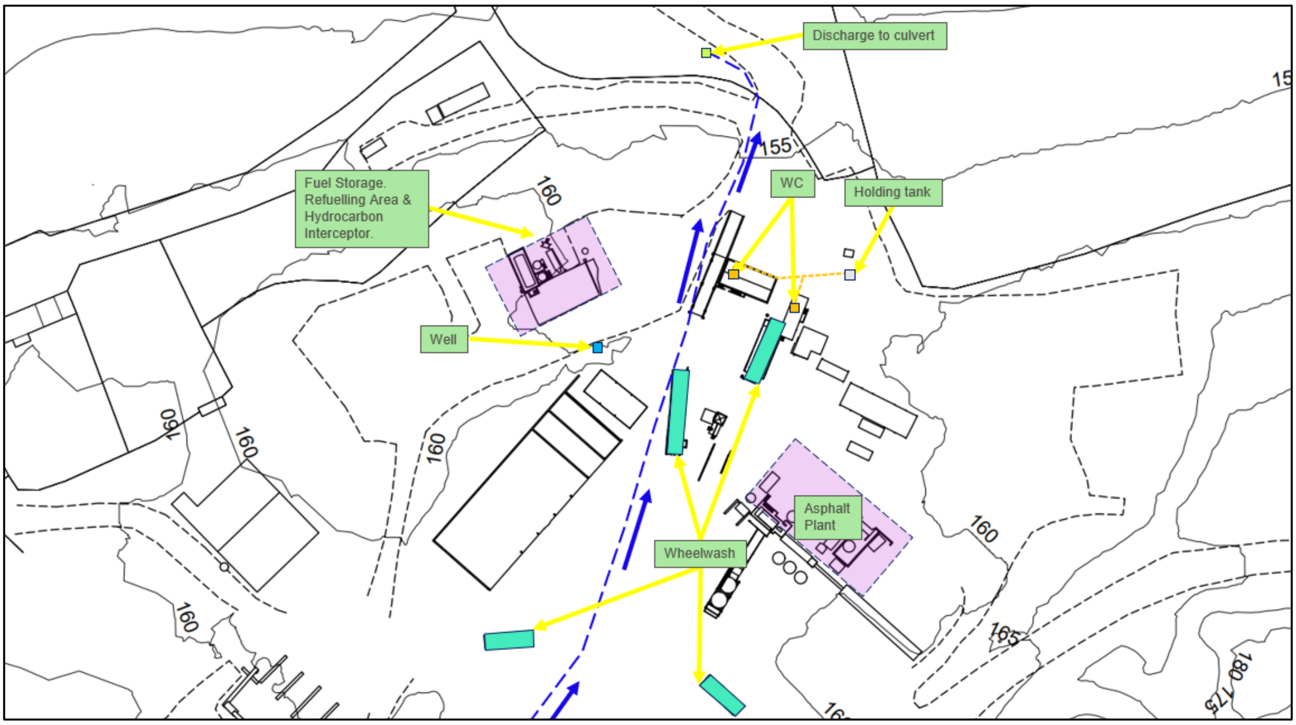


Figure 6.2: 2021 Site Layout, Key Infrastructure and Water Management in the Northern Area of the Site.

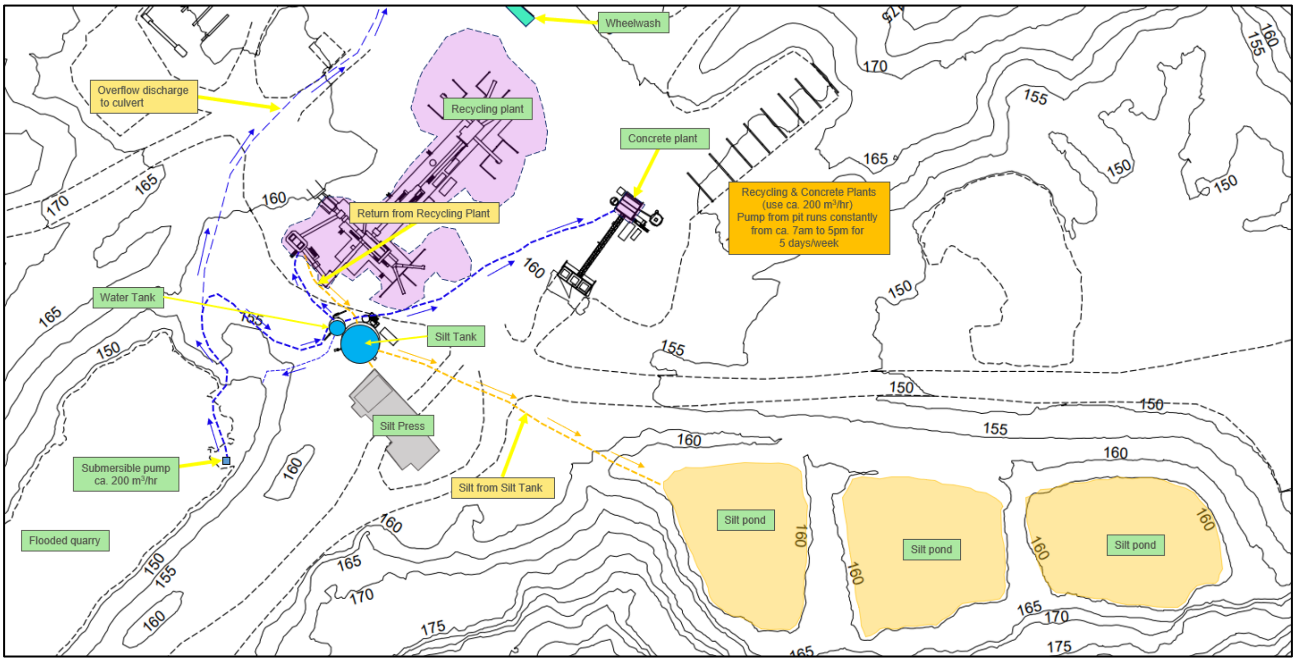


Figure 6.3: 2021 Site Layout, Key Infrastructure and Water Management in the Central and Southern Areas of the Site.

6.4.5 Geology

The geology of the Site is presented in detail in Chapter 5.0 of this EIAR (Land, Soils and Geology). Borehole logs are also provided in Chapter 5.0.

6.4.5.1 Superficial Deposits

The cover of superficial deposits on the Site has been progressively removed since 1990 due to quarrying activities and in 2021 these are observed to have been largely removed across the Site footprint but remaining present adjacent to the worked areas of the Site.

Superficial deposits on the Site are described as glacial tills derived from Silurian bedrock (EPA, 2021).

Subsoils are mapped by the EPA (2021) as being sandstone and shale tills which had a clayey texture and were derived from Lower Palaeozoic parent material around the northern perimeter of the Site and underlying the majority of the wider study area.

A thin organic topsoil, typically 100 mm to 200 mm in thickness was identified around the perimeter of the Site during the Site walkover (Viridus Consulting, 2020).

6.4.5.2 Bedrock

GSI mapping (GSI, 2021) indicates that the Site is underlain by the Carrighill Formation of Silurian calcareous greywacke, siltstone and shale. This is the youngest and most fine grained of the Kilcullen Group bedrock unit. There are no karst features in the immediate vicinity of the Site, with the nearest feature located approximately 10.8 km to the north of the Site.

The regional setting is one of large-scale northeast-southwest trending upward (anticline) and downward (syncline) fold features which are dissected by (predominantly) northwest-southeast trending faults. The Site is located on the northern limb of a syncline which dips around 50° to the south east. No faults are shown to cross the Site, with the closest fault located approximately 0.8 km from the Site (GSI, 2021).

Bedrock has progressively been extracted at the Site since 1990, to be processed and sold commercially.

6.4.5.3 Made Ground

There are small areas of made ground in the form of concrete pads and other concrete/tarmacadam hard standing areas around the quarry processing area, offices, and parking areas.

6.4.6 Surface Water- Hydrology

6.4.6.1 Rainfall and Climate Data

Table 6.5 presents rainfall data recorded at the Brittas (Glenaraneen) meteorological station (number 7923) which is located approximately 6 km to the south of the Site, for the period 1990-2020 (Met Eireann, 2021).

The rainfall recorded at the Brittas meteorological station consistently fluctuates through the review period, with a calculated average of 1,022.6 mm/a and a range of 783.8 (1991) to 1,317.5 (2009) mm/a. There is no increasing or decreasing trend in rainfall over the review period.

Evaporation or evapotranspiration data is not available at Brittas (Glenaraneen) meteorological station, with the closest available data at Dunsany, located ca. 20 km north of the Site.

GSI mapping (2021) indicates an effective rainfall (rainfall minus actual evapotranspiration) of approximately 416 mm/year across the Site footprint and the surrounding areas.

Table 6.5: Yearly Rainfall Data for Brittas (Glenaraneen) station no 7923 (Met Eireann, 2021).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Rainfall (mm/a)	1009.1	783.8	746.5	1208.6	1040.2	965.2	1028.8	790.8	1197.3	1084.6	1140.5

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Rainfall (mm/a)	817.0	1258.2	814.7	926.7	895.5	924.7	1071.7	1231.8	1317.5	943.7	990.7
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**		
Rainfall (mm/a)	1258.5	852.4	1300.1	1097.2	1011.9	987.1	998.7	1121.4	884.6		

Note: Yearly data is based on monthly rainfall data measured at Brittas meteorological Station. Full 12 months of data not available for years 1997, 2003, 2004, 2008, 2019 and 2020.

1 in 100 year storm event rainfall data was presented in previous reporting for the Site (Byrne Environmental, 2013b) and is summarised as follows:

- 15 minutes = 22 mm rainfall;
- 60 minutes = 34.5 mm rainfall; and
- 1440 minutes (1 day) = 87 mm rainfall.

6.4.6.2 Local Surface Water Flow Directions

On-Site Surface Water Flows

There are no surface water features (e.g. streams, rivers) located within, or immediately adjacent to the Site boundary. Based on the layout and topography of the Site in 1990 and 2021, any precipitation falling on the Site would either directly infiltrate the ground or flow towards the existing topographic low points: the two areas of excavation or the entrance to the Site.

The area in the northern portion of the Site where the office buildings and welfare facilities are located is relatively flat at ca. 158-160 mAOD. Around the perimeter of this area, which is still vegetated, the ground elevation can be slightly higher. From this point, the Site entrance to the N7 roadway decreases in elevation by around 15 m to reach a ground elevation of ca. 142 mAOD at the roadway intersection.

It is interpreted from the topographical survey that some informal bunding is used on the Site to control any surface water flows from higher elevation areas and prevent the movement of water off of the Site via the entrance way. Without the raised vegetated area between the access road and the storage and car park area any runoff from this area may flow directly downgradient onto the N7 roadway. Instead, any rainfall that does not infiltrate to ground is redirected into one of the topographical low-points of the Site.

Additionally, it was noted during a Site walkover carried out by Golder during heavy rainfall that there were no surface flows along the length of the entrance road. The entrance road was observed to camber, directing any rainfall which does not infiltrate at surface to infiltration gullies located at either side of the roadway.

Local Surface Water Features

Local surface water features are predominantly fed by rainfall runoff from higher topographical areas which collect in natural gullies and form headwaters for tributaries to larger streams and rivers. The river network in the area surrounding the Site is shown in Figure 6.4.

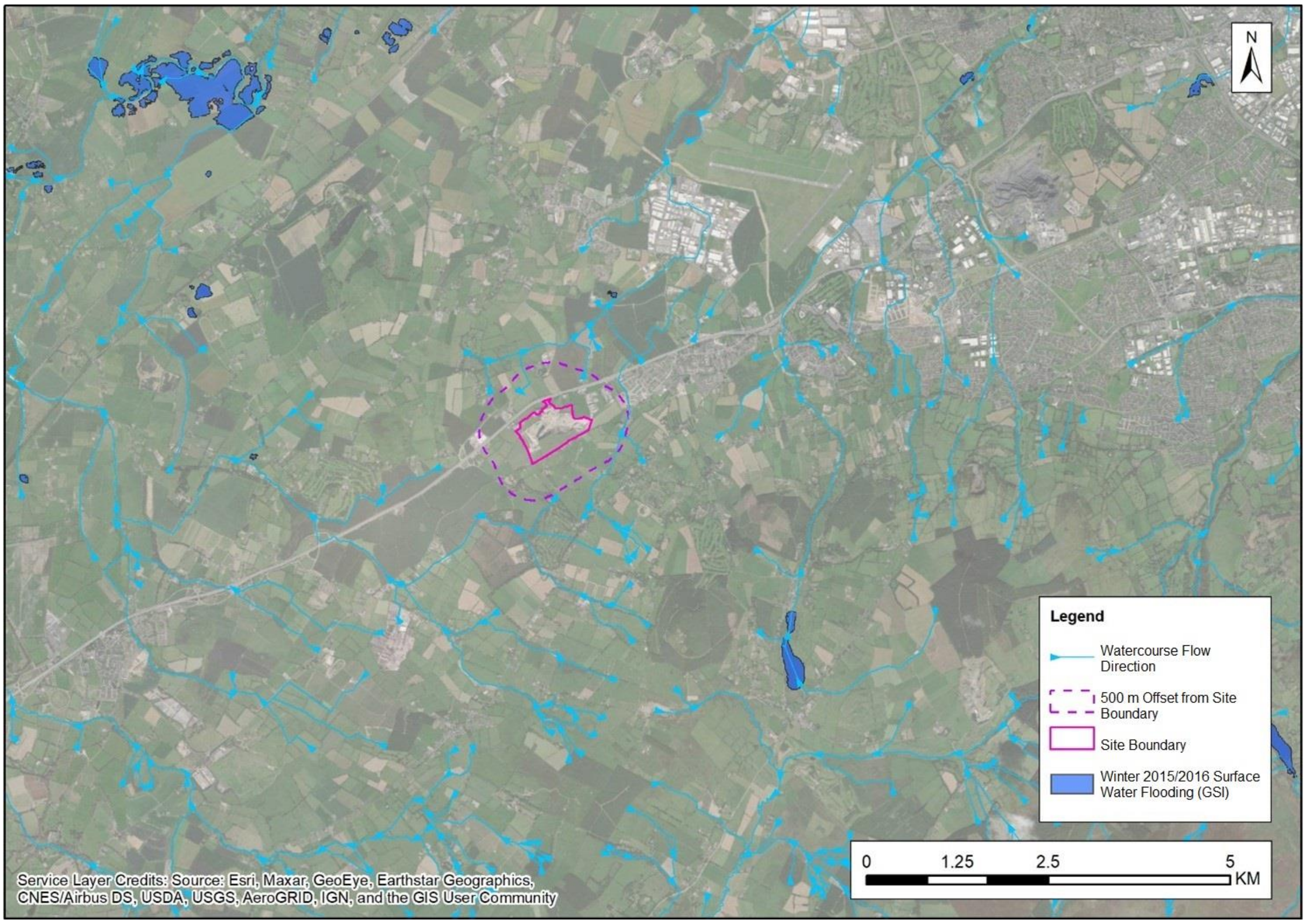


Figure 6.4: Local River Network, Flow Directions and Historic Surface Water Flooding in the Vicinity of the Site (after GSI, 2021).
Note: Contains Irish Public Sector Data (Geological Survey Ireland) licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND 4.0) International Licence.

The Site is located within the broader River Griffeen catchment which forms part of the wider River Liffey system. The Highdown Hill stream is located approximately 0.8 km to the north of the Site and flows northeast. The Tootenhill Stream is located approximately 0.5 km to the south-east of the Site and flows in a north-easterly direction. The Highdown Hill and Tootenhill Streams converge approximately 1.5 km northeast of the Site to become the River Griffeen, eventually joining the Liffey River system.

To the south of the Site (ca. 1.2 km) several small streams flow into the Kill East River with flows in a north-westerly direction to join the Painestown River ca. 5.7 km to the west of the Site. Flow continues in a north-westerly direction before joining the River Morell approximately 7.5 km to the west of the Site.

The River Camac is located approximately 1.8 km to the east of the Site and flows north.

Based on the available data and mapping, it is thought that flow directions in the local river network are likely to have remained largely unchanged since 1990.

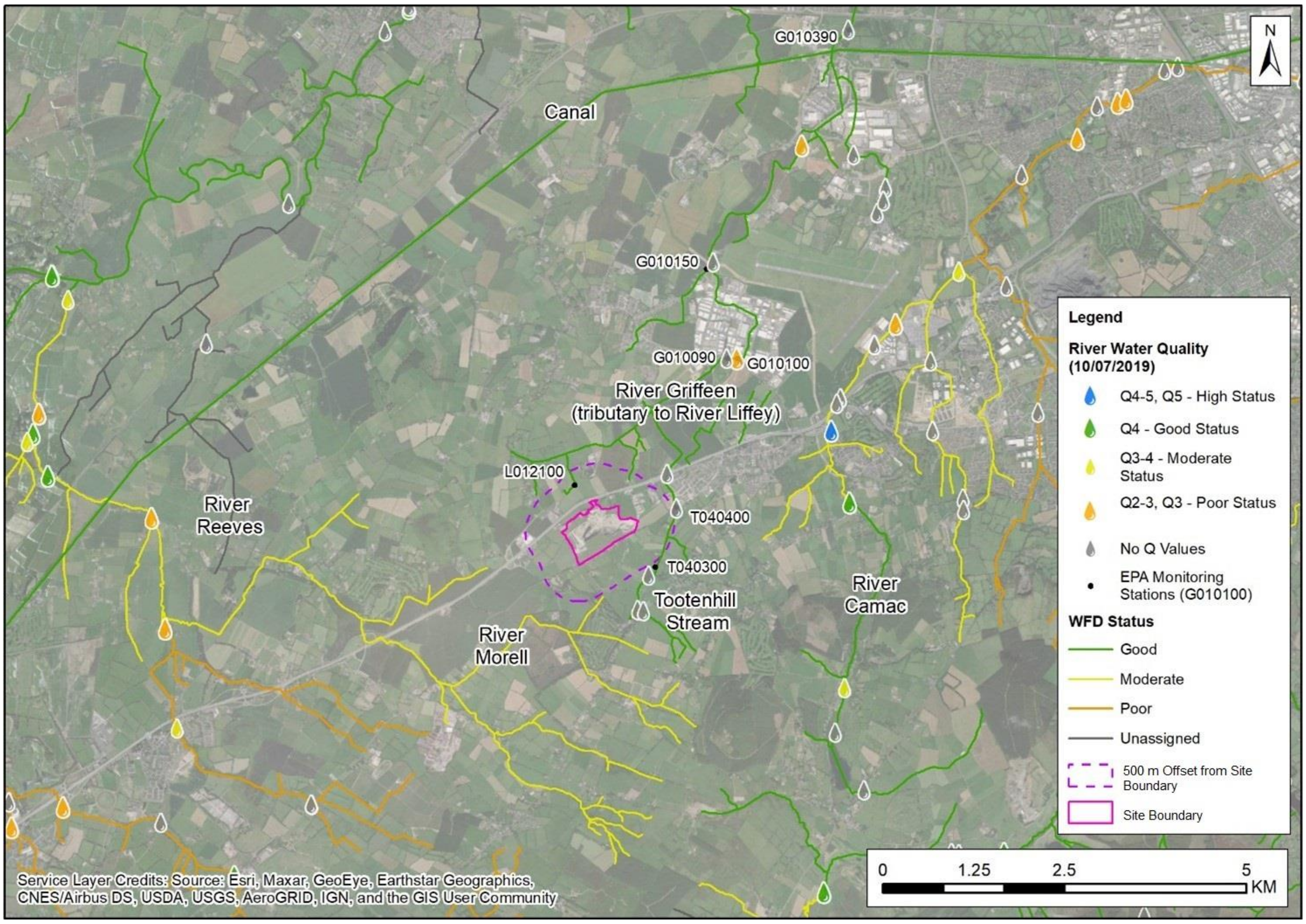
Previous reporting for the Site (Viridus, 2020) reported no evidence of overland surface water drainage out of the quarry or connectivity between the surface water pond features in the quarry and any local surface water features. Current 2021 conditions are consistent with this assessment.

6.4.6.3 *Local Surface Water Quality*

The local surface water quality through the review period has been derived using a combination of publicly available data, historic monitoring records requested from the EPA and Site-specific monitoring carried out at select locations between 2006 and 2021.

Publicly Available Water Quality Data

The WFD Status and River Quality (Q) values of each of the rivers, as assigned by the EPA, are shown spatially in Figure 6.5 and summarised in Table 6.6.



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 6.5: Local River WFD Designations, EPA River Quality Values, EPA Monitoring Stations (after EPA, 2021 and GSI, 2021).

Table 6.6: Summary of WFD Status and River Q Value in Surface Water Features Close to the Site (EPA, 2021).

River Name	WFD Status (2013-2018)	Station Code	River Q Value (and year recorded)	
River Liffey_170	Good	G010100/ Griffeen	2-3 – Poor (1991)	
River Camac_010	Good	C020050/ Camac	3-4 – Moderate (1986)	
		C020100/ Camac	3 – Poor (2019)	4– High (1991)
River Camac_020 (downstream)	Moderate	C020150/ Camac	4-5 – High (1991)	
		C020200/ Camac	2 – Bad	2 – Bad

River Name	WFD Status (2013-2018)	Station Code	River Q Value (and year recorded)	
			(1998)	(1990)
River Painstown_010	Poor	P010400/ Painestown	4 – Good (2019)	1-2– Bad (1990)
River Morell_040	Moderate	P010450/ Painestown	3 – Poor (1991)	

To the north and the east of the Site the River Griffeen (which is a tributary of the Liffey River system) is classified as 'good' under the River Waterbody WFD 2013-2018 system. The most recent river quality (Q Value) status was recorded at the College Road Station as 2-3 ('poor') in 1991.

Approximately 3.8 km to the southwest of the Site the River Painestown is classified as 'poor' under the River Waterbody WFD 2013-2018 system. At the Painestown Brook station the river quality (Q value) status is 4 ('good') in 2019 which has improved since 1991 when the Q value was 1-2 ('bad').

The River Morell is located to the south and west of the Site (minimum 810 m) and is classified as 'moderate' under the River Waterbody WFD 2013-2018 system. There is no available river quality data (Q value) until the Painestown Bridge (north of Alasty) monitoring station (Station number P010450), located after the River Painestown joins with the River Morell. The Q value here is 3 ('poor') and was last recorded in 1991.

The closest branch of the River Camac is 1.8 km to the east of the Site. The River Waterbody WFD 2013-2018 classifies this section of the river as 'moderate'. The River Q value along this stretch of river is available at four stations. The most upstream station (C020050) recorded a Q value of 3-4 ('moderate') in 1986, this decreases to 3 ('poor') by the monitoring station closest to the Site (C020100). Further downstream as the river flows through Rathcoole and adjacent to the Aerodrome, the Q value is recoded as 4-5 ('high') in 1991 and 2 ('bad') in 1998 at the two monitoring stations respectively. It is noted that this area receives urban waste water discharge from the Rathcoole and Newcastle areas (EPA, 2021).

EPA surface water quality monitoring data from 1995 to 2003 is available from three monitoring stations along the River Griffeen: 09G010090 and 09G010100 located downstream of the Site but upstream of Greenogue Business Park and Casement Aerodrome and 09G010350 located further downstream before Adamstown.

The EPA dataset includes a small range of parameters for assessing the surface water quality: biological oxygen demand (BOD), conductivity, dissolved oxygen, nitrates, nitrites, ortho-phosphate, pH, temperature, total oxidised nitrogen (TON), total ammonium, un-ionised ammonia and ammonia. A tabulated and graphical summary of this data by year is presented in Appendix 6.1.

The dataset is small and surface water screening criteria for these analytes are generally not available, however the following observations are made:

- Conductivity in the samples throughout the monitoring period from 1995 to 2003 is generally consistent and ranges between 582 µS/cm and 708 µS/cm across all of the monitoring stations;
- Concentrations of nitrate, nitrite and ortho-phosphate showed higher concentrations in samples from all three monitoring stations in the data prior to 2000 before showing a decreasing trend towards 2003 (the end of the monitoring period); and
- pH concentrations showed very little variability over the monitoring period or between monitoring stations ranging between 8.09 and 8.32.

2006-2013 Surface Water Quality Investigations

As part of previous investigations at the quarry Site, surface water monitoring was carried out in 2006, 2008 and 2013 (Byrne Environmental, 2015) on the nearby waterbodies. These water quality assessments were carried out to assess the quality of the surface waters within the vicinity of the quarry Site.

The results of the surface water sampling were compared by Byrne Environmental against guideline values from the European Communities Surface Water Regulations, 2009 (Statutory Instrument (S.I.) No. 272/2009) or the Surface Water Quality for Salmonid Waters Regulations (S.I. No. 293/1988). The water quality was found to be good, with generally low levels of BOD, COD, suspended solids and nutrients. Phosphate levels were found to be slightly elevated in SW2 and SW3, but this may also be as a result of agricultural run-off from the surrounding land. Sample SW2 is reported to have been collected from Tootenhill Stream, the location of samples SW1 and SW3 is unknown.

2020-2021 Surface Water Quality Investigations

During the 2020-2021 monitoring period surface water samples were taken by Golder from the following locations (see Figure 6.5):

- L012100 – Athgoe Stream EPA monitoring station, tributary of the River Griffeen. Located north of the Site (downslope of the Site).
- T040300 – Tootenhill Stream EPA monitoring station, tributary of the River Griffeen. Located southeast of the Site (upstream).
- T040400 – Tootenhill Stream EPA monitoring station, tributary of the River Griffeen. Located east of the Site (upstream).
- G010100 – Griffeen River EPA monitoring station. Located north east of the Site (downstream).
- G010150 – Griffeen River EPA monitoring station. Located north-northeast of the Site (downstream).
- SW1 – On-Site, western pond. Sample taken in the vicinity of the submersible pump area (Figure 6.3).

The western pond area (SW1) is considered to be a mixture of rainfall and groundwater, and is periodically pumped following periods of prolonged rainfall to a discharge culvert near the Site entrance. The discharge culvert drains to the N/M7 roadway drainage system, where it is assumed for the purposes of this assessment, to discharge to a tributary of the Griffeen close to Rathcoole.

Samples from SW1 were collected in June 2020 and January 2021. All other surface water samples were collected during January 2021. Each sample was tested at UKAS accredited Element Materials Technology laboratory for the following parameters:

- Dissolved metals: Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Lead, Magnesium, Mercury, Nickel, Potassium, Selenium, Sodium (2021 only), and Zinc;
- Total Hardness (Dissolved as $CaCO_3$);
- MTBE. Benzene, Toluene, Ethylbenzene, m/p Xylene, o-Xylene;
- Extractable Petroleum hydrocarbons (C8-C40);
- Sulphate;
- Chloride;
- Nitrate as NO_3;

- Nitrite as NO_2;
- Orthophosphate as PO_4;
- Total Oxidised Nitrogen;
- Ammoniacal Nitrogen as NH_4;
- Total Alkalinity as $CaCO_3$;
- Dissolved Oxygen (2020 only);
- Electrical Conductivity (2020 only);
- pH (2020 only);
- Total Organic Carbon; and
- Total Dissolved Solids.

The results of the groundwater and surface water quality analysis at the Site are presented in Appendix 6.1 and compared with the Environmental Quality Standards (EQS) for inland surface waters, as outlined in the European Communities Environmental Objectives (Surface Water) Regulations S.I. No.272/2009 including amendment S.I. No.386/2015. The maximum allowable concentration (MAC) for inland water EQS values have been applied as more than two samples would be required to establish an average (AA) concentration for comparison against the AA EQS values. Where a screening value does not exist the UK EQS were applied (Freshwaters specific pollutants and operational EQS and Freshwaters priority hazardous substances, priority substances and other pollutants[2]). Full screening results are presented as Appendix 6.2. The laboratory certificates for the results are included in Appendix 6.3.

Surface water is generally shown to be of good quality in 2020-2021 with no exceedances of the MAC EQS values during the 2020 and 2021 monitoring period, although it should be noted that the limit of detection for dissolved mercury (0.1 mg/l) exceeds the MAC of 0.07 mg/l. Dissolved mercury was found to be less than the limit of detection in all of the samples.

For completeness, the surface water data presented in Byrne Environmental (2015) was also compared against the same surface water screening values as the most recent 2020-2021 set of samples. No exceedances were found. A full summary of the data is also presented in Appendix 6.2.

6.4.7 Groundwater- Hydrogeology

6.4.7.1 Local Aquifers and their Properties

The clayey superficial deposits in the vicinity of the Site are not designated as an aquifer by the GSI, with the closest gravel aquifer located ca. 7 km to the south-west (GSI, 2021).

The GSI aquifer designation (GSI, 2021) for bedrock underlaying the Site is shown in Figure 6.6. Bedrock underlying the footprint of the Site (Carrighill Formation) falls within the catchment of the Kilcullen groundwater body which is defined as ‘good’ water quality under the WFD and has a designation of ‘Pu’ or ‘poorly productive bedrock’ (GSI, 2021). A ‘Pu’ poor aquifer is described by the GSI (GSI, 2017) as:

- Generally unproductive with generally few poorly connected fractures, fissures and joints;
- Having a shallow weathered zone of slightly higher permeability (top few m’s), which decreases with depth;

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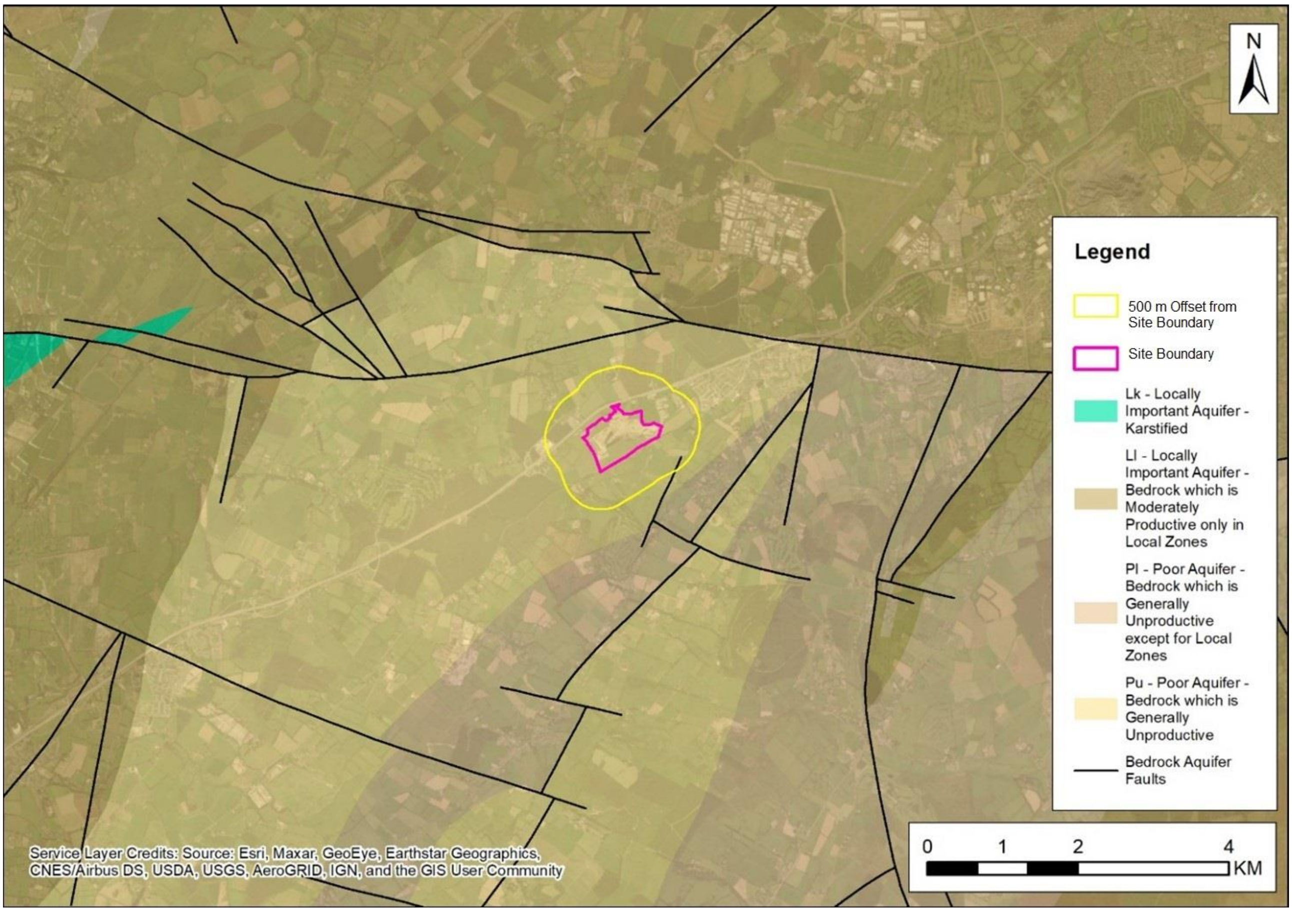
[2] https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit#screening-tests-freshwaters

- Having poor aquifer storage, short flow paths (tens of m’s) and low recharge acceptance;
- The presence of higher permeability fault zones is rare; and
- Groundwater baseflow contribution to surface water features is very limited.



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

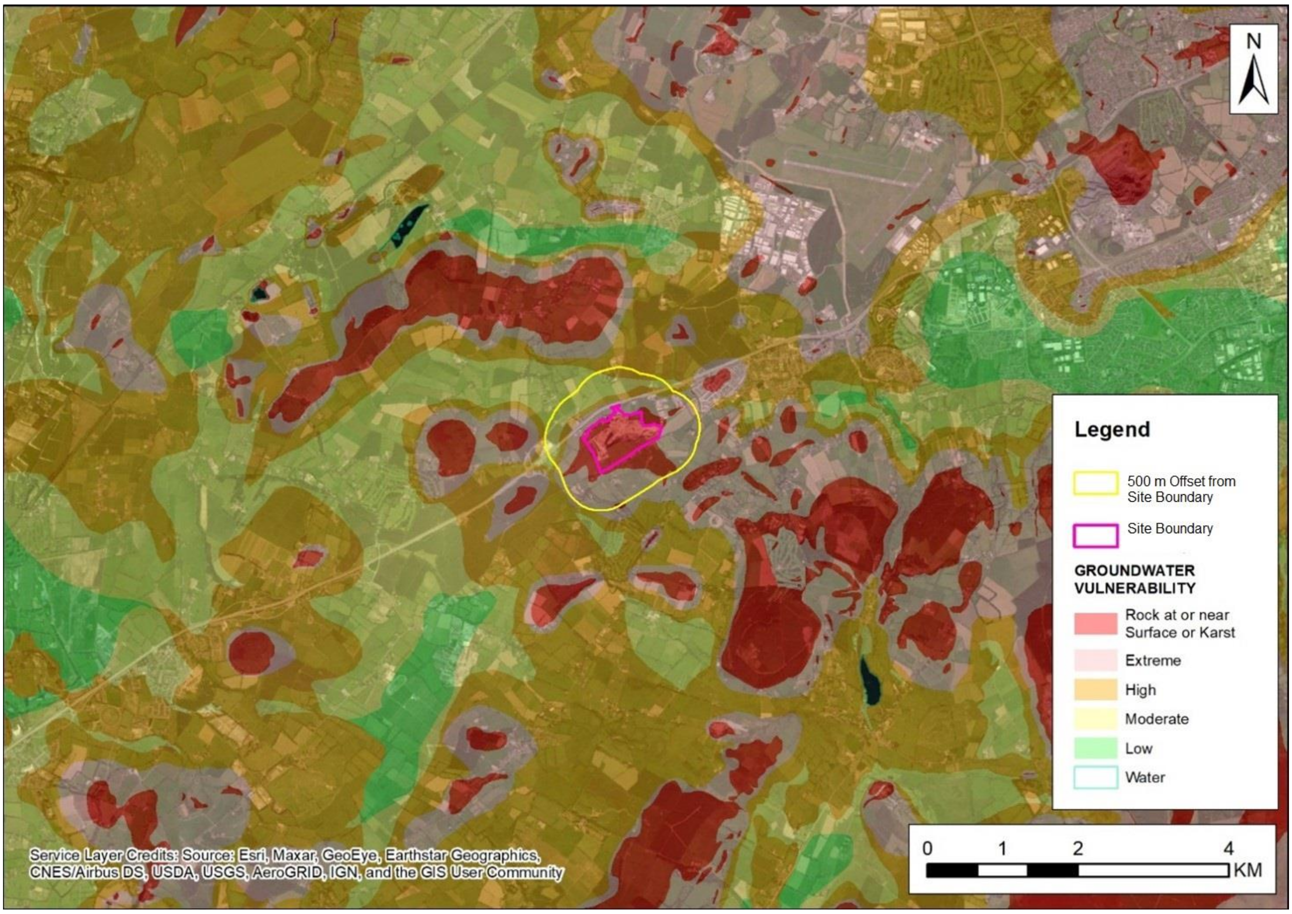
Figure 6.6: GSI Bedrock Aquifer Designations (after GSI, 2021).

Bedrock of the Tipperkevin Formation is located ca. 1.1 km to the south of the Site and is classified as a ‘Pl’ poor aquifer, which is described as generally unproductive except for local zones. Bedrock of the Lucan Formation is located approximately 1.7 km to the north of the Site and is classified a ‘Ll’ locally important aquifer, which is described as moderately productive only in local zones. Due to the unproductive nature of the Carrighill Formation, the Site is not interpreted to be in hydraulic connectivity with the aquifers of the Tipperkevin and Lucan Formations.

There are no records for estimated values for hydraulic conductivity at the Site, although values for bedrock geology similar to the Carrighill Formation can be found in the literature. Table 6.7 summarises the hydraulic conductivity for shale and cemented sandstone as found in Driscoll (1986), and Kelly *et al*. (2015) report a geomean transmissivity value of 5.5 m^2/day for ‘Pu’ aquifers.

Table 6.7: Hydraulic Conductivity Values (Driscoll, 1986).

Rock Type	Hydraulic Conductivity Ranges	
	Minimum	Maximum
Sandstone (cemented)	$1.00\text{x}10^{-5}$ m/d **$1.16\text{x}10^{-10}$ m/s**	$1.00\text{x}10^{-3}$ m/d **$1.16\text{x}10^{-8}$ m/s**
Shale	$1.00\text{x}10^{-9}$ m/d **$1.16\text{x}10^{-14}$ m/s**	$1.00\text{x}10^{-4}$ m/d **$1.16\text{x}10^{-9}$ m/s**



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 6.7: Groundwater Vulnerability Map (after GSI, 2021).

Groundwater Vulnerability (DELG/EPA/GSI, 1999) defines how easily groundwater may be contaminated by human activities. According to the GSI online mapping tool (GSI, 2021) the footprint of the Site is classified as ‘Rock at or near Surface or Karst’ (Figure 6.7). This is appropriate due to the presence of only thin superficial cover or exposed bedrock across much of the Site; the area immediately surrounding the Site generally has a groundwater vulnerability classification of ‘high’ to ‘extreme’ for the same reason. Groundwater vulnerability of unexcavated areas that were not yet subject to the stripping of clayey subsoils would have been classified as ‘high’ to ‘extreme’ in 1990.

Soils and subsoils under the footprint of the Site are classified by GSI mapping as being bedrock outcrop and subcrop with a potential recharge coefficient of 85%. However, the ability of the bedrock aquifer to accept all available groundwater recharge is considered to be low and therefore the groundwater recharge map presents a maximum allowable estimated recharge to bedrock of 100 mm/year (GSI,2021).

Subsoils and shallow bedrock at the Site were reported to accept drainage rates of between ca. 5 to 9 mm/min in site suitability assessments carried out in 2013 (Trinity Green, 2013).

6.4.7.2 *Local Groundwater Elevation*

Aerial photography from 1991 (Chapter 3.0 and Figure 6.8) suggests that there was no pond formation in the areas of extraction activities during baseline conditions and therefore significant quantities of groundwater had not yet been encountered at the Site. The lowest elevation of the quarry floor at this time is estimated to be ca. 158-160 mAOD (Substitute Consent Planning Application Drawing No. 05; Cross Sections) and therefore the potential piezometric surface across the quarried area in 1991 is assumed to have an elevation of less than 158 mAOD.

Whilst it is considered likely that small quantities of groundwater seepages may have been encountered within fractures or bedding planes at the southern extent of the quarry (which would have been operating below the elevation of upgradient groundwater), there is no evidence of groundwater pooling (Figure 6.8). It is therefore thought that any seepage volumes were small and recharged to unsaturated ground close to the quarry face. There are two small areas where ponded water may potentially be observed on the 1991 aerial photography (circled red on Figure 6.8); however, these are considered to be areas of rainfall runoff collected at a topographical low point (areas circled in red), and therefore not groundwater.

Figure 6.8: Area of Extraction Activities in 1991 (southern extent of Site, quarry floor is ca. 158-160 mAOD). Circled areas indicate potential locations of ponded water. Source of aerial imagery: Ordinance Survey Ireland.

It can be seen from aerial photography that ponded water was observed to first form in the pit area between 1995 and 2000. It is not known what the quarry floor elevation was at this time, but it can be seen to be lower than the central area, which has remained consistently at an elevation of ca. 158-160 mAOD through the review period. In 2004, there is no evidence of water ponding at the base of the west pit and, whilst no records exist to confirm, it is assumed that pumping was being employed to remove ponded water and allow deeper extraction of rock material.

In 2016, it can be seen that substantial flooding of the west pit had occurred. A bench in the southern pit wall can be seen in both 2016 and 2020 aerial photography (Figure 6.9) and is estimated from the 2020 topographical survey to be at an elevation of ca. 160 mAOD (Figure 6.10).

Figure 6.9: West Pond Area in 2016 and 2020. Circled Area = Bench ca. 160 mAOD. Source of Aerial Imagery: Ordinance Survey Ireland.

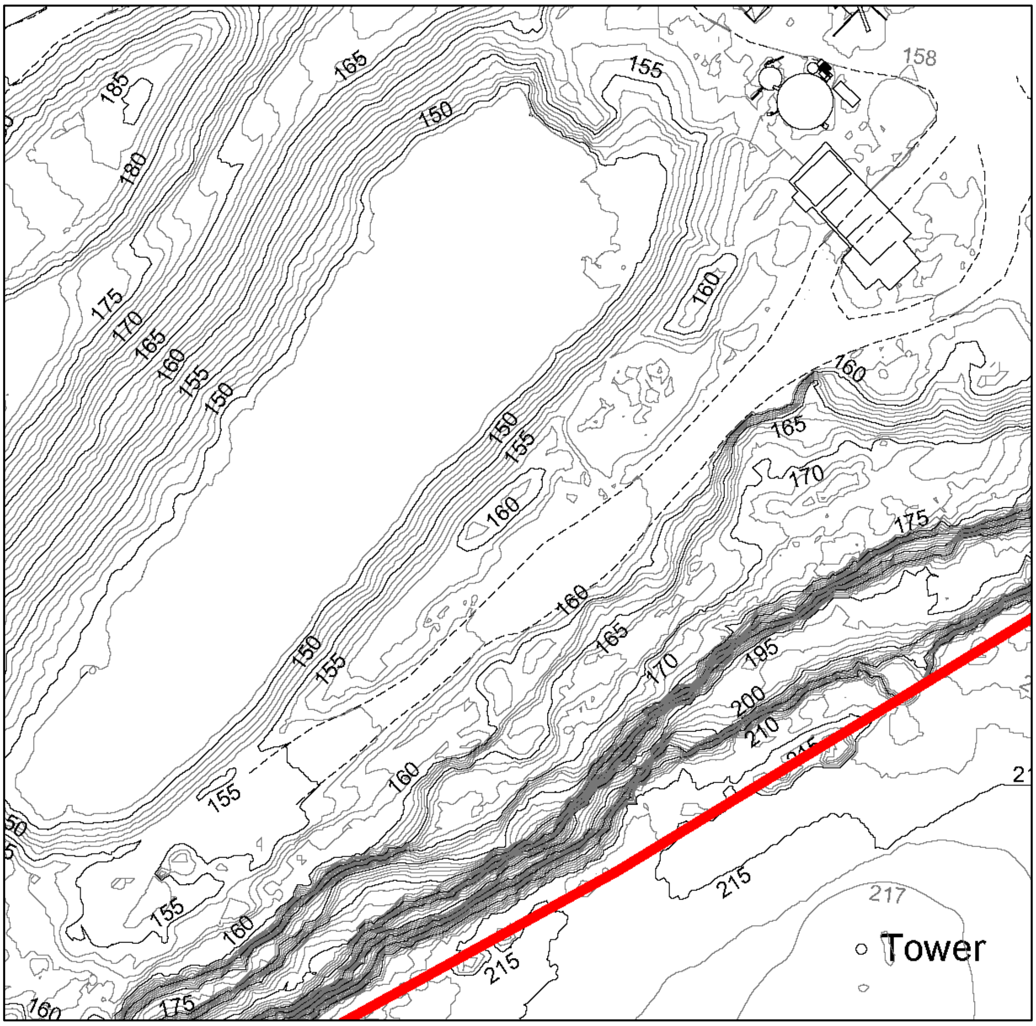


Figure 6.10: Site Topography Contours in 2020. Elevations are shown in mAOD. Circled Area = Bench ca. 160 mAOD.

The ponded water level is estimated from the 2016 aerial photography to be at an elevation approximately 5 m below this bench (ca. 155 mAOD). It is not known whether pumping was employed at this time, however, given the unsaturated nature of the quarry in 1990, which had an elevation of ca. 158-160 mAOD, this pond elevation is likely to represent unmanaged (i.e. rest) groundwater.

2006-2018 Groundwater Elevation Investigations

There were four groundwater boreholes within the Site boundary reported in the previous studies by Byrne Environmental (2013a; 2015) and Viridus Consulting (2020): the office well, workshop well (later referred to as ‘chipping plant well’), MW1 and MW2. An additional five groundwater monitoring locations were reported to be adjacent to the Site: Farm Well (appears to be a groundwater fed trough or spring), Yard Well (appears to be a groundwater fed trough or spring), L. Behan House Well (domestic well), Well A and Well B. The approximate location of these groundwater monitoring locations are shown in Figure 6.11. It should be noted than no coordinates are available for these locations and therefore have been approximately positioned using available mapping.

Figure 6.11: Location of Groundwater Wells Within and Immediately Adjacent to the Site 2006 to 2018 (Source of Aerial Imagery: Google Earth. Year: 2020).

Groundwater elevations in boreholes within and immediately adjacent to the Site were recorded as part of two previous investigations: Byrne Environmental (2015) measured groundwater elevation in six of the boreholes around the Site in October 2007 and April 2008, and Viridus Consulting (2020) monitored groundwater in four of the boreholes during April 2018.

The 2007 to 2018 elevations are summarised in Table 6.8. Whilst fluctuations in groundwater elevations are not unexpected within the Carrighill Formation due to its limited storage potential and low bulk permeability (KCC and GSI, 2002), it is noted that all locations were installed with pumping infrastructure and may have been subject to active pumping at the time of measurement.

It is also noted that whilst the same boreholes could not be monitored during the 2007, 2008 and 2018 investigations for direct comparison, groundwater elevations remain broadly similar across the Site ranging from ca. 134 mAOD in the northwest of the Site and between ca. 180-200 mAOD in the southeast area of the Site.

Table 6.8: Summary of Previous Groundwater Elevation Monitoring (Byrne Environmental, 2015; and Viridus Consulting, 2020).

Borehole ID	Groundwater Elevation (mAOD)		
	October 2007	April 2008	April 2018
Well A	134.65	134.70	134.57
Well B	137.13	137.00	-
Office Well 2007	149.00	-	-
Workshop Well / Chipping Plant Well[1]	176.68[2]	168.10[2]	147.53
L. Behan House Well	196.18	200.50	189.30
MW2	-	-	146.95

[1] Based on mapping and borehole names associated with previous reports, some changes to the naming conventions for boreholes is thought to have occurred. Byrne Environmental (2015) references to 'Workshop Well' are interpreted to become 'Chipping Plant Well' in the Viridus Consulting (2020) report.

[2] Mapping presented in Byrne Environmental 2015 shows the 'Workshop Well' to be located in the central area of the Site. However, the groundwater elevations reported in 2007 and 2008 are reported to be ca. 8 to 16 m above the surrounding ground elevation in this area and therefore the measurements are assumed to be incorrect.

During the 2018 investigation the west pond water level at the base of the excavations in the central area of the Site was recorded as 147 m (+/- 0.5m). This pond elevation level is included on groundwater elevation contours derived using borehole monitoring data from the same monitoring round in Figure 6.12. The groundwater contours show a consistent drop across the Site and do not show evidence of groundwater drawdown in the area of the western pit. It is inferred that the water in the pond is likely to be reflective of the groundwater table with contribution from ponding rainfall during precipitation events.

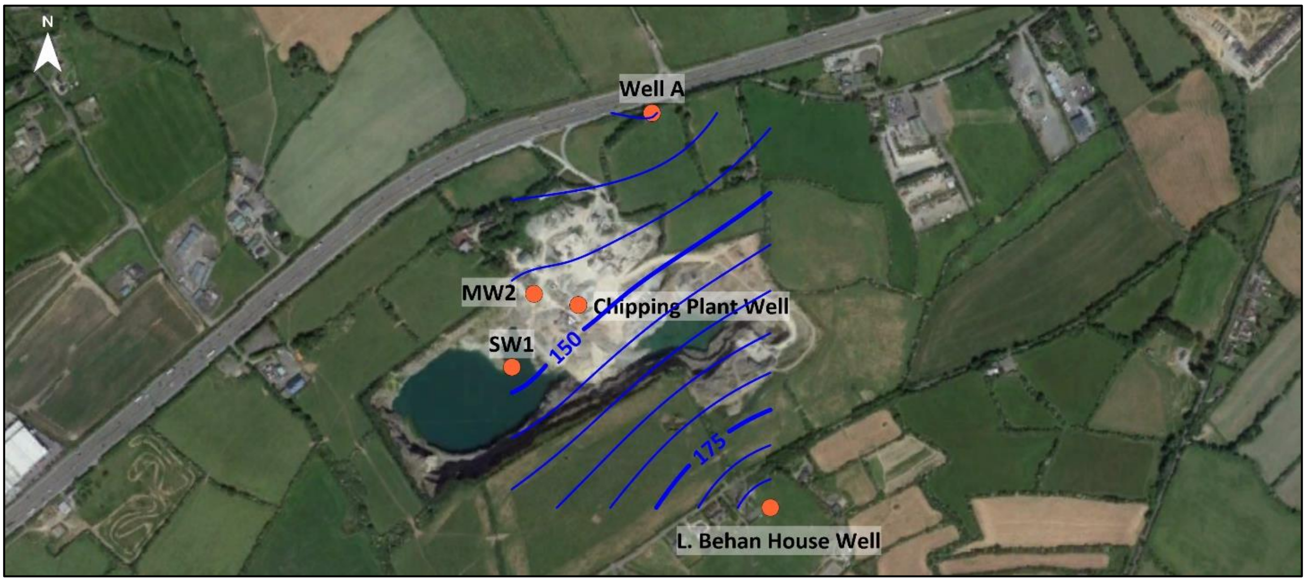


Figure 6.12: Groundwater Elevation Contours, Including West Pond Water Elevation (SW1), April 2018 (aerial imagery from Google Earth 2016). Groundwater elevations given in mAOD.

2020-2021 Groundwater Elevation Investigations

A Site walkover was carried out by Golder in March 2020 to establish which groundwater boreholes remained on and immediately adjacent to the Site. Since the previous studies were conducted, the Office Well borehole identified in 2007 has been replaced by a new Office Well. MW1, Well B and the Workshop/Chipping Plant Well have been lost. Well A, Farm Well and Yard Well were noted to be in existence and fitted with pumping headworks, prohibiting monitoring of groundwater level or sampling. L. Behan House Well was also found to remain in use, however the headworks were flooded with surface water runoff and leaf litter and groundwater elevation could also not be monitored at this location.

Four new groundwater monitoring boreholes (BH1-BH4) were installed at the Site in March 2020 and groundwater elevations were recorded in these boreholes periodically by Golder from March 2020 to February 2021. Borehole logs for these wells are presented in Chapter 5.0. A hydrograph of the groundwater elevations in the boreholes over this period is shown in Figure 6.13 and tabulated monitoring data is provided in Appendix 6.4. A seasonal variation of approximately 4-11 m is observed between summer and winter groundwater levels, again not unexpected within the Carrighill Formation (KCC and GSI, 2002).

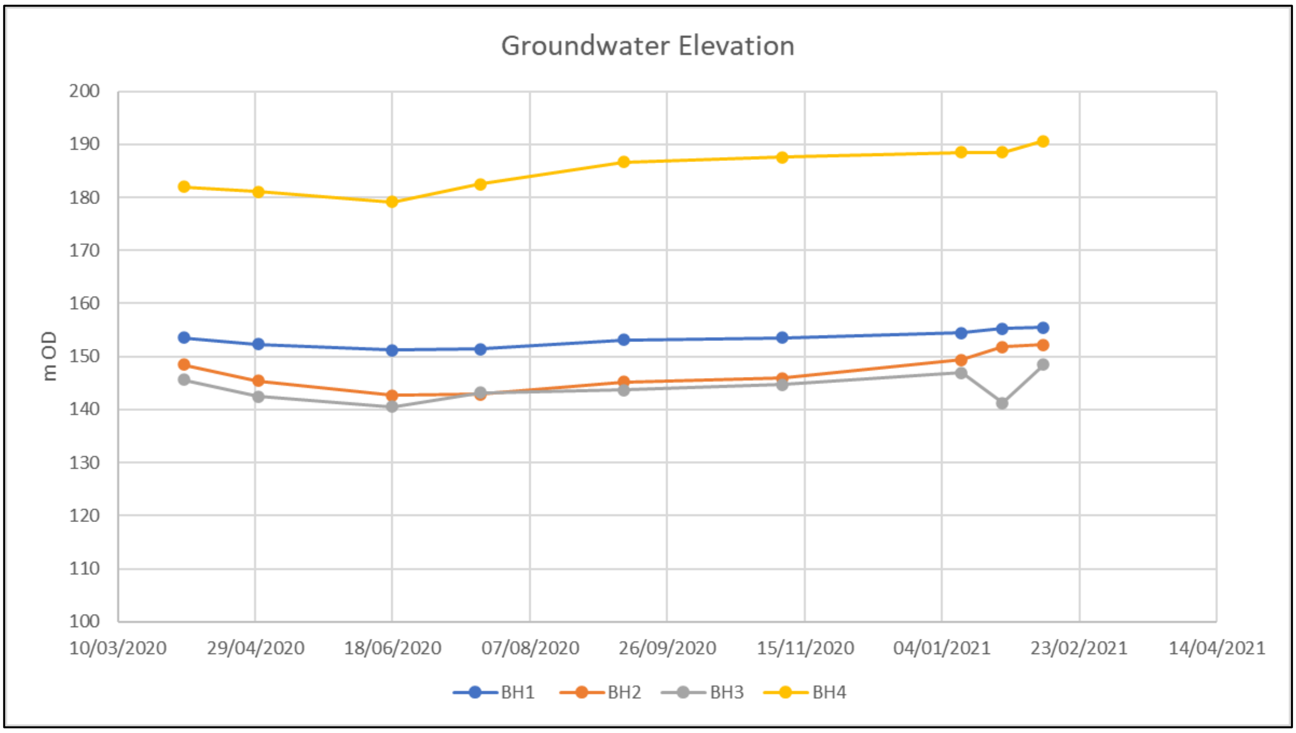


Figure 6.13: Groundwater Elevation 2020-2021

Groundwater elevation contours for this monitoring period for boreholes BH1-BH4 are shown in Figure 6.14 and Figure 6.15. The groundwater flow direction is from the southeast towards the northwest across the Site. This was found to be consistent across the 2020-21 monitoring period and in line with that observed in the previous 2015 and 2020 reports. Based on this flow direction BH4 is an upgradient borehole, BH1 is cross-gradient and BH2 and BH3 are downgradient of the Site.

During the 2020-21 monitoring period, the elevation of the water level in the western pond (SW1) has been recorded twice and the elevation of the eastern pond (SW2) measured once. Water elevations at SW1 and SW2 were both measured in October 2020 during a drone survey when the water level was recorded as 149 mAOD for both ponds. SW1 was measured again in February 2021 when the water level was recorded as 149.9 mAOD during a GPS survey of the monitoring locations. Water levels in the quarry ponds are still thought to be a reflection of the groundwater table with contribution from ponding rainfall during precipitation events.

Figure 6.16 presents groundwater contours which include the elevation of SW1 and SW2 with the borehole groundwater elevations from the closest available dataset. It is interpreted from the contours that whilst there is drawdown of the groundwater table in the vicinity of the west and east pond areas due to pumping within the west pond, this drawdown is localised to the excavated areas and does not appear to impact the groundwater elevation in the surrounding natural ground. This is in line with the limited connectivity of an unproductive (‘Pu’) aquifer with hydraulically connected flow paths of tens of metres only (see Section 6.4.7.2).

03 April 2020 30 April 2020

16 June 2020 20 July 2020

10 September 2020 07 November 2020

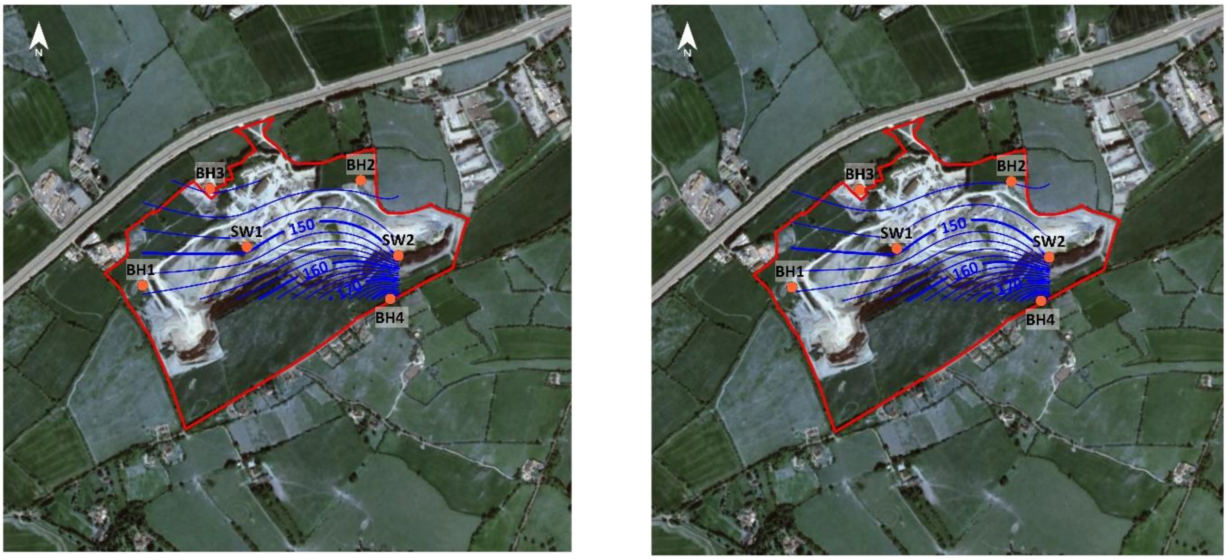
Figure 6.14: Groundwater Contours 2020 (aerial imagery from 2020). Groundwater elevations given in mAOD.

11 January 2021

26 January 2021

10 February 2021

Figure 6.15: Groundwater Contours 2021 (aerial imagery from 2020). Groundwater elevations given in mAOD.



10 September 2020 (SW1 & SW2 elevation October 2020) **07 November 2020 (SW1& SW2 elevation October 2020)**

26 January 2021 (SW1 elevation February 2021) **10 February 2021 (SW1 elevation February 2021)**

Figure 6.16: Groundwater elevation contour plots including water level in west and east quarry pond (SW1 and SW2 respectively) in 2020 and west quarry pond (SW1) in 2021. Aerial imagery from 2020, groundwater elevations given in mAOD.

6.4.7.3 *Local Groundwater Quality*

Site-specific groundwater quality data is not available for the Site in 1990, however it is noted that quarrying activities, whilst having been conducted prior to 1990, were operating above the resting groundwater table.

Baseline groundwater quality has been reported during previous investigations by Byrne Environmental (2015) and Viridus Consulting (2020). Golder supplemented this groundwater quality data through a sampling campaign carried out in 2020 and 2021.

2006-2018 Groundwater Quality Investigations

Groundwater quality at the Site has been presented in two previous investigations carried out on the Site: Byrne Environmental (2015) sampled groundwater from eight boreholes within or adjacent to the Site sporadically between 2006 and 2013, and Viridus Consulting (2020) sampled groundwater from four boreholes during 2018. Monitoring data is presented in Appendix 6.2 and monitoring locations are shown on Figure 6.11.

Groundwater samples collected during these investigations were analysed for a suite of metals, nitrates, nitrites, coliforms as well as generic water quality indicators such as pH, and conductivity.

Groundwater results from 2007 to 2013 were compared by Byrne Environmental (2015) to the relevant thresholds presented in the European Council Environmental Objectives (Groundwater) Regulations, 2010 (S.I. 9/2010). Byrne Environmental (2015) found one exceedance of the groundwater threshold values for nitrate as N in one groundwater sample collected from borehole MW1 in 2007 at a concentration of 13 mg/l compared to a threshold value of 8.5 mg/l. However, this threshold limit is incorrect, with a threshold of 37.5 mg/l reported in S.I. No.9/2010. The threshold value for arsenic was exceeded on four occasions in samples collected from MW2, Office Well, and the Chipping Plant Well in 2007 and Well A in 2013. Concentrations ranged from 10 mg/l to 35 mg/l compared to a threshold value of 7.5 mg/l.

The elevated arsenic concentrations are interpreted by Golder to be naturally occurring rather than related to plant or facilities at the Site. Arsenic is often naturally elevated in groundwater hosted in greywacke or shales, with poorly productive bedrock having increased probability of higher concentrations (McGrory *et al*., 2017).

All other parameters were reported by Byrne Environmental to be within normal values expected for groundwater. Ammonia, nitrate, metals and hydrocarbon levels were found to be low and there was limited evidence to suggest that the activities existing on the Site at the time of the investigation were impacting the underlying groundwaters.

As part of the Viridus Consulting (2020) study samples were collected from four locations on the Site: MW2 in the quarry, Well A to the north and the L. Behan House Well to the south. The water trough at the Farm Well, located to the north of the quarry was also sampled (although the water origin is unknown as no borehole was identified at the time). The results were not screened against any published standards at the time.

The groundwater quality was generally found to be ‘good’. Trace qualities of mineral oil were identified in the samples collected from L. Behan House Well, Well A and MW2 with concentrations of 0.02 mg/l, 0.10 mg/l and 0.03 mg/l reported for each respectively (lab detection level 0.01 mg/l).

The Farm Well sample showed some detected bacteria and also had a low mineral oil concentration (0.31 mg/l). The water in this sample has a higher pH and a lower alkalinity and conductivity compared to the samples from the other wells.

Viridus Consulting (2020) found no evidence that the quarry area was the source of the mineral oil contamination: Well A and the Farm Well are both located adjacent to the N7 roadway which is another potential source of hydrocarbons. Metals in the groundwater results did not show any elevated parameters originating from the quarry area.

For completeness, the groundwater results from the two previous investigations (2015 and 2020) have also been screened by Golder against current groundwater threshold values. EPA Interim Guideline Values for Groundwater Protection[3] were applied for parameters where thresholds were not identified in groundwater regulations S.I. No. 9/2010 or amendment S.I. No. 366/2016. A summary of the exceedances are presented in Table 6.9 and Table 6.10.

In the 2007-2013 data from Byrne Environmental (2015) a range of metals exceeded the guideline values, most frequently arsenic, barium and total coliforms (Table 6.9). Slightly elevated concentrations of iron, magnesium, manganese and potassium were also found when compared to the EPA interim guidelines and, similarly to arsenic, are also thought to be naturally occurring.

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[3] Towards Setting Guideline Values for the Protection of Groundwater in Ireland- Interim Report, EPA, 2003

In the samples from 2018 (Viridus, 2020) exceedances of the guideline values for metals (naturally occurring), orthophosphate, hydrocarbons and total coliforms were similarly observed. As reported by Viridus Consulting, the exceedances of hydrocarbons are thought to be due to off-Site sources rather than the activities occurring at the Site. Orthophosphate is similarly thought to derive from off-Site sources, such as the application of fertilisers by farmers, due to a lack of on-Site sources.

Table 6.9: Summary of screening exceedances from previous investigation data (Byrne Environmental, 2015)

Parameter	Units	Guideline Value	MW1		MW2	Office Well		Chipping Plant Well	Well A			Well B	L. Behan House		Yard Well
			2007	2010	2007	2007	2013	2007	2006	2007	2013	2007	2007	2013	2013
Potassium	mg/l	5	1.8	<2.34	3.5	2.5	5	6.4	-	0.9	<1	-	0.5	3	2
Magnesium	mg/l	50	25	<0.036	38	32	53	37	13.2	23	20	17.1	13	31	3
Arsenic	µg/l	7.5	7	-	35	10	3	20	-	2	10	-	7	5	<1
Barium	µg/l	100	130	-	141	110	-	621	-	50	-	-	66	-	-
Iron	mg/l	0.2	<0.1	-	<0.1	<0.1	-	<0.1	0.049	<0.1	-	0.218	<0.1	-	-
Manganese	µg/l	50	4	0.479	<2	174	-	3626	6	3	-	1	<2	-	-
Lead	µg/l	7.5	11	1.52	10	16	<1	11	-	11	<1	-	11	<1	<1
Total Coliforms	MPN/100ml	0	-	-	-	-	12	-	-	-	1	-	-	19	1
Faecal Coliforms	MPN/100ml	0	-	-	-	-	2	-	0	-	0	0	-	1	0

Table 6.10: Summary of screening exceedances from previous investigation data (Viridus, 2020).

Parameter	Units	Guideline Value	L. Behan Well	Well A	MW2	Farm Well
			2018			
Phosphate (Ortho/MRP) as P	mg/l	0.035	<0.005	0.046	0.041	0.017
EPH >C8 to <C40	mg/l	0.0075	0.02	0.01	0.03	0.31
EPH >C10 - C20	mg/l	0.01	<0.01	0.08	0.01	0.22
EPH >C20 - <C40	mg/l	0.01	0.02	0.02	0.02	0.09
Manganese- Dissolved	mg/l	0.05	<1.0	1.1	100	6.9
Arsenic- Dissolved	ug/l	7.5	12.4	5.2	3.5	-
Total Coliforms	MPN/100ml	0	0	0	0	10

2020-2021 Groundwater Quality Investigations

Groundwater samples were collected by Golder from the four newly installed boreholes on the Site (BH1-BH4) during June 2020 and January 2021. Additional samples were also collected from L. Behan House Well and Silt Pond 2 during the January 2021 sampling round. Each sample was tested at UKAS accredited Element Materials Technology laboratory for the following parameters[4]:

- Dissolved metals: Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Lead, Magnesium, Mercury, Nickel, Potassium, Selenium, Sodium (2021 only), and Zinc;
- Total Hardness (Dissolved as $CaCO_3$);
- MTBE. Benzene, Toluene, Ethylbenzene, m/p Xylene, o-Xylene;
- Extractable Petroleum Hydrocarbons (EPH, C8-C40);
- Sulphate;
- Chloride;
- Nitrate as NO_3;
- Nitrite as NO_2;
- Orthophosphate as PO_4;
- Total Oxidised Nitrogen;
- Ammoniacal Nitrogen as NH_4;
- Total Alkalinity as $CaCO_3$;
- Dissolved Oxygen (2020 only);
- Electrical Conductivity (2020 only);
- pH (2020 only);
- Total Organic Carbon; and
- Total Dissolved Solids.

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[4] Some parameters were only analysed in one sampling round: either June 2020 or January 2021

The results of the groundwater quality analysis at the Site are presented below and compared with the European Communities Environmental Objectives (Groundwater) Regulations regarding groundwater status, S.I. No.9/2010, including amendment S.I. No.366/2016; where a screening value does not exist, the EPA Interim Guideline Values for Groundwater Protection is applied. Full screening results are presented as Appendix 6.2 and a summary of the exceedances are presented in Table 6.11. The laboratory certificates for the results are included in Appendix 6.3.

Samples from BH4 upgradient of the Site had the most exceedances of the screening values. In the June 2020 sampling results dissolved arsenic and nickel and orthophosphate exceeded the screening criteria as well as hardness in the 2020 and 2021 sampling rounds. Ammoniacal nitrogen in samples from BH4 also exceeded the screening value in 2021. L. Behan House well is also located upgradient of the Site. This sample also showed elevated levels of arsenic and hardness. Elevated hardness is expected due to the nature of the surrounding bedrock.

BH2 and BH3 are considered to be downgradient of the Site. Dissolved arsenic concentrations exceeded in all samples, whilst hardness exceeds in both samples for BH2, ammoniacal nitrogen exceeds in BH3 during 2020 and orthophosphate in BH3 during in 2021. Elevated arsenic and hardness are thought to be naturally occurring. Ammoniacal nitrogen can be caused by blasting activities, however, the presence in upgradient groundwater suggests this may be caused by off-Site activities, such as applying fertiliser to agricultural land, similar to orthophosphate.

The sample from Silt Pond 2 was screened against the groundwater criteria as material from this facility may be in connectivity with the underlying groundwater, although it is noted that the accumulation of silt at the base of the silt ponds is likely to limit the infiltration to ground from these ponds. The sample exceeded the screening guidelines for dissolved potassium, hardness, sulphate, nitrite, orthophosphate and ammoniacal nitrogen.

Samples from SW1 are included in this screening assessment due to the potential connectivity between the water in the quarry ponds and the groundwater underlying the Site. The samples from SW1 exceeded groundwater screening guidelines in 2020 and 2021 for arsenic, potassium, hardness, sulphate and ammoniacal nitrogen as well as orthophosphate in 2020 and nitrite in 2021. Most analytes were found to be in the same order of magnitude as the groundwater samples, however potassium, hardness and sulphate were found to be slightly elevated compared to the groundwater samples.

The higher concentrations reported in the SW1 and Silt Pond 2 samples are not unexpected given the higher total dissolved solids reported for the samples, which is thought to derive from the elevated leaching from fine fragments of crushed rock contained in these waters. Whilst concentrations are elevated in these pond samples, these are noted to be higher than any of the samples taken from the boreholes upgradient, cross-gradient and downgradient of the Site, highlighting the limited potential for contaminant migration from the Site. On-Site water supply wells are not suitable for drinking water supply and it is noted by the Applicant that bottled water is used for drinking on-Site.

In summary, whilst some parameters show elevated concentrations in the samples taken, there is no evidence of migration of contaminants from the Site in groundwater and therefore there is no perceived degradation of off-Site groundwater quality due to the activities at the Site. It is also noted that hydrocarbons were not detected in any of the 2020-2021 samples indicating good practices with regards to fuel management and vehicle maintenance at the Site.

Table 6.11: Summary of Groundwater Screening Exceedances (2020-2021).

Parameter	Units	LOD	Guideline Value	BH01	BH02	BH03	BH04	L. Behan House	Silt Pond 2	SW1
June 2020										
Dissolved Arsenic	ug/l	<2.5	7.5	4.7	33.9	13.7	471.3	-	-	32.6
Dissolved Nickel	ug/l	<2	15	4	2	4	42	-	-	4
Dissolved Potassium	mg/l	<0.1	5	0.7	0.9	4	3.7	-	-	14.3
Total Hardness Dissolved (as $CaCO_3$)	mg/l	<1	200	187	255	165	264	-	-	437
Sulphate as SO_4	mg/l	<0.5	187.5	16	62.8	58.5	20.2	-	-	326
Ortho Phosphate as PO_4	mg/l	<0.06	0.035	<0.06	<0.06	<0.06	0.07	-	-	<0.06
Ammoniacal Nitrogen as NH_4[1]	mg/l	<0.03	0.065	0.1	0.05	0.09	<0.03	-	-	0.16
January 2021										
Dissolved Arsenic	ug/l	<2.5	7.5	12.7	17.4	24.8	7.2	13.3	6.1	69.9
Dissolved Potassium	mg/l	<0.1	5	0.5	0.7	3.4	0.5	0.5	6.2	13.4
Total Hardness Dissolved (as $CaCO_3$)	mg/l	<1	200	192	324	184	229	219	298	441
Sulphate as SO_4	mg/l	<0.5	187.5	7.1	98	37.5	7.6	9.4	283.5	346.7
Nitrite as NO_2	mg/l	<0.02	0.375	<0.02	<0.02	0.02	0.04	<0.02	0.42	0.53
Ortho Phosphate as PO_4	mg/l	<0.06	0.035	<0.06	<0.06	0.12	<0.06	<0.06	<0.06	<0.06
Ammoniacal Nitrogen as NH_4[1]	mg/l	<0.03	0.065	<0.03	<0.03	0.03	0.14	<0.03	0.15	0.94

1. Ammoniacal Nitrogen as NH4 screened against lower range of overall threshold value range for Ammonium.

6.4.8 Designated Sites

The Site is located in the WFD (Water Framework Directive) Kilcullen Groundwater body (which is generally described as poorly productive and of 'good' water quality) and the WFD surface water catchment for the Liffey and Dublin Bay via the River Griffeen. The River Griffeen is not designated as a salmonid river (EPA, 2021) but is known to contain large trout (IFI, 2019).

Natura 2000 sites encompass sites of international importance, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The closest Natura 2000 sites are:

- Red Bog SAC (site code 000397) – located 8.1 km to the south of the Site;
- Glenasmole Valley SAC (site code 001209) – located 8.1 km to the east of the Site; and
- Wicklow Mountains SAC (site code 002122) – located 8.1 km to the east of the Site.
- South Dublin Bay SAC (site code 000210) and South Dublin Bay and River Tolka SPA (site code 004024) – located 34 km measured in terms of possible hydrological pathway.

Further details on these Natura 2000 sites are included in the Stage 1 Screening for Appropriate Assessment (Golder, 2021), although due to their distance from the Site are not considered to be hydraulically connected.

6.4.9 Flood Risk

Surface water flood risk maps published by the Office of Public Works ('OPW') show that the Site is not located within a potential flood plain (OPW, 2021). This is expected given the elevated hillside location of the Site in relation to nearby watercourses. The closest waterbody to the Site (Tootenhill Stream, ca. 0.5 km east of the Site) is noted to have a limited potential flood plain of ca. 50 to 100 m distance from the stream under 1 in 1000 flood event scenarios (OPW, 2021). The closest reported areas for recurring historic flood events are located 2.8 km north-east of the Site in Rathcoole and ca. 3.1 km north of the Site in Newcastle Demesne.

GSI mapping (GSI, 2021) does not identify any areas of predicted or historic groundwater flooding in the vicinity of the Site, with the closest area at risk located ca. 12 km to the west of the Site. The closest areas identified by GSI mapping to have been subject to fluvial (river) or pluvial (rainfall) flooding are located ca. 1.8 km and ca. 9.5 km to the north and south-east respectively (see Figure 6.4).

Within the Site boundary, exposed groundwater and captured rainfall have been observed to pond at the topographical low points of the excavated area (see Section 6.4.6.2). The depth and spatial extent of the ponded areas have varied with changes to the geometry of the quarry floor throughout the review period.

In 2021, the pond areas in the east and west pits are maintained at an elevation of ca. 149 mAOD via pumped abstraction to meet Site water demands. These pond elevations are:

- 25 to 60 m lower than the surrounding natural topography of the western pit, which is ca. 174 mAOD and 209 mAOD to the north and south respectively;
- 25 to 35 m lower than the surrounding natural topography of the eastern pit, which is ca. 174 mAOD and 184 mAOD to the north and south respectively; and
- 9 to 11 m lower than the central and northern areas of the Site, which have an elevation of ca. 158 to 160 mAOD.

The lower pond elevation relative to the higher elevation surrounding areas has mitigated the risk of accidental discharges of large volumes of water from the Site to surrounding areas during the review period. There have been no reports found to indicate flooding from the Site to areas external to the Site boundary over the review period.

6.4.9.1 *Extreme Weather Events*

Extreme rainfall return periods for the Site are provided in Section 6.4.6.1 For storage of incident rainfall calculations, the runoff from a rainfall return event with a 1,440 minute (1 day), 1 in 100 year return period (87 mm) is taken to represent a worst case scenario. Over the ca. 28.8 ha operational area, the rainfall event will generate ca. 25,056 m^3 of water over the course of this period (assuming no percolation or evaporation during the event). Sufficient short-term water storage capacity is provided on the west pond alone, which has an area of ca. 1.3 ha and an available volume of 91,000 m^3 below a conservative spill height of 157 mAOD (assumes pumped pond elevation of 150 mAOD).

6.4.10 Local Water Users and Wastewater Systems

On a regional scale, GSI mapping (2021) indicates that there are no groundwater source protection zones within the Site boundary. The nearest groundwater source protection zone is located approximately 3.8 km to the south of the Site - the Kilteel Group Water Scheme (See Figure 6.17; GSI, 2021).

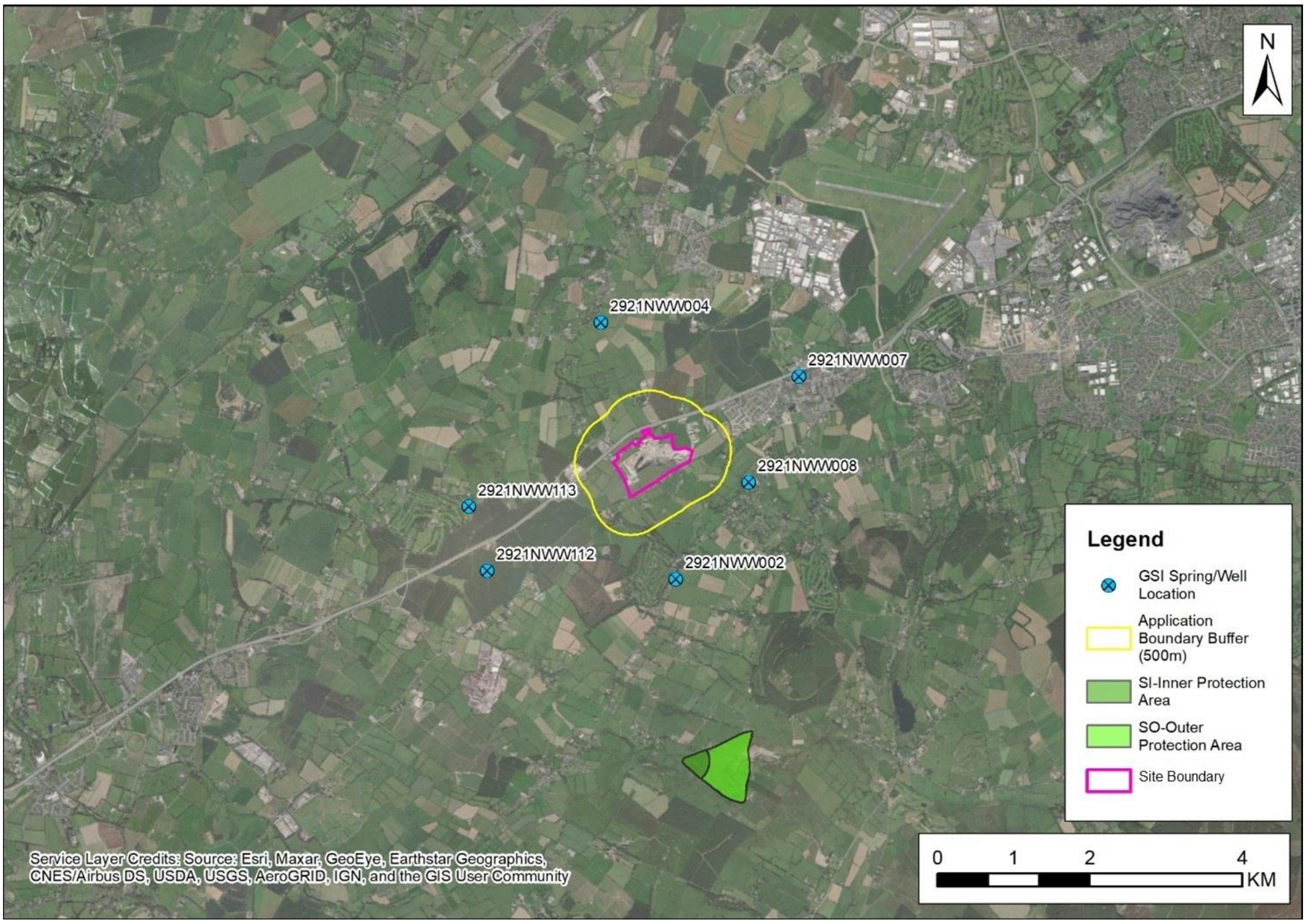

Figure 6.17: Regional Groundwater Source Protection Zones, Abstraction Boreholes and Springs (after GSI, 2021).

On-Site water supply wells and wastewater infrastructure is described in Section 6.4.4. In 2013, it was reported that there were three private wells located on land immediately adjacent to the Site: Well A, Well B and Yard Well (Byrne Environmental, 2015; see Figure 6.11). Viridus Consulting (2020) again identified the presence of these three wells, as well as a farm trough reportedly fed by groundwater located north of the quarry adjacent to the N7 roadway and an additional well located to the south of the Site at L. Behan's House. In 2021, only one on-Site well is identified (Figure 6.2).

In addition to the aforementioned water users, the location of the current local Irish Water network, associated residential/commercial supplies and foul water discharges are shown on Figure 6.18. Records of public planning applications for the local area have been used to identify private water supply wells and wastewater treatment facilities (e.g. septic tanks). Where water supply wells or wastewater systems could not be identified using planning records, these have been inferred where residential properties exist. These public records and interpreted water supply wells and wastewater treatment systems are also shown on Figure 6.18.

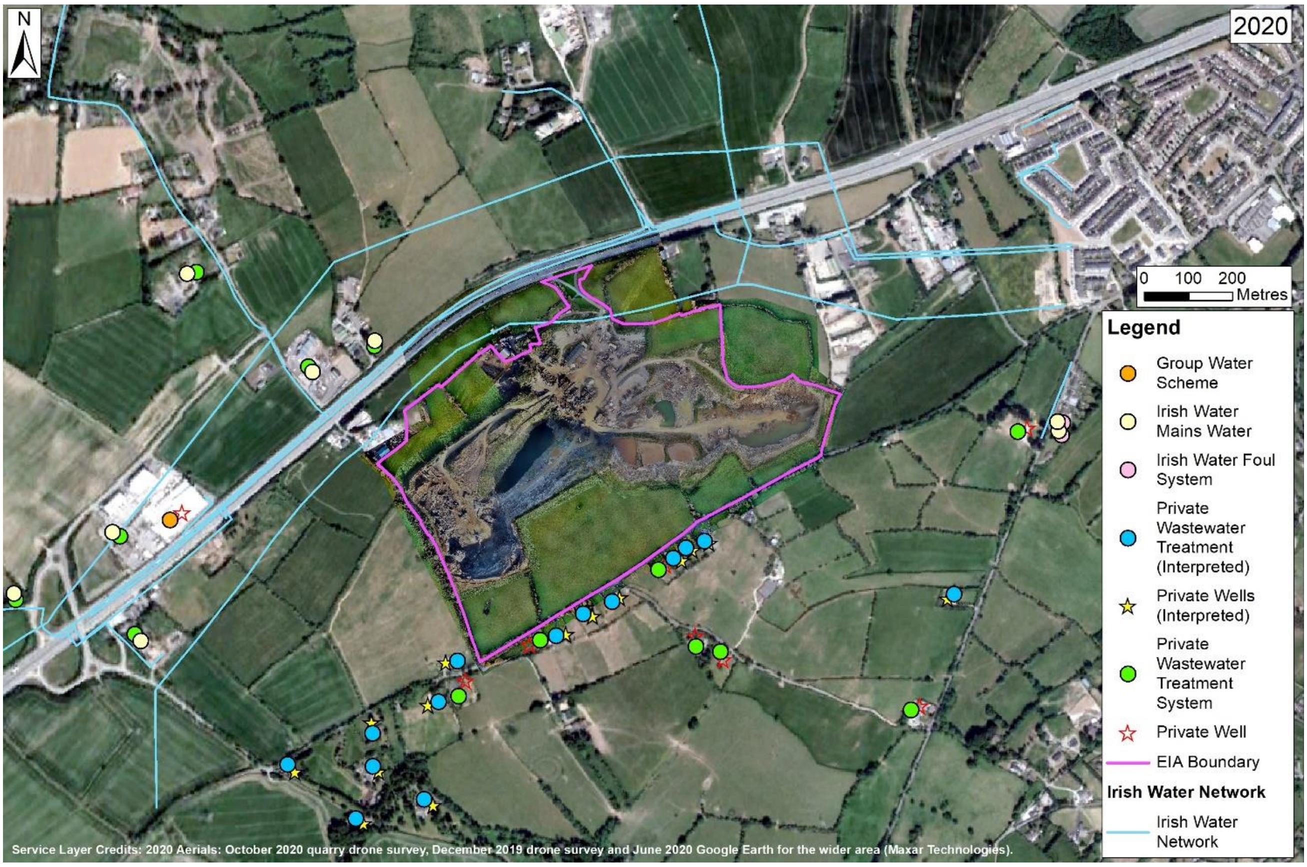

Figure 6.18: Local Water Mains (Irish Water), Foul Water Systems (Irish Water), Private Water Supply Wells and Private Wastewater Treatment Systems (in 2021, aerial imagery is from 2020).

Groundwater is used locally for domestic water supply in areas not serviced by the public mains water. There is interpreted to be a number of private wells located along the county roadway to the south of the Site. The closest interpreted water users are located approximately 0.3 km south (and upgradient) of the Site. The remaining area to the northeast and west of the Site are serviced by the public main water. This is consistent with local conditions reported in 2015 (Byrne Environmental, 2015) and aerial photography suggests that most residences were already present in 1990.

Additional to the above sources, the GSI online mapping tool (GSI, 2021) also holds records of groundwater boreholes or springs in the surrounding area; the location of wells identified within a 2.5 km radius are shown on Figure 6.17. Where information is available, these boreholes or springs are typically reported as have poor yield (ca. 21-28 m^3/day) and are used as agriculture or domestic supplies. GSI records held for these wells or springs state they were all in existence prior to 1990, with the exception of borehole 2921NWW002 (GSI reference), which is noted to have been drilled in 1999.

It is noted that, throughout the review period, the active quarrying areas have remained at least 100 m away from the Irish Water public mains supply (also referred to as the Liffey Aqueduct Arterial Culvert in Byrne Environmental, 2013a) which runs underneath the Site entrance road and within the Site boundary. The mains water is reported to be buried at a depth of more than 3 m below ground (Trinity Green, 2013). Potential impacts of the Site upon this mains water infrastructure are considered further in the Material Assets chapter (Chapter 12.0).

6.4.11 Water Balance

As discussed in Section 6.4.4, in 2021 groundwater is used at the Site for various activities. Detailed records of water usage on Site are not available, however using professional judgement and following discussion with the Applicant, estimates of operational water requirements are provided in Table 6.12.

Table 6.12: Estimated Site Operational Water Usage.

Site Use	Abstraction Source	Estimated Usage (m^3/day)	Estimated Usage (m^3/year)*
Hand washing and toilet flushing	Office Well	2	520
Wheel wash facilities	Office Well	2	520
Aggregate washing	West Pond	250	65,000
Total Volumes Required		254	66,040

**Assumes operational use of 5 days a week, 260 days per year.*

An estimate of the groundwater flow into the western pit under pumped conditions has been calculated using Darcy's Law (Oxford Reference, 2021) and is presented in Table 6.13. The calculated groundwater inflows to the west pit of 0.4 m^3/day and 146 m^3/year are noted to be low and whilst not unexpected for a poorly productive aquifer, there is potential for actual inflows to be up to an order of magnitude higher.

Table 6.13: Estimate of Groundwater Flow into the Western Pond Under Pumped Conditions.

Parameter	Value	Units	Source of Value
Hydraulic Conductivity (K)	1.00×10^{-3}	m/d	Maximum of range for cemented sandstone presented in Table 6.7 (Driscoll, 1986). Maximum used to reflect potential for localised enhanced hydraulic conductivity due to blasting.
Area (A)	6,235	m^2	Upgradient pond wall (pond depth multiplied by pond length)
Hydraulic Gradient (i)	0.063	-	Estimated based on 2021 contours
Depth of pond (D)	30	m	Assumes pond elevation of 150 mAOD and base elevation of 120 mAOD
Length of pond (L)	215	m	Upgradient pit wall length
Flow (Q) into pond	0.4	m^3/day	Calculated using Darcy's Law (Q=KAi)
Flow (Q) into pond	146	m^3/year	Calculated using Darcy's Law (Q=KAi)

A simplistic Site-wide water balance is presented in Table 6.14 and estimates that after Site water requirements are met, then up to an additional 97 m^3/day of water may be required to be managed by the Site (e.g. via ponding or discharge to the culvert) to maintain a pond water level of ca. 150 mAOD following periods of prolonged rainfall. It is however noted that operational water use is not well defined and recorded measurements would provide greater insight.

Table 6.14: 2021 Site-Wide Water Balance

Parameter		Value	Units	Source
1	Average rainfall	1,023	mm/year	As per Table 6.5
2	Effective rainfall	416	mm/year	GSI Mapping (GSI, 2021)
3	Recharge to groundwater	100	mm/year	GSI Mapping (GSI, 2021)
4	Available rainfall (after recharge)	316	mm/year	(2) minus (3)
5	Groundwater flow into west pond	146	m^3/year	As per Table 6.13
6	Operational site area	288,000	m^2	Operational area in 2021
7	Available water	91,154	m^3/year	(4) multiplied by (6) + (5)
8	Site operational usage	66,040	m^3/year	As per Table 6.12
9	Residual water ponded or discharged to culvert	25,114	m^3/year	(7) minus (8)
10	Residual water ponded or discharged to culvert	97	m^3/day	Operates periodically following periods of prolonged rainfall r

6.5 Hydrological and Hydrogeological Conceptual Model

This section describes the hydrogeological conceptual model for the Site summarising the information contained in Section 6.4 of this report.

Water enters the Site through direct rainfall precipitation and via the movement of groundwater through the subsurface which predominantly flows from southeast to northwest, coincident with local topography. In the excavated areas of the Site in the eastern and western areas water is present in the lowest elevations of the pits. The excavations on the Site intersect the groundwater table and therefore ponds are considered to be a mix of both groundwater and rainfall. Once present in the pit this water mass will be subject to evaporation and will provide some recharge to the underlying bedrock. Rainfall on other areas of the Site will predominantly infiltrate the ground where it will be subject to evapotranspiration or become groundwater. The stripping and/or removal of unsaturated ground will have lowered the ability of the Site to accept recharge to ground in excavated areas.

Flow in the bedrock is likely to be predominantly confined to bedding planes, faults and fractures due to the fine-grained, low porosity nature of the bedrock. The Site is located on the northern limb of a syncline which dips around 50° to the south east which is anticipated to restrict flow along bedding planes. No faults are reported to cross the Site, with the closest fault located approximately 0.8 km from the Site. Connectivity of fracture sets within the bedrock is expected to be low, with limited lateral connectivity (tens of meters from the Site) and decreasing hydraulic conductivity with depth as weathering of the rock reduces. There may be zones of increased hydraulic conductivity in the unexcavated upper weathered zones (or shallow zones subject to blasting) which can allow for rapid infiltration of rainwater.

Local surface water features are predominantly fed by rainfall runoff from higher topographical areas which collect in natural gullies and form headwaters for tributaries to larger streams and rivers. The topography of the Site and the surrounding area means that surface water runoff from the Site (e.g. in the event of flooding from the Site) could eventually reach the N/M7 dual carriageway or contribute to the River Griffeen.

As part of the water management system on the Site, water abstracted from the western quarry pit is periodically discharged following periods of prolonged rainfall to a culvert located on the northern portion of the Site adjacent to the N7 roadway. Water from this culvert is discharged into the roadway drainage system. It is unknown where the water in the roadway drainage system flows to from this point and it may discharge to a tributary of the River Griffeen near Rathcoole.

It is possible that relic and current infrastructure on the Site may form potential pathways between the ground surface and the groundwater table. Boreholes from previous water abstraction points are thought to still be present on the Site and may not be backfilled or decommissioned. As such these present a potential contamination pathway from surface.

6.6 Selection of Sensitive Receptors

Taking into account the conceptual model for the Site presented in Section 6.5 and the methodology for assessment presented in Section 6.3, the receptors and their assigned sensitivity are presented in Table 6.15.

Table 6.15: Water Receptors

Receptor	Reasoning	Sensitivity
Groundwater – quality and availability due to use as a resource and wider regulatory requirement to maintain good quality status	Bedrock under the Site is classified as a poorly productive aquifer with limited fracture connectivity (tens of metres). Local supplies are generally low yield, supporting single household domestic properties. Abstraction is shown to only cause dewatering close to the pit due to limited off-Site hydraulic connectivity.	**Negligible**
Surface Water – quality and availability due to use as a resource and wider regulatory requirement to maintain good quality status.	Downgradient river (River Griffeen) is classified as Good by WFD and likely in hydraulic connectivity with the Site via discharge to N/M7 dual carriageway drainage system.	**Medium**
Flooding – changes in presence and water flows on infrastructure immediately adjacent and downstream of the Site.	N/M7 dual carriageway is of national importance but not in flood risk area when Site is under pumped conditions. Potential exists for discharge from the Site to enter a tributary of the River Griffeen close to Rathcoole. Local area is predominantly at low	**Low**

Receptor	Reasoning	Sensitivity
	risk of flooding, with floodplains of limited extent (ca. 50-100 m) and limited residential or commercial development. Discharge volumes from the Site are unlikely to change flood risk.	
Flooding – changes in presence and water flows for on-Site plant and infrastructure.	Local importance, Site not in surface water flood risk area. Site is not at risk of flooding under pumped conditions.	**N/A (no pathway)**
Human Health – existing off-Site water users, water availability and quality	Bottled water is used to supply drinking water on Site. Existing water well users are located adjacent to the Site but are not considered to be in hydraulic connectivity with the Site. Irish Water public mains water supply also passes under the Site entrance road but is not considered to be in hydraulic connectivity with the Site.	**N/A (no pathway)**
Natura 2000 Designated Sites – degradation of protected sites due to changes in water quality or quantity (South Dublin Bay SAC and South Dublin Bay and River Tolka SPA)	Designated SAC/SPA site located 34 km from Site, measured in terms of possible hydrological pathway. Distance and dilution along pathway would mitigate against effects.	**High**
Natura 2000 Designated Sites – degradation of protected sites due to changes in water quality or quantity	Nearest SAC sites are 8.1 km from the Site and not considered to be in hydraulic connectivity with the Site.	**N/A (no pathway)**

6.7 Characteristics of the Development

The characteristics of the Development with regards to water are outlined in Sections 6.4.1 to 6.4.4. The conceptual restoration plan is presented as part of this substitute consent application.

6.7.1 Embedded Mitigation

In order to avoid the potential impacts to the water environment during the development on the Site since 1990 embedded design and commonly undertaken good practice mitigation measures were in place at the Site, these include/included:

- A holding tank and portable toilets are used on the Site, and are appropriately managed and maintained to prevent leaks to ground and the water environment. Equally welfare facilities on the Site and all plumbing are well maintained;
- Wheel washing is undertaken on the Site to reduce the deposition of material on the surrounding road network that could get into the water environment. Maintenance is undertaken to desilt the wheel wash facilities and avoid overflows of wash water. Wastewater from the wheel washes is contained within concrete structures rather than disposed of directly to ground;
- Wash water generated by the crushing, washing, screening and bagging plant is directed towards a water treatment tank where flocculant is added prior to discharging to contained silt ponds. The silt ponds are located above the groundwater table and are not allowed to overflow;
- A concrete plant is present on the Site which by design should be constructed such that no direct discharges to ground are allowed;
- Several storage tanks for diesel, vegetable oil and bitumen are associated with the asphalt plant. These are bunded with reinforced concrete and are secured to prevent vandalism (Byrne Environmental, 2013a);
- Refuelling takes place on hardstanding in a designated area of the Site and plant is well maintained to prevent uncontained releases of hydrocarbons to the ground (as confirmed by water quality results). It is noted that a hydrocarbon interceptor is installed at the Site;
- With specific reference to EPA guidance[5] on private well protection, there is a minimum of 30 m between potable wells and any sewage holding tanks or fuel storage, and a minimum of 5 m between a potable well and chemical storage;
- Bottled water is used for drinking water supply on-Site. Abstracted groundwater is only used for operational use in plant or for toilet flushing and hand washing in the offices;
- Runoff from the floor (and faces) of all areas of the extraction area slope towards a low elevation point on the Site to prevent any surface water run-off flowing from the Site;
- Pumping is employed to reduce the water level within the excavated areas and thereby reduces flood risk;
- Pumped water is only discharged at the discharge culvert following periods of prolonged rainfall. Discharged water does not come into contact with ‘dirty’ water from the washing plant; and
- Generally, works outside of the excavation areas are undertaken above the groundwater table limiting the connectivity of the groundwater with any potential sources.

When assessing and evaluating the potential effects of this Development on the water environment, these embedded mitigation measures are taken into consideration.

6.8 Potential Effects

The main activities which have been conducted during the development of the Site since 1990 and may cause an impact upon the water environment are as follows:

- Earthwork activities (e.g. excavation of quarry, movement of material);
- Pumping and dewatering of the quarry pits;

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[5] http://kildare.ie/CountyCouncil/Environment/SepticTanksorDomesticWasteWaterTreatmentSystems/SS%20Wells%20Web.pdf

- Blasting of rock using explosives;
- Crushing and washing of excavated rock;
- Use and parking of mechanical plant on the Site for excavation activities;
- Storage of hydrocarbons associated with the refuelling and asphalt production;
- Mixing and production of concrete; and
- Use of welfare facilities and holding tank.

Without mitigation additional to that which is already embedded in the Site infrastructure and design, the Site has the potential to have caused the following impacts over the review period:

- Changes in groundwater or surface water quality due to rock blasting, crushing or washing activities;
- Changes in surface water or groundwater quality due to releases from the asphalt, concrete or washing plant;
- Changes in surface water or groundwater quality from wastewater generated by on-Site welfare, holding tank and wheel wash facilities;
- Changes in surface water or groundwater quality from uncontrolled material storage;
- Changes in surface water or ground water quality caused by hydrocarbon leaks from fuel storage tanks or the unmanaged spillage of fuels or lubricants from Site plant or vehicles;
- Changes in groundwater levels and flow directions as a result of pumping; and
- Increased flooding risk due to off-Site discharge of pumped water via the Site discharge culvert.

6.8.1 Evaluation of Potential Effects

Using the methodology set out in Section 6.3 and the potential effects detailed above, an evaluation and assessment of the potential effects on the identified sensitive receptors is presented in Table 6.16. This assessment takes consideration of the embedded mitigation.

The magnitudes associated with the potential impacts at the Site are assigned either a negligible or low value due to:

- Limited off-Site hydraulic connectivity of groundwater has limited the migration of contaminants from the Site and localised the drawdown to areas immediately adjacent to the excavated areas throughout the review period;
- Low or undetected concentrations of hydrocarbons in groundwater and surface water throughout the review period and the presence of embedded mitigation to prevent contaminant migration;
- No exceedances of surface water EQS threshold values for inland waters and generally good quality of water in the River Griffeen observed throughout the review period (Appendix 6.2);
- The estimated low volumes of discharge to the culvert.

Combined with the negligible, low or medium sensitivity of the identified receptors, the potential adverse effects caused by the Site through the review period are **imperceptible or slight.**

Table 6.16: Evaluation of Initial Impacts and their Effect Significance

Project Phase	Receptor	Sensitivity	Source of Impact/Description of Change*	Impact Magnitude*	Level of Effect*
Operational	Groundwater	Negligible	Change in groundwater quality due to rock blasting, crushing and washing activities.	Low (adverse), direct, short term, reversible	Imperceptible or slight
			Change in groundwater quality due to releases from the asphalt or concrete plant.	Negligible (adverse), direct, short term, reversible	Imperceptible
			Change in groundwater quality from wastewater generated by on-Site welfare units, holding tank and wheel wash facilities.	Negligible (adverse), direct, short term, reversible	Imperceptible
			Change in groundwater quality from uncontrolled material storage.	Negligible (adverse), direct, short term, reversible	Imperceptible
			Change in groundwater quality caused by hydrocarbon leaks from fuel storage tanks or the unmanaged spillage of fuels or lubricants from plant or vehicles.	Negligible (adverse), direct, short term, reversible	Imperceptible
			Changes in groundwater levels and flow directions as a result of pumping.	Low (adverse), direct, temporary, reversible	Imperceptible or slight
	Surface Water	Medium	Change in surface water quality due to rock blasting, crushing or washing activities.	Negligible (adverse), indirect, short term, reversible	Imperceptible or slight
			Change in surface water quality due to releases from the asphalt, concrete plant.	Negligible (adverse), indirect, short term, reversible	Imperceptible or slight
			Change in surface water quality from wastewater generated by on-Site welfare units, holding tank and wheel wash facilities.	Negligible (adverse), indirect, short term, reversible	Imperceptible or slight

Project Phase	Receptor	Sensitivity	Source of Impact/Description of Change*	Impact Magnitude*	Level of Effect*
			Change in surface water quality from uncontrolled material storage.	Negligible (adverse), indirect, short term, reversible	Imperceptible or slight
			Change in surface water quality caused by hydrocarbon leaks from fuel storage tanks or the unmanaged spillage of fuels or lubricants from plant or vehicles.	Negligible (adverse), indirect, short term, reversible	Imperceptible or slight
	Flooding	Low	Increased flooding risk due to off-Site discharge of pumped water via the Site discharge culvert	Negligible (adverse), indirect, temporary, reversible	Imperceptible
	SAC/SPA	High	Change in surface water quality due to rock blasting, crushing or washing activities.	Negligible (adverse), indirect, short term, reversible	Slight
			Change in surface water quality due to releases from the asphalt, concrete plant.	Negligible (adverse), indirect, short term, reversible	Slight
			Change in surface water quality from wastewater generated by on-Site welfare units, holding tank and wheel wash facilities.	Negligible (adverse), indirect, short term, reversible	Slight
			Change in surface water quality from uncontrolled material storage.	Negligible (adverse), indirect, short term, reversible	Slight
			Change in surface water quality caused by hydrocarbon leaks from fuel storage tanks or the unmanaged spillage of fuels or lubricants from plant or vehicles.	Negligible (adverse), indirect, short term, reversible	Slight

* Taking account of embedded mitigation

6.9 Remedial Measures Required

Whilst the potential effects are shown to be **imperceptible or slight** (Section 6.8), in order to further mitigate the effects associated with the Development as it currently stands on the water environment and human health, the following additional remedial mitigation measures should be carried out:

- Wastewater from the wheel washes should be discharged via the on-Site hydrocarbon interceptor;
- Maintenance of vehicles and plant on Site should be carried out on hardstanding in the refuelling area where the hydrocarbon interceptor is located;
- An emergency spill kit (including absorbers) should be available for use in the event of an accidental spill on the quarry floor and key personnel trained in its use;
- Whilst it is acknowledged that potential contaminant migration pathways are short (tens of metres), any disused / redundant boreholes on the Site should be properly decommissioned so as to not pose additional potential pathways for surface contamination to reach the groundwater table;
- Discharges to the on-Site culvert should be further delineated to determine the flow path once it has been discharged from the Site and joined the N/M7 Dual carriageway drainage system;
- Dewatering and pumping from the quarry pits should be kept to a minimum (volume and duration) to avoid changes to the groundwater elevation and flow direction and to further protect the supply for other water users;
- Bottled water should continue to be used for drinking water on-Site;
- The Silt ponds should be inspected regularly for signs of any hydrocarbon contamination or for structural defects that may cause a leak of material or collapse of infrastructure; and
- Establish a formal Environmental Management Plan (EMP) for the Site and establish good record keeping of incidents and water use including pumping rates during future activities.

6.10 Residual Effects

The assessment concludes that the existing Development has not given rise to significant adverse effects on the water environment at or surrounding the Site during the review period of 1990 to 2021. In all cases the residual adverse effect is **not significant and not greater than slight.**

6.11 Cumulative Effects

There is potential for the effects caused by the Site to have cumulative effects with the following:

- Groundwater abstraction could combine with adjacent residential properties to dewater the aquifer;
- Hydrocarbons and suspended solids captured in the pond and discharged via the culvert could combine with sources arising from runoff from the N/M7 dual carriageway;
- Effects on surface water quality or flood risk in the River Griffeen could combine downstream with discharges from Rathcoole, Greenogue Business Park or Casement Aerodrome.

However, due to the predominant lack of hydraulic connectivity and **imperceptible or slight** nature of the effects assessed, there is not considered to be any potential for cumulative impacts to occur.

6.12 Monitoring

The following water monitoring is recommended to be carried out at the Site going forward, to monitor and allow mitigation of any future effects caused by continuation of the works:

- Groundwater level – groundwater levels should be monitored at the four borehole locations (BH1-BH4) and also at the on-Site ponds (SW1-SW2) on a minimum of a quarterly basis to monitor the effects of pumping and dewatering from the excavated areas.
- Groundwater quality – groundwater quality should be monitored on a minimum of a quarterly basis to capture any off-Site migration of impacts on water quality. As a minimum, monitoring should be completed at the four borehole locations (BH1-BH4) and also at the on-Site ponds (SW1-SW2).
- Discharge water quality – monthly quality samples should be collected at the culvert discharge point to assess the quality of water leaving the Site. Reassessment of the effect should be carried out if quality exceeds surface water EQS threshold values for inland waters.
- Abstraction, usage and discharge volumes – daily records of abstractions, discharges and on-Site water usage should be kept going forward, in order to appropriately characterise water movements on-Site and off-Site.

6.13 Difficulties Encountered

During this assessment the following have been noted which have caused difficulty is assessing the impacts on the water environment retrospectively, although they are not considered likely to have affected the outcome of the assessment:

- There is no available groundwater quality or elevation data from 1990;
- There is no surface water quality data from 1990;
- The pre-quarrying groundwater elevation is not known and an estimated ‘rest’ groundwater elevation is based on interpretation of aerial photography and topographical surveys;
- Assumptions have been made as to the infrastructure associated with the residential properties located in close vicinity to the southern boundary; and
- Water abstraction, use and discharge rates are not measured on-Site and are therefore estimated.

6.14 Summary and Conclusions

This assessment considers the potential impacts and effects on the water environment over the period of operation at the quarry Site since 1990.

Efforts were made to establish baseline conditions from 1990 and any changes in the quality of the water environment at the Site during the operational period since then, through desk-based review of available groundwater and surface water data, accessing publicly available data and, interrogation of recent groundwater and surface water quality data.

The main receptors that could be affected by changes to the water environment due to activities undertaken at the Site through the review period were identified and potential effects were assessed. Receptor linkages are limited by the low potential for hydraulic connectivity of groundwater at the Site with the surrounding area. Identified receptors in hydraulic connectivity with the Site were groundwater, surface water and flood risk areas. Receptor pathways for Natura 2000 sites and human health were not identified.

Known design and embedded mitigation measures were considered during the initial assessment of impacts and effects. Where additional mitigation measures could be incorporated to reduce the impacts and effects further, these were identified. A residual assessment of impacts and effects was not required and there were no potential cumulative effects identified.

A small number of difficulties were encountered during this assessment (such as lack of early baseline data) and recommendations for ongoing monitoring at the Site have been presented.

In summary, the significance of effects arising to selected receptors resulting from the different potential impact sources are predicted to be **negligible or slight and therefore not significant** in terms of this assessment.

6.15 References

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APPENDIX 6.1

River Quality Data Summary Table

Table 6-1: Summary of Available River Quality Data 1995-2003

River Monitoring Station	Year	Analyte	No of Samples	Minimum	Average	Maximum	Units
09G01 0090	2001	BOD	5	-2	-2	-2	mg/l
09G01 0090	2002	BOD	6	-2	-1.2	2	mg/l
09G01 0090	2003	BOD	8	-2	1.2	2	mg/l
09G01 0090	2001	Conductivity @25 °C	5	555	582	598	µS/cm
09G01 0090	2002	Conductivity @25 °C	6	581	626	654	µS/cm
09G01 0090	2003	Conductivity @25 °C	8	512	618	676	µS/cm
09G01 0090	2001	Dissolved Oxygen	5	93	106	139	% Sat
09G01 0090	2002	Dissolved Oxygen	6	92	98	107	% Sat
09G01 0090	2003	Dissolved Oxygen	8	91	101	115	% Sat
09G01 0090	2001	Dissolved Oxygen	5	9.5	11.2	14.2	mg/l
09G01 0090	2002	Dissolved Oxygen	6	9.4	10.4	11.1	mg/l
09G01 0090	2003	Dissolved Oxygen	8	9.3	10.7	11.8	mg/l
09G01 0090	2001	Nitrate	5	1.08	3.19	4.65	mg/l
09G01 0090	2002	Nitrate	6	2.59	3.88	5.32	mg/l
09G01 0090	2003	Nitrate	8	2.65	3.83	5.32	mg/l
09G01 0090	2001	Nitrite	5	-0.01	0.009	0.017	mg/l
09G01 0090	2002	Nitrite	6	0.023	0.033	0.043	mg/l
09G01 0090	2003	Nitrite	8	0.021	0.032	0.044	mg/l
09G01 0090	2001	Ortho-Phosphate	5	0.02	0.06	0.18	mg/l
09G01 0090	2002	Ortho-Phosphate	6	0.03	0.09	0.17	mg/l
09G01 0090	2003	Ortho-Phosphate	8	0.03	0.09	0.2	mg/l
09G01 0090	2001	pH	5	7.9	8.1	8.2	pH Units
09G01 0090	2002	pH	6	7.9	8.2	8.4	pH Units
09G01 0090	2003	pH	8	7.9	8.2	8.4	pH Units
09G01 0090	2001	Temperature	5	6.5	10.9	15.3	°C
09G01 0090	2002	Temperature	6	5.9	10.5	15.3	°C
09G01 0090	2003	Temperature	8	5.8	10.6	15.2	°C
09G01 0090	2001	Total Ammonium	5	0.04	0.05	0.07	mg/l
09G01 0090	2002	Total Ammonium	6	0.07	0.08	0.1	mg/l
09G01 0090	2003	Total Ammonium	8	0.09	0.12	0.17	mg/l
09G01 0090	2001	Total Oxidised Nitrogen (TON)	5	2.84	3.49	4.4	mg/l
09G01 0090	2002	Total Oxidised Nitrogen (TON)	6	1.79	3.25	4.61	mg/l
09G01 0090	2003	Total Oxidised Nitrogen (TON)	8	1.98	3.10	4.36	mg/l
09G01 0090	2001	Un-ionised Ammonia	5	0.000845	0.0023953	0.0047727	mg/l
09G01 0090	2002	Un-ionised Ammonia	6	0.001767	0.0028822	0.0043566	mg/l
09G01 0090	2003	Un-ionised Ammonia	8	0.002477	0.0036144	0.0055827	mg/l
09G01 0100	1995	Ammonia	3	0.049	0.208	0.327	mg/l
09G01 0100	1998	Ammonia	2	0.072	0.142	0.212	mg/l
09G01 0100	1999	Ammonia	2	0.151	0.196	0.241	mg/l
09G01 0100	2000	Ammonia	15	0.11811	0.302271	0.538409	mg/l
09G01 0100	1995	BOD	3	1.19	1.54	2.05	mg/l
09G01 0100	1998	BOD	4	1	1	2	mg/l
09G01 0100	1999	BOD	1	1	1	1	mg/l
09G01 0100	2001	BOD	5	-2	2	3	mg/l
09G01 0100	2002	BOD	6	-2	0	2	mg/l
09G01 0100	2003	BOD	8	-2	-2	-2	mg/l
09G01 0100	1995	Conductivity @ 20°C	3	589	633	662	µS/cm
09G01 0100	1998	Conductivity @ 20°C	4	642	673	736	µS/cm
09G01 0100	1999	Conductivity @ 20°C	3	664	680	703	µS/cm
09G01 0100	2000	Conductivity @ 20°C	16	565	659	694	µS/cm
09G01 0100	2001	Conductivity @25 °C	5	558	653	698	µS/cm
09G01 0100	2002	Conductivity @25 °C	6	587	672	716	µS/cm
09G01 0100	2003	Conductivity @25 °C	8	555	582	598	µS/cm
09G01 0100	1995	Dissolved Oxygen	2	89	95	100	% Saturation
09G01 0100	1998	Dissolved Oxygen	3	92	107	118	% Saturation
09G01 0100	1999	Dissolved Oxygen	3	91	94	98	% Saturation
09G01 0100	2000	Dissolved Oxygen	19	11.48	81.10	108.3	% Saturation

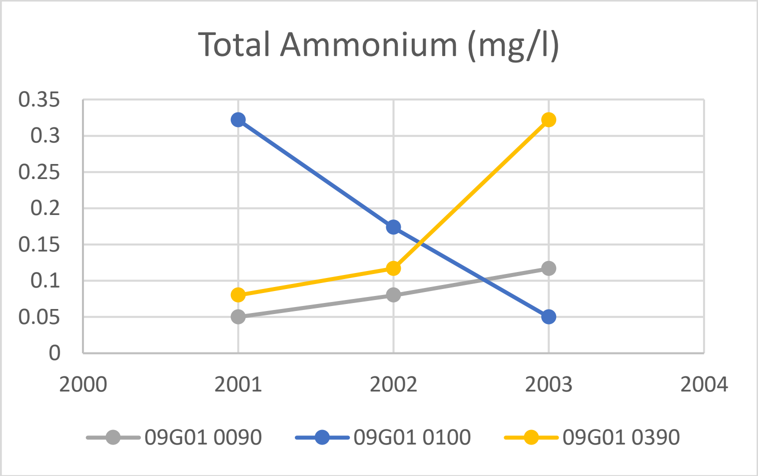
River Monitoring Station	Year	Analyte	No of Samples	Minimum	Average	Maximum	Units
09G01 0100	2001	Dissolved Oxygen	5	95	101	112	% Sat
09G01 0100	2002	Dissolved Oxygen	6	96	102	114	% Sat
09G01 0100	2003	Dissolved Oxygen	8	93	106	139	% Sat
09G01 0100	2001	Dissolved Oxygen	5	9.7	10.6	11.5	mg/l
09G01 0100	2002	Dissolved Oxygen	6	9.8	10.8	11.5	mg/l
09G01 0100	2003	Dissolved Oxygen	8	9.5	11.2	14.2	mg/l
09G01 0100	1995	Nitrate	3	2.817	4.442	5.353	mg/l
09G01 0100	1996	Nitrate	1	7.268	7.268	7.268	mg/l
09G01 0100	1998	Nitrate	3	27.2888	28.7743	31.4973	mg/l
09G01 0100	1999	Nitrate	2	29.81833	30.75306	31.68779	mg/l
09G01 0100	2000	Nitrate	1	26.8901	26.8901	26.8901	mg/l
09G01 0100	2001	Nitrate	5	2.34	3.39	4.74	mg/l
09G01 0100	2002	Nitrate	6	2.2	3.2	4.7	mg/l
09G01 0100	2003	Nitrate	8	1.08	3.19	4.65	mg/l
09G01 0100	1998	Nitrite	3	0.25584	0.29192	0.3444	mg/l
09G01 0100	1999	Nitrite	2	0.246	0.41492	0.58384	mg/l
09G01 0100	2000	Nitrite	15	0.105353	0.1834414	0.2797359	mg/l
09G01 0100	2001	Nitrite	5	0.025	0.031	0.036	mg/l
09G01 0100	2002	Nitrite	6	0.02	0.028	0.032	mg/l
09G01 0100	2003	Nitrite	8	-0.01	0.009	0.017	mg/l
09G01 0100	1995	Ortho-phosphate	2	0.079	0.174	0.268	mg/l
09G01 0100	1997	Ortho-phosphate	16	0.108	0.269	0.57	mg/l
09G01 0100	1998	Ortho-phosphate	4	0.063	0.119	0.164	mg/l
09G01 0100	1999	Ortho-phosphate	2	0.095	0.126	0.156	mg/l
09G01 0100	2000	Ortho-phosphate	15	0.07591	0.135133	0.218295	mg/l
09G01 0100	2001	Ortho-phosphate	5	-0.01	0.08	0.16	mg/l
09G01 0100	2002	Ortho-phosphate	6	-0.01	0.08	0.16	mg/l
09G01 0100	2003	Ortho-phosphate	8	0.02	0.06	0.18	mg/l
09G01 0100	1995	pH	3	8.15	8.27	8.4	pH units
09G01 0100	1998	pH	4	8.17	8.22	8.27	pH units
09G01 0100	1999	pH	3	7.98	8.09	8.2	pH units
09G01 0100	2000	pH	16	8.03	8.24	8.45	pH units
09G01 0100	2001	pH	5	7.9	8.3	8.4	pH Units
09G01 0100	2002	pH	6	8.1	8.3	8.4	pH Units
09G01 0100	2003	pH	8	7.9	8.1	8.2	pH Units
09G01 0100	1995	Phosphorous	3	0.079	0.507	1.174	mg/l
09G01 0100	1995	Suspended Solids	3	7	18	32	mg/l
09G01 0100	1995	Temperature	2	6.1	12.1	18.1	°C
09G01 0100	1998	Temperature	3	7.2	9.7	13.1	°C
09G01 0100	1999	Temperature	3	7.7	8.0	8.1	°C
09G01 0100	2000	Temperature	16	4.9	7.3	8.9	°C
09G01 0100	2001	Temperature	5	6.4	11.5	16.4	°C
09G01 0100	2002	Temperature	6	6.4	11.6	16.3	°C
09G01 0100	2003	Temperature	8	6.5	10.9	15.3	°C
09G01 0100	2001	Total Ammonium	5	0.08	0.32	1.03	mg/l
09G01 0100	2002	Total Ammonium	6	0.07	0.17	0.34	mg/l
09G01 0100	2003	Total Ammonium	8	0.04	0.05	0.07	mg/l
09G01 0100	2001	Total Oxidised Nitrogen (TON)	5	1.38	2.48	3.95	mg/l
09G01 0100	2002	Total Oxidised Nitrogen (TON)	6	1.49	2.52	3.82	mg/l
09G01 0100	2003	Total Oxidised Nitrogen (TON)	8	2.84	3.49	4.4	mg/l
09G01 0100	2001	Un-ionised Ammonia	5	0.002952	0.0098670	0.0304748	mg/l
09G01 0100	2002	Un-ionised Ammonia	6	0.002827	0.0080992	0.0230386	mg/l
09G01 0100	2003	Un-ionised Ammonia	8	0.000845	0.0023953	0.0047727	mg/l
09G01 0390	1995	Ammonia	3	0.026	0.126	0.273	mg/l
09G01 0390	1998	Ammonia	2	0.248	0.250	0.252	mg/l
09G01 0390	1999	Ammonia	2	0.129	0.187	0.244	mg/l
09G01 0390	2000	Ammonia	2	0.09	0.18	0.27	mg/l
09G01 0390	1995	BOD	3	1.76	2.34	3.49	mg/l
09G01 0390	1998	BOD	4	1	2	3	mg/l

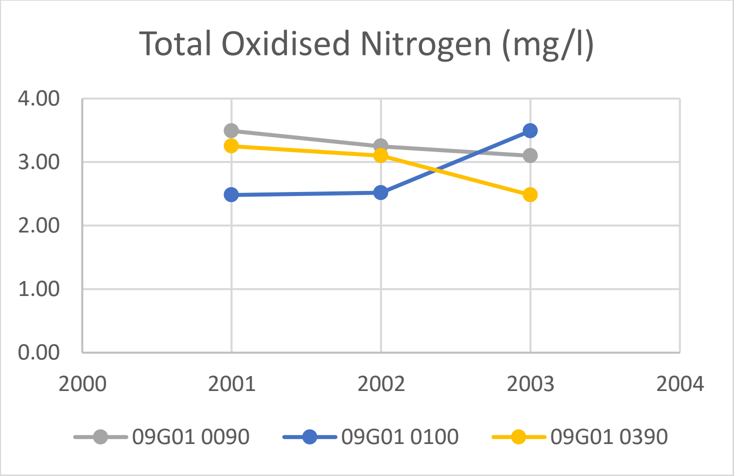
River Monitoring Station	Year	Analyte	No of Samples	Minimum	Average	Maximum	Units
09G01 0390	1999	BOD	2	1	1	1	mg/l
09G01 0390	2001	BOD	17	-2	-1	2	mg/l
09G01 0390	2002	BOD	18	-2	1	2	mg/l
09G01 0390	2003	BOD	20	-2	2	3	mg/l
09G01 0390	1995	Conductivity @ 20°C	3	594	648	689	µS/cm
09G01 0390	1998	Conductivity @ 20°C	4	655	691	757	µS/cm
09G01 0390	1999	Conductivity @ 20°C	3	688	693	697	µS/cm
09G01 0390	2000	Conductivity @ 20°C	2	699	706	712	µS/cm
09G01 0390	2001	Conductivity @ 25°C	17	581	626	654	µS/cm
09G01 0390	2002	Conductivity @ 25°C	18	512	618	676	µS/cm
09G01 0390	2003	Conductivity @ 25°C	20	558	653	698	µS/cm
09G01 0390	1995	Dissolved Oxygen	2	83	92	101	% Saturation
09G01 0390	1998	Dissolved Oxygen	3	94	106	114	% Saturation
09G01 0390	1999	Dissolved Oxygen	3	92	94	95	% Saturation
09G01 0390	2000	Dissolved Oxygen	2	94	95	95	% Saturation
09G01 0390	2001	Dissolved Oxygen	17	92	98	107	% Sat
09G01 0390	2002	Dissolved Oxygen	18	91	101	115	% Sat
09G01 0390	2003	Dissolved Oxygen	20	95	101	112	% Sat
09G01 0390	2001	Dissolved Oxygen	17	9.4	10.4	11.1	mg/l
09G01 0390	2002	Dissolved Oxygen	18	9.3	10.7	11.8	mg/l
09G01 0390	2003	Dissolved Oxygen	20	9.7	10.6	11.5	mg/l
09G01 0390	1995	Nitrate	3	1.941	4.109	5.394	mg/l
09G01 0390	1996	Nitrate	1	7.346	7.346	7.346	mg/l
09G01 0390	1998	Nitrate	3	26.87681	28.69459	31.8517	mg/l
09G01 0390	1999	Nitrate	2	29.93794	30.70876	31.47958	mg/l
09G01 0390	2000	Nitrate	2	25.6054	28.0198	30.4341	mg/l
09G01 0390	2001	Nitrate	17	2.59	3.88	5.32	mg/l
09G01 0390	2002	Nitrate	18	2.65	3.83	5.32	mg/l
09G01 0390	2003	Nitrate	20	2.34	3.39	4.74	mg/l
09G01 0390	1998	Nitrite	3	0.31816	0.35096	0.3772	mg/l
09G01 0390	1999	Nitrite	2	0.2952	0.43788	0.58056	mg/l
09G01 0390	2000	Nitrite	2	0.1312	0.1312	0.1312	mg/l
09G01 0390	2001	Nitrite	17	0.023	0.033	0.043	mg/l
09G01 0390	2002	Nitrite	18	0.021	0.032	0.044	mg/l
09G01 0390	2003	Nitrite	20	0.025	0.031	0.036	mg/l
09G01 0390	1995	Ortho-phosphate	2	0.095	0.122	0.148	mg/l
09G01 0390	1997	Ortho-phosphate	16	0.115	0.315	0.658	mg/l
09G01 0390	1998	Ortho-phosphate	4	0.117	0.148	0.2	mg/l
09G01 0390	1999	Ortho-phosphate	2	0.095	0.126	0.156	mg/l
09G01 0390	2000	Ortho-phosphate	3	0.08	0.1	0.1	mg/l
09G01 0390	2001	Ortho-Phosphate	17	0.03	0.09	0.17	mg/l
09G01 0390	2002	Ortho-Phosphate	18	0.03	0.09	0.2	mg/l
09G01 0390	2003	Ortho-Phosphate	20	-0.01	0.08	0.16	mg/l
09G01 0390	1995	pH	3	8.17	8.29	8.37	pH units
09G01 0390	1998	pH	4	8.23	8.26	8.28	pH units
09G01 0390	1999	pH	3	7.97	8.12	8.2	pH units
09G01 0390	2000	pH	2	8.1	8.1	8.1	pH units
09G01 0390	2001	pH	17	7.9	8.2	8.4	pH Units
09G01 0390	2002	pH	18	7.9	8.2	8.4	pH Units
09G01 0390	2003	pH	20	7.9	8.3	8.4	pH Units
09G01 0390	1995	Phosphorous	3	0.095	0.494	1.239	mg/l
09G01 0390	1995	Suspended Solids	3	6	11	18	mg/l
09G01 0390	1995	Temperature	2	6	12.3	18.6	°C
09G01 0390	1998	Temperature	3	7.3	9.8	13.2	°C
09G01 0390	1999	Temperature	3	7.7	8.0	8.2	°C
09G01 0390	2000	Temperature	2	4.6	6.4	8.1	°C
09G01 0390	2001	Temperature	17	5.9	10.5	15.3	°C
09G01 0390	2002	Temperature	18	5.8	10.6	15.2	°C
09G01 0390	2003	Temperature	20	6.4	11.5	16.4	°C

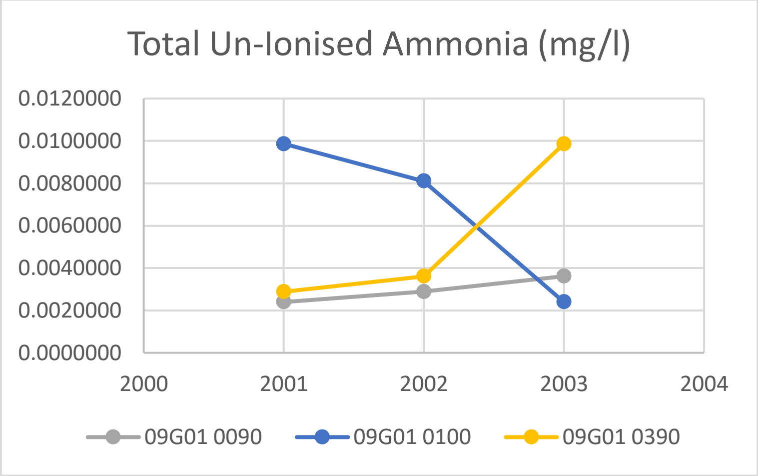
River Monitoring Station	Year	Analyte	No of Samples	Minimum	Average	Maximum	Units
09G01 0390	2001	Total Ammonium	17	0.07	0.08	0.1	mg/l
09G01 0390	2002	Total Ammonium	18	0.09	0.12	0.17	mg/l
09G01 0390	2003	Total Ammonium	20	0.08	0.32	1.03	mg/l
09G01 0390	2001	Total Oxidised Nitrogen (TON)	17	1.79	3.25	4.61	mg/l
09G01 0390	2002	Total Oxidised Nitrogen (TON)	18	1.98	3.10	4.36	mg/l
09G01 0390	2003	Total Oxidised Nitrogen (TON)	20	1.38	2.48	3.95	mg/l
09G01 0390	2001	Un-ionised Ammonia	17	0.001767	0.0028822	0.0043566	mg/l
09G01 0390	2002	Un-ionised Ammonia	18	0.002477	0.0036144	0.0055827	mg/l
09G01 0390	2003	Un-ionised Ammonia	20	0.002952	0.0098670	0.0304748	mg/l

Figure 6-1: Time Series Graphs of Key Water Quality Parameters

Figure 6-1: Time Series Graphs of Key Water Quality Parameters (cont.)







APPENDIX 6.2

GW and SW Sample Screening

Table 1: Screening of 2020-2021 Surface Water Samples

						Sample ID	SW1	SW1	L012100	T040400	T040300	G010100	G010150
						Description	On Site pit water		Headwater of River	Monitoring Station	Monitoring Station	Monitoring Station	Monitoring Station
						Sampled Date	18/06/2020	27/01/2021	27/01/2021	27/01/2021	27/01/2021	27/01/2021	27/01/2021
			Maximum Allowable Concentration (MAC)										
Test	Units	LOD	SI 272 of 2009 EQS for Inland SW	SI 286 of 2015 EQS for Inland SW	UK EQS Freshwater Specific Pollutants	UK EQS Freshwater Priority Hazardous Substances							
Dissolved Arsenic	µg/l	<2.5	-	-	-	-	32.6	69.9	10.3	3.3	6.2	7.8	10
Dissolved Boron	µg/l	<12	-	-	-	-	51	51	22	15	14	26	18
Dissolved Cadmium [1]	µg/l	<0.5	Variable	Variable	-	Variable	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Calcium	mg/l	<0.2	-	-	-	-	141.1	143	111.4	72.8	71.7	98.2	103.4
Total Dissolved Chromium [2]	µg/l	<1.5	32	-	32	-	1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dissolved Copper	µg/l	<7	-	-	-	-	<7	<7	<7	<7	<7	<7	<7
Dissolved Lead	µg/l	<5	-	14	-	14	<5	<5	<5	<5	<5	<5	<5
Dissolved Magnesium	mg/l	<0.1	-	-	-	-	20.1	19.8	13.8	5.3	5.2	6.9	9.4
Dissolved Mercury	µg/l	<1	0.07	0.07	-	0.07	<1	<1	<1	<1	<1	<1	<1
Dissolved Nickel	µg/l	<2	-	34	-	34	4	5	<2	<2	<2	<2	<2
Dissolved Potassium	mg/l	<0.1	-	-	-	-	14.3	13.4	5.5	1.2	1.3	2	1.9
Dissolved Selenium	µg/l	<3	-	-	-	-	<3	<3	<3	<3	<3	<3	<3
Dissolved Sodium	mg/l	<0.1	-	-	-	-	-	29.6	15.7	10.2	10.2	16.8	15.1
Dissolved Zinc	µg/l	<3	-	-	-	-	10	4	3	<3	<3	3	3
Total Hardness Dissolved (as CaCO3)	mg/l	<1	-	-	-	-	437	441	336	204	201	274	298
Methyl Tertiary Butyl Ether	µg/l	<0.1	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzene	µg/l	<0.5	50	50	-	50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/l	<5	-	-	380	-	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	µg/l	<1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1
m/p-Xylene	µg/l	<2	-	-	-	-	<2	<2	<2	<2	<2	<2	<2
o-Xylene	µg/l	<1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1
EPH (C8-C40)	µg/l	<10	-	-	-	-	<10	<10	<10	<10	<10	<10	<10
Sulphate as SO4	mg/l	<0.5	-	-	-	-	326	346.7	24.3	13.8	13.6	28.3	24.4
Chloride	mg/l	<0.3	-	-	-	-	32.9	28.5	42.3	17.2	17.4	33.2	30.9
Nitrate as NO3	mg/l	<0.2	-	-	-	-	30.9	33.6	16.3	12.8	12.9	14.2	21.4
Nitrite as NO2	mg/l	<0.02	-	-	-	-	0.18	0.53	<0.02	<0.02	<0.02	0.05	<0.02
Ortho Phosphate as PO4	mg/l	<0.06	-	-	-	-	<0.06	<0.06	0.16	<0.06	<0.06	0.1	<0.06
Total Oxidised Nitrogen as N	mg/l	<0.2	-	-	-	-	7	7.7	3.7	2.9	2.9	3.2	4.8
Ammoniacal Nitrogen as NH4	mg/l	<0.03	-	-	-	-	0.16	0.94	0.04	<0.03	0.04	0.07	0.04
Total Alkalinity as CaCO3	mg/l	<1	-	-	-	-	108	114	286	182	182	236	242
Dissolved Oxygen	mg/l	<1	-	-	-	-	9	-	-	-	-	-	-
Electrical Conductivity @25C	uS/cm	<2	-	-	-	-	1029	-	-	-	-	-	-
pH	pH units	<0.01	-	-	6-9	-	8.12	-	-	-	-	-	-
Total Organic Carbon	mg/l	<2	-	-	-	-	8	5	<2	<2	<2	<2	<2
Total Dissolved Solids	mg/l	<35	-	-	-	-	741	725	449	263	256	369	484

Exceeds Screening Value

'-' No Value

1. Screening value is variable dependent on the hardness of the water as CaCO3 (mg/l)

2. Screened against standard for Chromium III

Table 2: Retrospective Screening of 2006-2013 Surface Water Samples

					Sample ID	SW1	SW2 Tootenhill Stream		SW3
					Sampled Date	Jun-06	Jun-06	Sep-13	Feb-08
		Maximum Allowable Concentration (MAC)							
Test	Units	SI 272 of 2009 EQS for Inland SW	SI 286 of 2015 EQS for Inland SW	UK EQS Freshwater Specific Pollutants	UK EQS Freshwater Priority Hazardous Substances				
pH	pH Units	-	-	**6-9**	-	8.4	7.9	8.06	7.95
TSS	mg/l	-	-	-	-	<5	<5	2	<10
BOD	mg/l	-	-	-	-	<2	<2	<2	<2
COD	mg/l	-	-	-	-	<10	<10	8	<15
Ammonia as N	mg/l	-	-	-	-	<0.2	<0.2	<0.02	<0.2
TOC	mg/l	-	-	-	-	-	-	4.2	-
Nitrate as N [1]	mg/l	-	-	-	-	3.83	6.3	1.4	5.51
Chloride	mg/l	-	-	-	-	16	21	14.7	-
Phosphate	mg/l	-	-	-	-	0.02	<0.02	0.08	0.24
Calcium	mg/l	-	-	-	-	82	99	109	-
Sodium	mg/l	-	-	-	-	7.9	8.7	14	-
Magnesium	mg/l	-	-	-	-	6.1	15	9	-
Potassium	mg/l	-	-	-	-	0.4	0.9	2	-
Zinc	mg/l	-	-	-	-	-	-	<1	-
Arsenic	mg/l	-	-	-	-	-	-	3	-
Cadmium [2]	mg/l	Variable	Variable	-	Variable	-	-	<1	-
Chromium [3]	mg/l	**32**	-	**32**	-	-	-	<1	-
Nickel	mg/l	-	**34**	-	**34**	-	-	<1	-
Lead	mg/l	-	**14**	-	**14**	-	-	<1	-
Total Petroleum Hydrocarbons	mg/l	-	-	-	-	-	-	<50	-

Exceeds Screening Value

'-' No Value

1. Screened against standard for Nitrate as NO3
2. *Screening value is variable dependent on the hardness of the water as CaCO3 (mg/l)*
3. *Screened against standard for Chromium III*

Table 3: Screening of 2020-2021 Groundwater Samples

				Sample ID	BH01	BH02	BH03	BH04	BH01	BH02	BH03	BH04	L.BEHAN HOUSE	SILT POND 2	SW1	SW1
				Sampled Date	18/06/2020	18/06/2020	18/06/2020	18/06/2020	26/01/2021	26/01/2021	26/01/2021	26/01/2021	26/01/2021	27/01/2021	18/06/2020	27/01/2021
Test	Units	LOD	SI 9 of 2010, inc. SI 366 of 2016	EPA Interim GW Values											*On Site pit water*	
Dissolved Arsenic	µg/l	<2.5	7.5	10	4.7	33.9	13.7	471.3	12.7	17.4	24.8	7.2	13.3	6.1	32.6	69.9
Dissolved Boron	µg/l	<12	750	1000	18	15	32	16	17	21	23	<12	14	25	51	51
Dissolved Cadmium	µg/l	<0.5	3.75	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Calcium	mg/l	<0.2	-	200	53.3	55.3	49.9	39.6	54.8	88.1	54.8	60.7	68	112.2	141.1	143
Total Dissolved Chromium	µg/l	<1.5	37.5	30	<1.5	<1.5	12.9	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	1.8	1.5	<1.5
Dissolved Copper	µg/l	<7	1500	30	<7	<7	<7	<7	<7	<7	<7	<7	13	<7	<7	<7
Dissolved Lead	µg/l	<5	7.5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Magnesium	mg/l	<0.1	-	50	12.9	27.9	9.5	39.3	13.1	24.8	11.3	18.3	11.6	4.1	20.1	19.8
Dissolved Mercury	µg/l	<1	0.75	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Nickel	µg/l	<2	15	20	4	2	4	42	<2	<2	<2	2	<2	<2	4	5
Dissolved Potassium	mg/l	<0.1	-	5	0.7	0.9	4	3.7	0.5	0.7	3.4	0.5	0.5	6.2	14.3	13.4
Dissolved Selenium	µg/l	<3	-	-	<3	<3	16	<3	<3	<3	<3	<3	<3	<3	<3	<3
Dissolved Sodium	mg/l	<0.1	150	150	-	-	-	-	6.9	14.8	11.5	6.6	8.3	9.2	-	29.6
Dissolved Zinc	µg/l	<3	75000	100	5	5	<3	5	<3	4	<3	13	24	<3	10	4
Total Hardness Dissolved (as CaCO3)	mg/l	<1	-	200	187	255	165	264	192	324	184	229	219	298	437	441
Methyl Tertiary Butyl Ether	µg/l	<0.1	10	30	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzene	µg/l	<0.5	0.75	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/l	<5	525	10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	µg/l	<1	-	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
m/p-Xylene	µg/l	<2	-	10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
o-Xylene	µg/l	<1	-	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
EPH (C8-C40)	µg/l	<10	7.5	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Sulphate as SO4	mg/l	<0.5	187.5	200	16	62.8	58.5	20.2	7.1	98	37.5	7.6	9.4	283.5	326	346.7
Chloride	mg/l	<0.3	187.5	30	10.9	14.1	17.6	11.6	10.6	18.9	15	8.5	11.8	7.4	32.9	28.5
Nitrate as NO3	mg/l	<0.2	37.5	25	33.6	17.3	23.7	8.9	15.8	35.2	23.2	14	19.3	1.3	30.9	33.6
Nitrite as NO2	mg/l	<0.02	0.375	0.1	<0.02	<0.02	0.3	0.12	<0.02	<0.02	0.02	0.04	<0.02	0.42	0.18	0.53
Ortho Phosphate as PO4	mg/l	<0.06	-	0.03	<0.06	<0.06	<0.06	0.07	<0.06	<0.06	0.12	<0.06	<0.06	<0.06	<0.06	<0.06
Total Oxidised Nitrogen as N	mg/l	<0.2	-	NAC*	7.6	3.9	5.4	2	3.6	7.9	5.2	3.2	4.4	0.4	7	7.7
Ammoniacal Nitrogen as NH4[1]	mg/l	<0.03	0.065	-	0.1	0.05	0.09	<0.03	<0.03	<0.03	0.03	0.14	<0.03	0.15	0.16	0.94
Total Alkalinity as CaCO3	mg/l	<1	-	NAC*	158	176	130	260	180	212	140	218	206	32	108	114
Dissolved Oxygen	mg/l	<1	-	NAC*	9	9	7	7	-	-	-	-	-	-	9	-
Electrical Conductivity @25C	uS/cm	<2	1875	1000	415	527	447	512	-	-	-	-	-	-	1029	-
pH	pH units	<0.01	-	6.5 - 9.5	8.17	8.25	8.21	8.31	-	-	-	-	-	-	8.12	-
Total Organic Carbon	mg/l	<2	-	NAC*	<2	<2	4	<2	<2	<2	4	<2	<2	6	8	5
Total Dissolved Solids	mg/l	<35	-	1000	271	357	335	333	229	441	278	247	271	476	741	725

🟥 Exceeds Screening Value

'NAC' No Abnormal Change

'-' No Value

SW1 samples screened against groundwater standards in additon to surface water standards due to the potential for direct discharge to groundwater.

[1] Screened against lower range of overall threshold value range for Ammonium

Table 3: Retrospective Screening of 2007-2018 Groundwater Samples

		Report Reference		Byrne (2015)												
			Sample ID	MW1		MW2	Office Well		Chipping Plant Well	Well A			Well B	L. Behan House		Yard Well
			Sampled Date	2007	2010	2007	2007	2013	2007	2006	2007	2013	2007	2007	2013	2013
Test	Units	SI 9 of 2010, inc. SI 366 of 2016	EPA Interim GW Values													
Conductivity	uS/cm	1875	1000	634	540	763	800	724	748	621	624	478	536	503	546	160
pH	pH Units	-	6.5 - 9.5	7.9	7.6	7.7	7.7	7.31	7.6	7.3	7.7	7.4	6.99	7.6	7.2	7.72
Ammonia as N [1]	mg/l	0.175	-	<0.02	<0.2	<0.02	<0.02	<0.02	0.1	0.001	<0.02	<0.02	0.011	0.07	<0.02	<0.02
Ammonium as NH4 (calc) [2]	mg/l	0.065	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride	mg/l	187.5	30	19.4	18.8	24.1	31.7	11.8	22.1	10.1	28.8	9.4	-	11.6	15.9	6.4
Nitrate as N [3]	mg/l	37.5	25	13	3.2	5.1	5.3	1.0	<0.05	4.09	4.2	2.8	2.5	5.9	2.2	0.8
Nitrite as N [4]	mg/l	0.375	0.1	<0.03	<0.015	<0.03	<0.03	0.008	<0.03	0.019	<0.03	0.006	0.027	<0.03	0.007	0.008
Sulphate	mg/l	187.5	200	75	65.7	70.6	98.3	-	55	-	69.7	-	-	13.9	-	-
Calcium	mg/l	-	200	81	<0.012	90	99	82	78	-	75	73	-	82	92	39
Potassium	mg/l	-	5	1.8	<2.34	3.5	2.5	5	6.4	-	0.9	<1	-	0.5	3	2
Magnesium	mg/l	-	50	25	<0.036	38	32	53	37	13.2	23	20	17.1	13	31	3
Sodium	mg/l	150	150	12	<0.076	15	23	28	16	-	21	11	-	5.8	30	13
Arsenic	µg/l	7.5	10	7	-	35	10	3	20	-	2	10	-	7	5	<1
Barium	µg/l	-	100	130	-	141	110	-	621	-	50	-	-	66	-	-
Chromium	µg/l	37.5	30	<2	8.13	<2	<2	<1	<2	-	<2	<1	-	<2	<1	<1
Cadmium	µg/l	3.75	5	<2	0.108	<2	<2	<1	<2	-	<2	<1	-	<2	<1	<1
Cobalt	µg/l	-	-	<2	-	<2	<2	-	3	-	<2	-	-	<2	-	-
Copper	µg/l	1500	30	<2	123	<2	<2	-	<2	-	<2	-	-	2	-	-
Iron	mg/l	-	0.2	<0.1	-	<0.1	<0.1	-	<0.1	0.049	<0.1	-	0.218	<0.1	-	-
Manganese	µg/l	-	50	4	0.479	<2	174	-	3626	6	3	-	1	<2	-	-
Nickel	µg/l	15	20	<2	-	<2	<2	2	5	-	<2	<1	-	<2	<1	<1
Lead	µg/l	7.5	10	11	1.52	10	16	<1	11	-	11	<1	-	11	<1	<1
Tin	µg/l	-	-	50	-	48	51	-	49	-	49	-	-	50	-	-
Zinc	µg/l	75000	100	5	-	<2	2	3	<2	-	10	3	-	2	7	10
Mercury	µg/l	0.75	1	<1	-	<1	<1	-	<1	-	<1	-	-	<1	-	-
Cyanide	µg/l	37.5	10	<0.01	-	<0.01	<0.01	-	0.01	-	<0.01	-	-	<0.01	-	-
Phosphate (Ortho/MRP) as P	mg/l	0.035	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulfide	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH	µg/l	7.5	10	<10	<46	<10	<10	<10	<10	-	<10	<50	-	<10	<50	<50
EPH >C8 to <C40	mg/l	0.0075	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH >C8 - C10 (Petrol Range)	mg/l	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH >C10 - C20 (Diesel Range)	mg/l	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH >C20 - <C40 (Motor Oil Range)	mg/l	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness-Dissolved (CaCO3)	µg/l	-	200000	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3: Retrospective Screening of 2007-2018 Groundwater Samples

		Report Reference		Byrne (2015)												
		Sample ID		MW1		MW2	Office Well		Chipping Plant Well	Well A			Well B	L. Behan House		Yard Well
		Sampled Date		2007	2010	2007	2007	2013	2007	2006	2007	2013	2007	2007	2013	2013
Test	Units	SI 9 of 2010, inc. SI 366 of 2016	EPA Interim GW Values													
Manganese- Dissolved	mg/l	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium- Dissolved	mg/l	-	200	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium- Dissolved	mg/l	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium- Dissolved	mg/l	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium- Dissolved	mg/l	150	150	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic- Dissolved	µg/l	7.5	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium- Dissolved	µg/l	3.75	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium- Dissolved	µg/l	37.5	30	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper- Dissolved	mg/l	1.5	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead- Dissolved	µg/l	7.5	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel- Dissolved	µg/l	15	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc- Dissolved	µg/l	75000	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury- Dissolved	µg/l	0.75	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Coliforms	MPN/100ml	-	0	-	-	-	-	12	-	-	-	1	-	-	19	1
Faecal Coliforms	MPN/100ml	-	0	-	-	-	-	2	-	0	-	0	0	-	1	0
BOD	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COD	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E.coli	MPN/100ml	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Suspended Solids	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity Total (R2 pH 4.5) (CaCO3)	mg/l	-	NAC*	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids (TDS)	mg/l	-	1000	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

[1] *Screened against standard for Ammonium as N*

[2] *Screened against lower range of overall threshold value range for Ammonium*

3. Screened against standard for Nitrate as NO3

4. Screened against standard for Nitrite as NO2

Table 3: Retrospective Screening of 2007-2018 Groundwater Samples

		Report Reference		Viridus (2020)			
			Sample ID	Behan Well	Well A	MW2	Farm Well
			Sampled Date	2018	2018	2018	2018
Test	Units	SI 9 of 2010, inc. SI 366 of 2016	EPA Interim GW Values				
Conductivity	uS/cm	1875	1000	520	610	793	155
pH	pH Units	-	6.5 - 9.5	7.4	7.3	7.4	7.8
Ammonia as N [1]	mg/l	0.175	-	<0.005	0.009	<0.005	0.020
Ammonium as NH4 (calc) [2]	mg/l	0.065	-	<0.006	0.011	<0.006	0.026
Chloride	mg/l	187.5	30	22	19	36	12
Nitrate as N [3]	mg/l	37.5	25	6.1	2.4	3.0	0.57
Nitrite as N [4]	mg/l	0.375	0.1	<0.005	<0.005	<0.005	<0.005
Sulphate	mg/l	187.5	200	13	85	110	22
Calcium	mg/l	-	200	-	-	-	-
Potassium	mg/l	-	5	-	-	-	-
Magnesium	mg/l	-	50	-	-	-	-
Sodium	mg/l	150	150	-	-	-	-
Arsenic	µg/l	7.5	10	-	-	-	-
Barium	µg/l	-	100	-	-	-	-
Chromium	µg/l	37.5	30	-	-	-	-
Cadmium	µg/l	3.75	5	-	-	-	-
Cobalt	µg/l	-	-	-	-	-	-
Copper	µg/l	1500	30	-	-	-	-
Iron	mg/l	-	0.2	-	-	-	-
Manganese	µg/l	-	50	-	-	-	-
Nickel	µg/l	15	20	-	-	-	-
Lead	µg/l	7.5	10	-	-	-	-
Tin	µg/l	-	-	-	-	-	-
Zinc	µg/l	75000	100	-	-	-	-
Mercury	µg/l	0.75	1	-	-	-	-
Cyanide	µg/l	37.5	10	-	-	-	-
Phosphate (Ortho/MRP) as P	mg/l	0.035	0.03	<0.005	0.046	0.041	0.017
Sulfide	mg/l	-	-	0.05	<0.03	<0.03	<0.03
TPH	µg/l	7.5	10	-	-	-	-
EPH >C8 to <C40	mg/l	0.0075	0.01	0.02	0.10	0.03	0.31
EPH >C8 - C10 (Petrol Range)	mg/l	-	0.01	<0.01	<0.01	<0.01	<0.01
EPH >C10 - C20 (Diesel Range)	mg/l	-	0.01	<0.01	0.08	0.01	0.22
EPH >C20 - <C40 (Motor Oil Range)	mg/l	-	0.01	0.02	0.02	0.02	0.09
Hardness-Dissolved (CaCO3)	µg/l	-	200000	270	310	440	60

Table 3: Retrospective Screening of 2007-2018 Groundwater Samples

		Report Reference		Viridus (2020)			
			Sample ID	Behan Well	Well A	MW2	Farm Well
			Sampled Date	2018	2018	2018	2018
Test	Units	SI 9 of 2010, inc. SI 366 of 2016	EPA Interim GW Values				
Manganese- Dissolved	mg/l	-	0.05	<1.0	1.1	100	6.9
Calcium- Dissolved	mg/l	-	200	84	79	110	21
Magnesium- Dissolved	mg/l	-	50	14.7	27.7	41.1	1.7
Potassium- Dissolved	mg/l	-	5	0.6	1.2	2.7	0.8
Sodium- Dissolved	mg/l	150	150	10.8	20.2	23.4	7.9
Arsenic- Dissolved	µg/l	7.5	10	12.4	5.2	3.5	-
Cadmium- Dissolved	µg/l	3.75	5	<0.1	<0.1	<0.1	-
Chromium- Dissolved	µg/l	37.5	30	<1.0	<1.0	<1.0	-
Copper- Dissolved	mg/l	1.5	0.03	0.004	<0.003	<0.003	-
Lead- Dissolved	µg/l	7.5	10	<0.3	<0.3	0.4	-
Nickel- Dissolved	µg/l	15	20	<0.5	<0.5	1.9	-
Zinc- Dissolved	µg/l	75000	100	13	4.0	6.7	-
Mercury- Dissolved	µg/l	0.75	1	<0.02	<0.02	<0.02	-
Total Coliforms	MPN/100ml	-	0	0	0	0	10
Faecal Coliforms	MPN/100ml	-	0	-	-	-	-
BOD	mg/l	-	-	1.2	1.1	<1.0	1.6
COD	mg/l	-	-	13	16	38	10
E.coli	MPN/100ml	-	-	0	0	0	10
Suspended Solids	mg/l	-	-	<5	<5	<5	6
Alkalinity Total (R2 pH 4.5) (CaCO3)	mg/l	-	NAC*	213	221	275	43
Total Dissolved Solids (TDS)	mg/l	-	1000	239	342	469	59

Notes:

[1] *Screened against standard for Ammonium as N*

[2] *Screened against lower range of overall threshold value range for Ammonium*

3. Screened against standard for Nitrate as NO3

4. Screened against standard for Nitrite as NO2

APPENDIX 6.3

Laboratory Reports for Water Samples

Element Materials Technology
Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

P: +44 (0) 1244 833780
F: +44 (0) 1244 833781

W: www.element.com

Golder Associates Ltd
Town Centre House
Dublin Road
Naas
Co Kildare
Ireland

Attention : Ruth Treacy

Date : 26th June, 2020

Your reference : 20137776

Our reference : Test Report 20/7972 Batch 1

Location : Behans

Date samples received : 22nd June, 2020

Status : Final report

Issue : 1

Six samples were received for analysis on 22nd June, 2020 of which six were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Authorised By:

Simon Gomery BSc
Project Manager

Client Name:	Golder Associates Ltd	**Report :**	**Liquid**
Reference:	20137776		
Location:	Behans		
Contact:	Ruth Treacy	**Liquids/products:**	V=40ml vial, G=glass bottle, P=plastic bottle
EMT Job No:	20/7972		H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

EMT Sample No.	1-6	7-12	13-18	19-24	25-30	31-36					LOD/LOR	Units	Method No.
Sample ID	GW1	GW2	GW3	GW4	SW1	GW5							
Depth													
COC No / misc													
Containers	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G							
Sample Date	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020							
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Surface Water	Ground Water							
Batch Number	1	1	1	1	1	1							
Date of Receipt	22/06/2020	22/06/2020	22/06/2020	22/06/2020	22/06/2020	22/06/2020							
Dissolved Arsenic #	4.7	33.9	13.7	471.3	32.6	33.1					<2.5	ug/l	TM30/PM14
Dissolved Boron	18	15	32	16	51	15					<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5					<0.5	ug/l	TM30/PM14
Dissolved Calcium #	53.3	55.3	49.9	39.6	141.1	56.1					<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	12.9	<1.5	1.5	<1.5					<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	<7	<7					<7	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	<5	<5	<5	<5					<5	ug/l	TM30/PM14
Dissolved Magnesium #	12.9	27.9	9.5	39.3	20.1	28.1					<0.1	mg/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	<1	<1					<1	ug/l	TM30/PM14
Dissolved Nickel #	4	2	4	42	4	<2					<2	ug/l	TM30/PM14
Dissolved Potassium #	0.7	0.9	4.0	3.7	14.3	0.8					<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	16	<3	<3	<3					<3	ug/l	TM30/PM14
Dissolved Zinc #	5	5	<3	5	10	5					<3	ug/l	TM30/PM14
Total Hardness Dissolved (as CaCO3)	187	255	165	264	437	258					<1	mg/l	TM30/PM14
Methyl Tertiary Butyl Ether #	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1					<0.1	ug/l	TM15/PM10
Benzene #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5					<0.5	ug/l	TM15/PM10
Toluene #	<5	<5	<5	<5	<5	<5					<5	ug/l	TM15/PM10
Ethylbenzene #	<1	<1	<1	<1	<1	<1					<1	ug/l	TM15/PM10
m/p-Xylene #	<2	<2	<2	<2	<2	<2					<2	ug/l	TM15/PM10
o-Xylene #	<1	<1	<1	<1	<1	<1					<1	ug/l	TM15/PM10
Surrogate Recovery Toluene D8	106	105	105	104	101	103					<0	%	TM15/PM10
Surrogate Recovery 4-Bromofluorobenzene	106	103	106	105	102	105					<0	%	TM15/PM10
EPH (C8-C40) #	<10	<10	<10	<10	<10	<10					<10	ug/l	TM5/PM30
Sulphate as SO4 #	16.0	62.8	58.5	20.2	326.0	64.6					<0.5	mg/l	TM38/PM0
Chloride #	10.9	14.1	17.6	11.6	32.9	14.3					<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	33.6	17.3	23.7	8.9	30.9	17.8					<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	<0.02	<0.02	0.30	0.12	0.18	<0.02					<0.02	mg/l	TM38/PM0
Ortho Phosphate as PO4 #	<0.06	<0.06	<0.06	0.07	<0.06	<0.06					<0.06	mg/l	TM38/PM0
Total Oxidised Nitrogen as N #	7.6	3.9	5.4	2.0	7.0	4.0					<0.2	mg/l	TM38/PM0
Ammoniacal Nitrogen as NH4 #	0.10	0.05	0.09	<0.03	0.16	<0.03					<0.03	mg/l	TM38/PM0
Total Alkalinity as CaCO3 #	158	176	130	260	108	180					<1	mg/l	TM75/PM0
Dissolved Oxygen	9	9	7	7	9	9					<1	mg/l	TM58/PM0
Electrical Conductivity @25C #	415	527	447	512	1029	536					<2	uS/cm	TM76/PM0
pH #	8.17	8.25	8.21	8.31	8.12	8.23					<0.01	pH units	TM73/PM0
Total Organic Carbon #	<2	<2	4	<2	8	<2					<2	mg/l	TM60/PM0
Total Dissolved Solids #	271	357	335	333	741	390					<35	mg/l	TM20/PM0

Client Name:	Golder Associates Ltd
Reference:	20137776
Location:	Behans
Contact:	Ruth Treacy

EMT Job No.	Batch	Sample ID	Depth	EMT Sample No.	Analysis	Reason
No deviating sample report results for job 20/7972						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.

Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

EMT Job No.: 20/7972

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Limits of detection for analyses carried out on as received samples are not moisture content corrected. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Sufficient amount of sample must be received to carry out the testing specified. Where an insufficient amount of sample has been received the testing may not meet the requirements of our accredited methods, as such accreditation may be removed.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.

Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

Measurement Uncertainty

Measurement uncertainty defines the range of values that could reasonably be attributed to the measured quantity. This range of values has not been included within the reported results. Uncertainty expressed as a percentage can be provided upon request.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
>>	Results above calibration range, the result should be considered the minimum value. The actual result could be significantly higher, this result is not accredited.
*	Analysis subcontracted to an Element Materials Technology approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

EMT Job No: 20/7972

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM5	Modified 8015B v2:1996 method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) within the range C8-C40 by GCFID. For waters the solvent extracts dissolved phase plus a sheen if present.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM15	Modified USEPA 8260B v2:1996. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021A v2:2014. Preparation of solid and liquid samples for GC headspace analysis.				
TM15	Modified USEPA 8260B v2:1996. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021A v2:2014. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM20	Modified BS 1377-3:1990/USEPA 160.1/3 (TDS/TS: 1971) Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM30	Determination of Trace Metals by ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry): WATERS by Modified USEPA Method 200.7, Rev. 4.4, 1994; Modified EPA Method 6010B, Rev.2, Dec 1996; Modified BS EN ISO 11885:2009: SOILS by Modified USEP	PM14	Preparation of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for Dissolved metals, and remain unfiltered for Total metals then acidified				
TM30	Determination of Trace Metals by ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry): WATERS by Modified USEPA Method 200.7, Rev. 4.4, 1994; Modified EPA Method 6010B, Rev.2, Dec 1996; Modified BS EN ISO 11885:2009: SOILS by Modified USEP	PM14	Preparation of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for Dissolved metals, and remain unfiltered for Total metals then acidified	Yes			
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods: Chloride 325.2 (1978), Sulphate 375.4 (Rev.2 1993), o-Phosphate 365.2 (Rev.2 1993), TON 353.1 (Rev.2 1993), Nitrite 354.1 (1971), Hex Cr 7196A (1992), NH4+ 350.1 (Rev.2 1993 (comparabl	PM0	No preparation is required.	Yes			
TM58	APHA SMEWW 5210B:1999 22nd Edition. Comparible with ISO 5815:1989. Measurement of Biochemical Oxygen Demand. When cBOD (Carbonaceous BOD) is requested a nitrification inhibitor is added which prevents the oxidation of reduced forms of nitrogen, such as am	PM0	No preparation is required.				
TM60	TC/TOC analysis of Waters by High Temperature Combustion followed by NDIR detection. Based on the following modified standard methods: USEPA 9060A (2002), APHA SMEWW 5310B:1999 22nd Edition, ASTM D 7573, and USEPA 415.1.	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 (1982) and 9045D Rev. 4 - 2004) and BS1377-3:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			

EMT Job No: 20/7972

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM75	Modified US EPA method 310.1 (1978). Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			
TM76	Modified US EPA method 120.1 (1982). Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			

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Golder Associates Ltd
Town Centre House
Dublin Road
Naas
Co Kildare
Ireland

4225

Attention :	Ruth Treacy
Date :	9th February, 2021
Your reference :	20137776
Our reference :	Test Report 21/1215 Batch 1
Location :	L. Behons Rathcoole
Date samples received :	29th January, 2021
Status :	Final report
Issue :	1

Thirteen samples were received for analysis on 29th January, 2021 of which twelve were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Authorised By:

Boden

Paul Boden BSc

Senior Project Manager

Please include all sections of this report if it is reproduced

Element Materials Technology

Client Name: Golder Associates Ltd
Reference: 20137776
Location: L. Behons Rathcoole
Contact: Ruth Treacy
EMT Job No: 21/1215

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

EMT Sample No.	1-7	8-14	15-21	22-28	29-35	36-42	43-49	50-56	57-63	64-70			
Sample ID	BH03	BH02	BH04	BH01	L.BEHAN HOUSE	SW01	SILT POND 2	L012100	T040400	T040300			
Depth													
COC No / misc													
Containers	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G	V H HN P G			
Sample Date	26/01/2021	26/01/2021	26/01/2021	26/01/2021	26/01/2021	27/01/2021	27/01/2021	27/01/2021	27/01/2021	27/01/2021			
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021	29/01/2021			
Dissolved Arsenic #	24.8	17.4	7.2	12.7	13.3	69.9	6.1	10.3	3.3	6.2	<2.5	ug/l	TM30/PM14
Dissolved Boron	23	21	<12	17	14	51	25	22	15	14	<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM30/PM14
Dissolved Calcium #	54.8	88.1	60.7	54.8	68.0	143.0	112.2	111.4	72.8	71.7	<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	1.8	<1.5	<1.5	<1.5	<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7	<7	<7	13	<7	<7	<7	<7	<7	<7	ug/l	TM30/PM14
Dissolved Lead #	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	ug/l	TM30/PM14
Dissolved Magnesium #	11.3	24.8	18.3	13.1	11.6	19.8	4.1	13.8	5.3	5.2	<0.1	mg/l	TM30/PM14
Dissolved Mercury #	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM30/PM14
Dissolved Nickel #	<2	<2	2	<2	<2	5	<2	<2	<2	<2	<2	ug/l	TM30/PM14
Dissolved Potassium #	3.4	0.7	0.5	0.5	0.5	13.4	6.2	5.5	1.2	1.3	<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	ug/l	TM30/PM14
Dissolved Sodium #	11.5	14.8	6.6	6.9	8.3	29.6	9.2	15.7	10.2	10.2	<0.1	mg/l	TM30/PM14
Dissolved Zinc #	<3	4	13	<3	24	4	<3	3	<3	<3	<3	ug/l	TM30/PM14
Total Hardness Dissolved (as CaCO3)	184	324	229	192	219	441	298	336	204	201	<1	mg/l	TM30/PM14
Methyl Tertiary Butyl Ether #	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ug/l	TM15/PM10
Benzene #	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ug/l	TM15/PM10
Toluene #	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	ug/l	TM15/PM10
Ethylbenzene #	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM15/PM10
m/p-Xylene #	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	ug/l	TM15/PM10
o-Xylene #	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	ug/l	TM15/PM10
Surrogate Recovery Toluene D8	60	97	97	101	99	106	104	108	111	111	<0	%	TM15/PM10
Surrogate Recovery 4-Bromofluorobenzene	56	94	94	99	95	103	99	103	106	108	<0	%	TM15/PM10
EPH (C8-C40) #	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	ug/l	TM5/PM30
Sulphate as SO4 #	37.5	98.0	7.6	7.1	9.4	346.7	283.5	24.3	13.8	13.6	<0.5	mg/l	TM38/PM0
Chloride #	15.0	18.9	8.5	10.6	11.8	28.5	7.4	42.3	17.2	17.4	<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	23.2	35.2	14.0	15.8	19.3	33.6	1.3	16.3	12.8	12.9	<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	0.02	<0.02	0.04	<0.02	<0.02	0.53	0.42	<0.02	<0.02	<0.02	<0.02	mg/l	TM38/PM0
Ortho Phosphate as PO4 #	0.12	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	0.16	<0.06	<0.06	<0.06	mg/l	TM38/PM0
Total Oxidised Nitrogen as N #	5.2	7.9	3.2	3.6	4.4	7.7	0.4	3.7	2.9	2.9	<0.2	mg/l	TM38/PM0
Ammoniacal Nitrogen as NH4 #	0.03	<0.03	0.14	<0.03	<0.03	0.94	0.15	0.04	<0.03	0.04	<0.03	mg/l	TM38/PM0
Total Alkalinity as CaCO3 #	140	212	218	180	206	114	32	286	182	182	<1	mg/l	TM75/PM0
Total Organic Carbon #	4	<2	<2	<2	<2	5	6	<2	<2	<2	<2	mg/l	TM60/PM0
Total Dissolved Solids #	278	441	247	229	271	725	476	449	263	256	<35	mg/l	TM20/PM0

Client Name: Golder Associates Ltd
Reference: 20137776
Location: L. Behons Rathcoole
Contact: Ruth Treacy
EMT Job No: 21/1215

Report : **Liquid**

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

Please see attached notes for all abbreviations and acronyms

EMT Sample No.	71-77	78-84									LOD/LOR	Units	Method No.
Sample ID	G010100	G010150											
Depth													
COC No / misc													
Containers	V H HN P G	V H HN P G											
Sample Date	27/01/2021	27/01/2021											
Sample Type	Surface Water	Surface Water											
Batch Number	1	1											
Date of Receipt	29/01/2021	29/01/2021											
Dissolved Arsenic #	7.8	10.0									<2.5	ug/l	TM30/PM14
Dissolved Boron	26	18									<12	ug/l	TM30/PM14
Dissolved Cadmium #	<0.5	<0.5									<0.5	ug/l	TM30/PM14
Dissolved Calcium #	98.2	103.4									<0.2	mg/l	TM30/PM14
Total Dissolved Chromium #	<1.5	<1.5									<1.5	ug/l	TM30/PM14
Dissolved Copper #	<7	<7									<7	ug/l	TM30/PM14
Dissolved Lead #	<5	<5									<5	ug/l	TM30/PM14
Dissolved Magnesium #	6.9	9.4									<0.1	mg/l	TM30/PM14
Dissolved Mercury #	<1	<1									<1	ug/l	TM30/PM14
Dissolved Nickel #	<2	<2									<2	ug/l	TM30/PM14
Dissolved Potassium #	2.0	1.9									<0.1	mg/l	TM30/PM14
Dissolved Selenium #	<3	<3									<3	ug/l	TM30/PM14
Dissolved Sodium #	16.8	15.1									<0.1	mg/l	TM30/PM14
Dissolved Zinc #	3	3									<3	ug/l	TM30/PM14
Total Hardness Dissolved (as CaCO3)	274	298									<1	mg/l	TM30/PM14
Methyl Tertiary Butyl Ether #	<0.1	<0.1									<0.1	ug/l	TM15/PM10
Benzene #	<0.5	<0.5									<0.5	ug/l	TM15/PM10
Toluene #	<5	<5									<5	ug/l	TM15/PM10
Ethylbenzene #	<1	<1									<1	ug/l	TM15/PM10
m/p-Xylene #	<2	<2									<2	ug/l	TM15/PM10
o-Xylene #	<1	<1									<1	ug/l	TM15/PM10
Surrogate Recovery Toluene D8	109	110									<0	%	TM15/PM10
Surrogate Recovery 4-Bromofluorobenzene	104	106									<0	%	TM15/PM10
EPH (C8-C40) #	<10	<10									<10	ug/l	TM5/PM30
Sulphate as SO4 #	28.3	24.4									<0.5	mg/l	TM38/PM0
Chloride #	33.2	30.9									<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	14.2	21.4									<0.2	mg/l	TM38/PM0
Nitrite as NO2 #	0.05	<0.02									<0.02	mg/l	TM38/PM0
Ortho Phosphate as PO4 #	0.10	<0.06									<0.06	mg/l	TM38/PM0
Total Oxidised Nitrogen as N #	3.2	4.8									<0.2	mg/l	TM38/PM0
Ammoniacal Nitrogen as NH4 #	0.07	0.04									<0.03	mg/l	TM38/PM0
Total Alkalinity as CaCO3 #	236	242									<1	mg/l	TM75/PM0
Total Organic Carbon #	<2	<2									<2	mg/l	TM60/PM0
Total Dissolved Solids #	369	484									<35	mg/l	TM20/PM0

Notification of Deviating Samples

Client Name: Golder Associates Ltd
Reference: 20137776
Location: L. Behons Rathcoole
Contact: Ruth Treacy

EMT Job No.	Batch	Sample ID	Depth	EMT Sample No.	Analysis	Reason
No deviating sample report results for job 21/1215						

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.

Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

EMT Job No.: 21/1215

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Limits of detection for analyses carried out on as received samples are not moisture content corrected. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Sufficient amount of sample must be received to carry out the testing specified. Where an insufficient amount of sample has been received the testing may not meet the requirements of our accredited methods, as such accreditation may be removed.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.

Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

Measurement Uncertainty

Measurement uncertainty defines the range of values that could reasonably be attributed to the measured quantity. This range of values has not been included within the reported results. Uncertainty expressed as a percentage can be provided upon request.

ABBREVIATIONS and ACRONYMS USED

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NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
>>	Results above calibration range, the result should be considered the minimum value. The actual result could be significantly higher, this result is not accredited.
*	Analysis subcontracted to an Element Materials Technology approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

HWOL ACRONYMS AND OPERATORS USED

HS	Headspace Analysis.
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent.
CU	Clean-up - e.g. by florisil, silica gel.
1D	GC - Single coil gas chromatography.
Total	Aliphatics & Aromatics.
AL	Aliphatics only.
AR	Aromatics only.
2D	GC-GC - Double coil gas chromatography.
#1	EH_Total but with humics extracted.
#2	EU_Total but with fatty acids extracted.
_	Operator - underscore to separate acronyms (exception for +).
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total
MS	Mass Spectrometry.

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM5	Modified 8015B v2:1996 method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) within the range C8-C40 by GCFID. For waters the solvent extracts dissolved phase plus a sheen if present.	PM30	Water samples are extracted with solvent using a magnetic stirrer to create a vortex.	Yes			
TM15	Modified USEPA 8260B v2:1996. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021A v2:2014. Preparation of solid and liquid samples for GC headspace analysis.				
TM15	Modified USEPA 8260B v2:1996. Quantitative Determination of Volatile Organic Compounds (VOCs) by Headspace GC-MS.	PM10	Modified US EPA method 5021A v2:2014. Preparation of solid and liquid samples for GC headspace analysis.	Yes			
TM20	Modified BS 1377-3:1990/USEPA 160.1/3 (TDS/TS: 1971) Gravimetric determination of Total Dissolved Solids/Total Solids	PM0	No preparation is required.	Yes			
TM30	Determination of Trace Metals by ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry): WATERS by Modified USEPA Method 200.7, Rev. 4.4, 1994; Modified EPA Method 6010B, Rev.2, Dec 1996; Modified BS EN ISO 11885:2009: SOILS by Modified USEP	PM14	Preparation of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for Dissolved metals, and remain unfiltered for Total metals then acidified				
TM30	Determination of Trace Metals by ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry): WATERS by Modified USEPA Method 200.7, Rev. 4.4, 1994; Modified EPA Method 6010B, Rev.2, Dec 1996; Modified BS EN ISO 11885:2009: SOILS by Modified USEP	PM14	Preparation of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for Dissolved metals, and remain unfiltered for Total metals then acidified	Yes			
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods: Chloride 325.2 (1978), Sulphate 375.4 (Rev.2 1993), o-Phosphate 365.2 (Rev.2 1993), TON 353.1 (Rev.2 1993), Nitrite 354.1 (1971), Hex Cr 7196A (1992), NH4+ 350.1 (Rev.2 1993) – All anions comparable to BS ISO 15923-1: 2013l	PM0	No preparation is required.	Yes			
TM60	TC/TOC analysis of Waters by High Temperature Combustion followed by NDIR detection. Based on the following modified standard methods: USEPA 9060A (2002), APHA SMEWW 5310B:1999 22nd Edition, ASTM D 7573, and USEPA 415.1.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1 (1978). Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			

APPENDIX 6.4

GW Level Summary Table

Table 1: Summary of groundwater level measurements (m OD) 2020-2021

Well ID	BH1	BH2	BH3	BH4
Easting (ITM)	699497.4	700126.9	699691.7	700211.7
Northing (ITM)	725650.7	725954.4	725930.4	725611.6
Top of Cover (mOD)	175.07	175.48	161.17	195.37
Ground Level (mOD)	174.75	174.91	160.64	194.57
Casing Height (m)	0.32	0.57	0.53	0.80
Groundwater Elevation (m OD)				
03/04/2020	153.49	148.47	145.65	181.94
30/04/2020	152.34	145.39	142.48	181.11
18/06/2020	151.25	142.64	140.55	179.12
20/07/2020	151.38	142.91	143.21	182.54
10/09/2020	153.14	145.20	143.66	186.70
07/11/2020	153.52	145.94	144.68	187.55
11/01/2021	154.49	149.41	146.89	188.53
26/01/2021	155.31	151.81	141.20	188.52
10/02/2021	155.44	152.25	148.49	190.66