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**BCL
HYDRO**

Suttles Stone Quarries
Swanworth Quarry
Worth Matravers, Dorset

**Planning Application for Northward Extension to Existing
Mineral Extraction and Restoration**

Hydrogeological Risk Assessment

Final Report
December 2021



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Document History				
Date	Version No.	BCL Ref.	Comments	Issued to
Oct 2021	01	B/SL/SWTH_HRA/21	Draft report	Client
Oct 2021	01	B/SL/SWTH_HRA/21	Final report	Client

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BCL CONSULTANT HYDROGEOLOGISTS' EXPERIENCE & QUALIFICATIONS

BCL is an independent consultancy specialising in all aspects of hydrogeology and hydrology as they relate to minerals extraction, waste disposal, water supply and related industries.

Paul Burfitt (the author of this report) holds a first degree [Geophysics (Geology)] conferred by Liverpool University, 1992 and a Master of Science Degree [Hydrogeology], Birmingham University, 1998. Paul Burfitt has worked in the Earth Sciences since 1992 and as a Hydrogeologist since 1998.

BCL has provided specialist services, advice and reporting to the extractive, waste and related industries since 2000. During this time employees of the company have worked on over 225 quarries/related sites throughout the British Isles. This includes over 20-years of active involvement at sites located in Dorset and the wider locality.

During the aforementioned period BCL's work has included:

- Installation and management of information collection systems;
- Data interpretation;
- Conceptualisation of hydrogeological systems;
- Identification of potential impacts (quarry operations and infilling);
- Formulation of mitigation measures;
- Management and undertaking of operational impact monitoring and impact assessment;
- Review and auditing of contingency mitigation schemes, and;
- Reporting in connection with proposed developments within varying hydrogeological terrains at over 250 quarries throughout the United Kingdom and Republic of Ireland.

This report has been prepared by BCL Consultant Hydrogeologists Limited with all reasonable skill, care and diligence, within the terms of the Contract made with the Client. The report is confidential to the Client and BCL Consultant Hydrogeologists Limited accepts no responsibility to third parties to whom this report may be made known. No part of this report may be reproduced without prior written approval of BCL Consultant Hydrogeologists Limited. Where data supplied by third parties has been reproduced herein, the originators conditions regarding further reproduction or distribution of that data should be sought and observed. Any site-specific data collection and interpretation thereof described by this report should be assumed to be the work of BCL Consultant Hydrogeologists Limited unless stated otherwise.

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TECHNICAL EXECUTIVE SUMMARY

This section of the HRA report is intended only to provide a technical overview of the setting of the proposed infill, the principal inputs with which the numerical HRA model has been furnished, the scope of modelling assessment carried out and the approach to enumeration of Control Levels and Compliance Limits.

Technical Executive Summary	
Site Setting	
Landfill Category	Inert
Landfill Form	Infilling of as yet un-worked limestone quarry located to the north of the existing operation at Swanworth Quarry, Dorset. Depth of extraction between 17 - 28mbgl, infill over some 14.75ha.
Landfill Engineering	Basal and sidewall lining in accordance with requirements of Landfill Directive.
Duration	20-years.
Aquifer	Secondary A Bedrock Aquifer (Portland Sand), Principal Aquifer (Portland Stone).
Conceptual Hydrogeological & Site Models	
Level of Study	HRA is supported by a previous Hydrological & Hydrogeological Impact Investigation*.
Groundwater Levels	8-No. Site piezometers (2-no. upstream & 2-no. downstream of the Northern Extension, 4 no. downstream within existing quarry site). Data record: February 2019 to present.
Groundwater Quality	16-no. monitoring rounds collecting groundwater samples from minimum 5-no. extension area piezometers; suite of laboratory analysis February 2019 to July 2021.
Extant Groundwater Quality	Some elevated species present in baseline – ammoniacal nitrogen, nitrate, and zinc.
The Numerical Model	
Model Code	RAM Version 3. Environmental Simulations International.
Modelled Chemicals	Arsenic, chloride, lead, mercury, nickel, sulphate and zinc.
Source Term Concentrations	All chemicals enumerated at max permissible concentration based on leachate testing of material classified as inert under BS EN 12457-2-2002.
Kd Values	LandSim Manual values.
Infiltration	315mm/yr.
Modelled Scenarios	Swanworth_RAM_HRA1_Lev3 : Assessment of water quality within the Portland Sand aquifer immediately underlying the site. Swanworth_RAM_SENS1_Lev3 : Sensitivity analysis (increased leachate source term concentrations). Swanworth_RAM_SENS2_Lev3 : Sensitivity analysis (reduction in aquifer permeability). Swanworth_RAM_SENS3_Lev3 : Sensitivity analysis (reduction in mixing zone width). Swanworth_RAM_RL1_Lev3 : Rogue Loads assessment (varying source term concentration to be non-compliant as inert material).
Proposed Control Levels & Compliance Limits	
Control Levels: Chloride, sulphate and nickel : Statistical analysis of baseline data – set at 2 standard deviation value. Arsenic, lead and mercury : hazardous substances, Control Level set at Compliance Limit. None of the proposed Control Levels exceed UK-DWS.	
Compliance Limits: Chloride, sulphate and nickel : Statistical analysis of baseline data – set at 3 standard deviation value. Arsenic, lead and mercury : value set at Limit of Detection. None of the proposed Compliance Limits exceed UK-DWS.	
Proposed Monitoring, Assessment & Contingency Protocols	
Routine Monitoring: Quarterly.	
Contingency Monitoring: Monthly upon exceedance of Control Levels or Compliance Limits, reverting to quarterly only following 2-no. successive monthly monitoring rounds undertaken without breach of Control Levels and / or 3-no. successive monitoring rounds undertaken without breach of Compliance Limits.	
Contingency Actions: To be implemented upon 3-no. consecutive breaches of Control Levels and / or 2-no. consecutive breaches of Compliance Limits.	
* Prepared in support of planning application for mineral extraction at the Site: "Swanworth Quarry, Worth Matravers, Dorset. Planning Application for a Northward Extension to Existing Mineral Extraction and Restoration. Hydrological & Hydrogeological Impact Assessment. BCL. 6th May 2020. Ref. QPLSSQ.SWANWORTH.H&HIA20.02".	

1 INTRODUCTION

1.1 Background

- 1.1.1 Suttle Stone Quarries (SSQ) have applied to Dorset Council (DC) for planning permission to permit the extraction of Portland Stone limestone, within a lateral northward extension (the Northern Extension) to Swanworth Quarry, located on the Isle of Purbeck, Dorset.
- 1.1.2 The Northern Extension has been included as an “Allocated Site” (MS-3) within the Bournemouth, Christchurch, Poole and Dorset Minerals Sites Plan 2019.
- 1.1.3 A site location plan, showing both the existing quarry/working area and Northern Extension (together referred to herein as the ‘Site’) is provided at *figure 1* (all figures are appended to the end of this report).
- 1.1.4 The Northern Extension covers some 14.75 hectares (ha) areal extent and the existing site/working area some 37.3ha. These are herein together referred to as the ‘Site’
- 1.1.5 The aforementioned planning application has been prepared on behalf of SSQ by specialist minerals planning consultancy Quarryplan (GB) Limited (QPL). The application includes for restoration of the Northern Extension extraction area, to a combination of agricultural land and wildlife after uses.
- 1.1.6 An Environmental Statement (ES) has been prepared to accompany the planning application for the Northern Extension. The ES addresses the potential impact of the proposals on several aspects of the local environment. BCL Consultant Hydrogeologists Limited (BCL) were commissioned to undertake the required Hydrogeological and Hydrological Impact Assessment (H&HIA¹), to assess the potential for development to impact upon the water environment.
- 1.1.7 In response to the planning application made in relation to the Northern Extension, DC have issued a Regulation 25 Notice (R25) requesting some additional details in relation to the proposed development. A copy of the R25 is provided at *appendix 1*.
- 1.1.8 The R25 includes requirement for a Hydrogeological Risk Assessment (HRA) to be conducted ‘suitable for an environmental permit application’. In this regard, QPL has instructed BCL to conduct the required HRA, the results of which are presented herein.
- 1.1.9 The HRA has been developed following extensive discussion and site meetings with the Environment Agency (EA - Barbara Keenan, Hydrogeology Technical Specialist) and has included specific additional assessment/testing seeking to clarify the local hydrogeological setting and aquifer character, in response to matters raised within the R25.

1.2 Aim of HRA

- 1.2.1 This HRA report presents the findings of a hydrological and hydrogeological Baseline Study and quantitative Risk Assessment that is intended to inform consultations in relation to the required Environmental Permit (EP) application and should be read alongside the H&HIA report prepared for the Site¹.

¹ Swanworth Quarry, Worth Matravers, Dorset. Planning Application for a Northward Extension to Existing Mineral Extraction and Restoration. Hydrological & Hydrogeological Impact Assessment. BCL.6th May 2020. Ref. QPL.SSQ.SWANWORTH.H&HIA20.02.

1.3 HRA approach & outcomes

- 1.3.1 Previous collection and interpretation of baseline data has been made within the H&HIA¹. Together with additional investigation undertaken as part of this assessment, this has facilitated the formulation of a Conceptual Hydrogeological Model (CHM) for the locality. The CHM describes the nature and interaction between the groundwater and surface water systems operating at and around the Site.
- 1.3.2 The CHM has been used to conduct a detailed quantitative HRA to assess the impact of the planned inert infill upon the water environment.
- 1.3.3 The primary tools used to inform the quantitative aspects of the HRA has been the Environmental Simulations International RAM² and Golder Associates (GA) Landsim³ modelling software packages.
- 1.3.4 Where appropriate, the results of the HRA have provided feed-back information for enhancement of measures designed to protect that environment.
- 1.3.5 The results of the HRA have also informed the development of a groundwater monitoring program to run concurrent with and following completion of infilling.
- 1.3.6 The monitoring program has been designed to:
- Determine the effectiveness of measures adopted for the protection of the water environment, *and*;
 - Inform modification of those measures over time as appropriate.
- 1.3.7 This has included the derivation of groundwater quality Control Levels and Compliance Limits for incorporation into a future EP.

1.4 National Planning Policy & technical guidance

- 1.4.1 Where appropriate, the design of the inert infill area, methodology and scope of site-specific data-collection, formulation of the CHM, approach to impact assessment and selection of calculation methodologies have been informed by prevailing national guidance and industry standard procedures, including:
- "National Planning Policy Framework" (NPPF), Department for Communities and Local Government (DCLG), March 2012;
 - "Planning Practice Guidance to the National Planning Policy Framework" (PPG: DCLG, March 2014;
 - "Hydrogeological Impact Appraisal for Dewatering Abstractions", Boak R, Bellis L, Low R, Mitchell R, Hayes P, McKelvey P, Neale S, EA Science Report SC040020/SR1, April 2007;
 - "Groundwater Protection: Principles and Practice" (GP3) Version 1.1, EA, August 2013;
 - Landfill Developments: Groundwater Risk Assessment for Leachate (<https://www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate>);

² RAM Version 3. Environmental Simulations International.

³ LandSim Release 2 Manual / Version 2.5 Addendum / Version 2.5.17 Addendum, Golder Associates / EA, EA R&D Publication 120.

- “Additional guidance for hydrogeological risk assessments for landfills and the derivation of groundwater control levels and compliance limits”, EA Horizontal Guidance Note H1 – Annex J3, Version 2.1, December 2011⁴;
- “Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels” (LFTGN01), EA, March 2003⁵;
- “Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water” (LFTGN02), EA, February 2003⁴, and;
- “Techniques for the Interpretation of Landfill Monitoring Data” (Guidance Notes), EA Final technical report P1-471, 2002.

1.5 Data sources

- 1.5.1 Published and site-specific data sources, together with assessment and calculation methodologies referenced by the HRA are listed at *appendix 2*.

1.6 Report structure

- 1.6.1 Baseline characterisation of the topography, geology, hydrology and hydrogeology of the Site area, and summary of the local Conceptual Hydrogeological Model, is presented at *section 2*.
- 1.6.2 An account of the planned infill design, including working methods, depths, and elevations to apply during infilling and for the support of the proposed restoration, is given at *section 3*.
- 1.6.3 An assessment of the proposed infill operation, undertaken in accordance with the Source, Pathway, Receptor (SPR) model for risk assessment is presented at *section 4*.
- 1.6.4 Parameter selection, model simulation results and sensitivity analysis are described and discussed at *section 5*.
- 1.6.5 Control and compliance values are discussed and derived at *section 6*, together with specifications for frequency and scope of groundwater quality monitoring and contingency actions to apply concurrent with the operation and restoration of the infill operation.
- 1.6.6 Report conclusions are presented at *section 7* and recommendations presented at *section 8*.

4 Now withdrawn; referenced for specific technical guidance only.

5 No longer referenced by current guidance. Referred to here for details of specific technical methodologies where current guidance provides no alternatives.

2 BASELINE CONDITIONS

2.1 Site Setting and Study Area

2.1.1 Site Location

2.1.1.1 The Site is located close to the southern coast of the Isle of Purbeck peninsula, Dorset, being centred upon National Grid Reference (NGR) 3970, 0782, some 630 metres (m) northwest of Worth Matravers, 1.67 kilometres (km) southwest of Kingston and 3.3km south of Corfe Castle.

2.1.2 Topography

2.1.1 The landscape of the area is dominated by distinct west to east oriented topographic trends that reflect the structure and relative resistance to weathering of underlying strata.

2.1.2 The Purbeck Hills, which are located some 3.8km north of the Site at their closest approach, form a narrow ridge attaining almost 200 metres above Ordnance Datum (maOD), spanning the peninsula from Worbarrow Bay in the west to Ballard Point in the east.

2.1.3 To the south of the Purbeck Hills extends an almost parallel broader but shallower west to east oriented coastal plateau upon which the Site is situated.

2.1.4 The plateau attains an elevation of some 120maOD at the span across the coast from Brandy Bay in the west to Durlston Head in the East.

2.1.5 The Purbeck Hills and the coastal plateau are separated by lower lying ground of the Wealden Valley, the floor of which resides at between some 40maOD and 50maOD.

2.1.6 The Purbeck Hills are underlain by Chalk whilst the coastal plateau is underlain by limestones; both more resistant to weathering than the sandstones and mudstones underlying the intervening Wealden Valley.

2.1.7 The Site is situated at the head of a steeply incised northeast to southwest oriented valley (combe) which broadens and deepens south-westwards to open to the coast at Chapman's Pool, within the Encombe Estate (*figure 2*).

2.1.8 Ordnance Survey (OS) mapping refers to the northern Y-shaped upper reach of the combe, where it abuts the north-western Site boundary, as Coombe Bottom (note – the spelling of Combe and Coombe varies locally) and names the lower reaches to the southwest as Hill Bottom (the two reaches named by the OS being collectively referred to here as Quarry Combe).

2.1.9 The two upper limbs of Quarry Combe slope from some 120maOD to 90maOD where they converge to abut the north-western Site boundary. From here the combe falls at an average gradient of 1:20 (0.05) towards the coast.

2.1.10 Quarry Combe is joined midway along its traverse towards the coast by two minor parasitic valleys that open into its western and eastern flanks and is joined upon the western flank close to the coast by the lowest reach of the north to south oriented Westhill Combe.

2.1.11 The upper reach of Westhill Combe originates some 1.1km west of the Site at around 127maOD, from where it falls and broadens southwards towards the coast at an average gradient of 1:11.5 (0.086).

- 2.1.12 Two further steeply incised valleys, Winspit Bottom and Seacombe Bottom, open to the coast beyond higher ground to the south and southeast of the Site.

2.1.3 Land Use

- 2.1.1 The existing site comprises an active consented limestone quarry with a boundary area of some 37.3ha, situated within a rural landscape dominated by live-stock grazing and arable farming.
- 2.1.2 The current main area of mineral extraction is located within the north-eastern part of the site where workings have progressed over a number of benches to a lowest floor elevation of some 70maOD across a relatively small basal floor area of approximately 3,800 square metres (m²).
- 2.1.3 Site offices, weighbridge and car parking facilities are situated to the north of the current main area of mineral extraction, adjacent the quarry entrance road which parallels the northern boundary.
- 2.1.4 The south-western section of the current site contains the mineral processing plant, mineral stocking yard, quarry operations offices, maintenance workshops, welfare facilities and vehicle parking, these elements of the quarry residing within a relatively level area of former quarrying at some 80maOD.
- 2.1.5 The upper benches along the quarry's eastern boundary have previously been restored to regular slopes using imported inert waste materials and quarry waste stone.
- 2.1.6 The south-eastern section of the Site is currently undergoing restoration; as with the formerly restored eastern boundary, imported inert waste materials and quarry waste stone are being used to create regular slopes across the exhausted quarry faces in this area.

2.2 Quarry Operations

2.2.1 Mineral Extraction

- 2.2.1.1 Mineral extraction is undertaken using conventional drilling and blasting techniques, workings having progressed to a basal elevation of some 70maOD within the current main area of working.
- 2.2.1.2 Extraction has taken place over four principal benches with a maximum face height between individual benches of 10m.
- 2.2.1.3 From review of historical surveys produced from 1987 onwards, the lowest section of mineral extraction over the last 30-years appears to have been situated against the central eastern boundary of the site.
- 2.2.1.4 Now over-tipped and restored, historical survey indicates workings in this area to have progressed downwards to some 71maOD.

2.2.2 Mineral Processing

- 2.2.2.1 As blasted limestone is loaded by hydraulic excavator to wheeled dump trucks for transportation to a fixed primary crusher located in the plant area within the south-western section of the site.

- 2.2.2.2 Crushed primary aggregate is fed through a series of vibrating screens and a secondary crusher to produce a range of product sizes.
- 2.2.2.3 In recent years the Site has typically produced some 120,000 tonnes per annum (tpa) of aggregate; future production is anticipated to be maintained at, or around, this level.

2.2.3 Recycling & Deposit for Recovery

- 2.2.3.1 Imported inert waste materials are stored, screened and crushed at the site to produce recycled aggregate for re-sale into the local construction and civil engineering markets, the unsalable portion of which is recovered for use as restoration infill.
- 2.2.3.2 The recycling and infilling operation is authorised by EA Permit No. EPR/CB3030RQ, which allows recycling for re-sale of 30,000tpa and the deposit of 75,000tpa for restoration.
- 2.2.3.3 The Permit specifies a schedule of permissible materials using European Waste Codes (EWC's) to describe those materials that may be imported for recycling for re-sale with a more restrictive schedule applying to recovered materials deposited for restoration.
- 2.2.3.4 The Permit requires adherence to a Waste Recovery Plan⁶ which specifies Waste Acceptance Criteria (WAC) limits for the protection of groundwater quality by ensuring that only inert materials are used in restoration.
- 2.2.3.5 The WAC limits represent maximum permissible eluate concentrations (which accord with those required by the relevant regulations⁷) for several determinands which are applied to evaluate the results of leaching tests carried out upon waste materials prior to and / or after importation to the Site. Example WAC certificates for accepted waste are provided at *appendix 3*.

2.3 Ecological Designations

2.3.1 Statutorily Protected Sites of Ecological Importance

- 2.3.1.1 Details for the location of designated areas of ecological importance in the vicinity of the Northern Extension have been obtained from Natural England (NE) and are reproduced at *figure 3*.
- 2.3.1.2 There are no Special Protection Areas (SPA's), Sites, National Nature Reserves (NNR), or Local Nature Reserves (LNR), within a 2.5km radius of the combined boundaries of the currently permitted quarry and the Northern Extension.
- 2.3.1.3 Full details of the statutorily protected Sites are provided within the H&HIA. A summary providing details of sites located within 2.5km of the combined boundaries of the Site are provided at *table 1*.

⁶ "Waste Recovery Plan for Swanworth Quarry", Mott McDonald for SSQ, September 2011, Document Ref. EES/286952/B4/01C.

⁷ Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC – "The Landfill Directive" (2003/33/EC).

Table 1 Non-Statutorily Protected Sites located within 2km of the Extension Area

Site Name	Distance* & Direction	Type	Summary Description / Reason for Citation
Isle of Portland to Studland Cliffs SAC	80m SW	B,G	A single unit SAC of cliffed coastline some 40 km in length which support species-rich calcareous grassland with species that are rare in the UK, such as wild cabbage <i>Brassica oleracea</i> var. <i>oleracea</i> , early spider-orchid <i>Ophrys sphegodes</i> and Nottingham catchfly <i>Silene nutans</i> .
St. Albans Head to Durlston Head SAC	1,270m SE	B,G	The SAC also holds semi-natural dry grassland in both inland and coastal situations on both chalk and limestone. This site hosts the priority habitat type "orchid rich sites" and contains extensive species-rich examples of <i>Brachypodium pinnatum</i> grassland in the southern part of its UK range. Smaller areas of <i>Festuca ovina</i> – <i>Avenula pratensis</i> grassland occur on shallow soils on steeper slopes. Transitions from calcareous grassland to both chalk heath and acid grassland are also present. The site has well-developed terricolous and saxicolous lichen and bryophyte communities associated with open turf, chalk rock and pebbles, and flinty soils.
South Dorset Coast SSSI	80m SW	B&G	A stretch of coastline that combines internationally important geological interest with a rich range of wildlife habitats supporting populations of several rare plants and animals. The coastal cliffs expose a complete section through the Upper Jurassic and Cretaceous succession and includes the type localities for the Kimmeridge Clay, the Kimmeridgian Stage, the base of the Portlandian Stage and the Purbeck Beds as well as the standard reference section for the Oxfordian of southern England. The SSSI is also of national importance for its physiographic interest and also includes one of the main areas of unimproved chalk grassland in the country. Among the rare plants are the Carrot Broomrape <i>Orobancha maritima</i> and the strongest national populations of Wild Cabbage <i>Brassica oleracea</i> .
Blashenwell Farm SSSI	1.55km NW	G	This SSSI has been notified for the occurrence of tufa deposition.
Dorset Heaths SAC	1.33km N	B	A complex of 37-no. SSSIs, most of which include fine transitions between European dry heaths and wet lowland heathland and mires, as well as other habitats such as woodland, grassland, pools, saltmarsh and reedswamp. The common characteristics of the <i>Erica tetralix</i> – <i>Sphagnum compactum</i> wet heaths are the dominance of cross-leaved heath <i>Erica tetralix</i> , heather <i>Calluna vulgaris</i> and purple moor-grass <i>Molinia caerulea</i> , and the presence of a diverse group of rare species.
Corfe Common SSSI	1.33km N	B	The SSSI comprises the only large remaining area of uncultivated land on the Purbeck Wealden Beds and is of great botanical interest, the flora of the flushes being of particular richness.
Dorset Heathlands Ramsar	1.33km N	B	Contains large areas of dry heath, wet heath and valley mire, and these often occur together in mosaics and zonations of heathland vegetation. Typically the wet heath occupies areas of impeded drainage on the lower valley sides and less steeply-sloping ground. The habitat supports Dartford warbler at population levels of national importance with smaller populations of Hen harrier and Merlin.
* At closest distance between closest boundaries of statutorily protected site and the Proposed Extension. B – Biological, G – Geological, SSSI: Site of Special Scientific Interest, SAC: Special Area of Conservation.			

2.3.1.4 The coastal fringe to the south of the Site form part of the South Dorset Coast Site of Special Scientific Interest (SSSI); the local section of this SSSI, the boundary of which extends locally up Quarry Combe to directly about the south-eastern boundary of the Site, is also designated as Special Area of Conservation (part of the Isle of Portland to Studland Cliffs SAC).

2.3.1.5 Both the SSSI and SAC citations have been conferred due to abundant nationally and internationally important geological, physiographic and ecological interest and also constitute part of the Dorset and East Devon World Heritage Site (WHS).

2.3.2 Non-Designated Sites of Ecological Importance

2.3.2.1 Details for the location of non-designated sites of ecological importance are summarised at *table 2* and locations reproduced at *figure 3*.

Table 2 Non-Statutorily Protected Sites located within 2km of the Extension Area

Site Name	Distance & Direction*	Summary Description
Swanworth Quarry HRS	15m NW	The footprint of the HRS encompasses most of the existing quarry. It is designated for the restored areas of calcareous grassland within areas of exhausted mineral extraction.
Coombe Bottom HRS	45m E	The Site and the habitat interest comprises a single pond.
West of the Lookout HRS	245m E	The Site and the aspirational habitat interest comprises a single pond, now ploughed in.
South of the Lookout HRS	530m E	The Site and the habitat interest comprises a single pond, now ploughed in.
Kingston Toll CV	625m W	The Site and is noted for butterfly-orchids <i>Platanthera</i> sp., common spotted-orchid <i>Dactylorhiza fuchsii</i> , twayblade <i>Listera</i> sp. and white helleborine <i>Cephalanthera damasonium</i> .
The Plantation SNCI	635m W	c. 25.7 ha in surface area. It is cited as a deciduous plantation with broadleaved woodland and neutral grassland.
West of Hafflington Wood HRS	700m NE	The Site and the habitat interest comprises a single pond.
Scholes Copse SNCI	720m N	c.1.4ha of semi-natural broadleaved woodland with calcareous grassland.
Hafflington Wood SNCI & ASNW	720m NE	Comprising c.2.7 ha of ancient deciduous woodland on a gentle North-facing slope.
West of Downshay Wood HRS	915m E	The Site and the habitat interest comprises a single pond.
Lower Scholes Farm HRS	855m N	The Site and the habitat interest comprises a single pond.
Westhill Wood SNCI & ASNW	950m SW	5.1 ha in surface area. It is cited as a semi-natural deciduous woodland and ancient woodland site.
* At closest distance between closest boundaries of statutorily protected site and the Proposed Extension. HRS: Habitat Restoration Site, SNCI: Site of Nature Conservation Interest, ASNW: Area of semi-Natural Woodland		

2.4 Geological Setting

2.4.1 Background

2.4.1.1 The geology of the district has been characterised by reference to the following:

- BGS maps, publications and borehole logs;
- Geological logs of mineral evaluation boreholes drilled at the Site;
- Geological and hydrogeological reports made in respect of the Site;
- Walk-over reconnaissance survey.

2.4.1.2 An extract of the relevant regional geological mapping data for the locality encompassing the Northern Extension, together with a cross section for the area, is presented at *figure 4*. A summary of the stratigraphic sequence for the area is provided at *table 3*. In order to set the site in context, a summary of the regional geology is provided below.

2.4.2 Regional Geology

2.4.2.1 The local strata are folded into an anticlinal structure, the axis of which is oriented broadly from west to east and passes close to (or through) the northern section of the Northern Extension.

The larger part of the Northern Extension and the existing quarry are located on the southern limb of the anticline, the strata here dipping sub-horizontally southwards towards the coast.

Table 3 Summary Stratigraphic Sequence					
Age	Group	Formation			Description
Cretaceous	White Chalk	Portsmouth Chalk		Chalk	Not relevant to assessment
		Seaford Chalk			
		Lewes Chalk			
		Holywell Nodular Chalk			
	Grey Chalk	Zig Zag Chalk			
	Greensand	Upper Greensand		Sands, Sandstones and Mudstones	
		Gault Formation		Sandy Mudstones	
		Lower Greensand		Sands, Sandstones and Mudstones	
		The Wealden		Extensive units of Sandstone and Mudstone with laterally discontinuous coarse-grained Sandstones.	
	Purbeck Group	Durlston	Peveril Point	Multiple Limestones, Micritic Mudstones and Mudstone units with varying calcitic content	
			Stair Hole		
		Lulworth	Worbarrow Tout		
			Mupe		
Jurassic	Portland Group	Portland Stone	Portland Freestone	Limestones. The economic mineral of the existing quarry and the Northern Extension. Cherty beds towards base.	14m to 18m
			Portland Chert		10m to 15m 15m to 22m
		Portland Sand		Interbedded sandstone/dolomite, with marl beds and subordinate limestones.	20m to 50m
		Kimmeridge Clay		Mudstones (calcareous or kerogen-rich or silty or sandy); thin siltstone and cementstone beds; locally sands and silts	Up to 465m

2.4.2.2 The very shallow dip of the southern limb of the anticline produces little stratigraphic variation at outcrop across the relatively flat Purbeck Plateau, whereas progressively older strata are revealed within the steeply incised combs opening to the coast.

2.4.2.3 The northern limb of the anticline is considerably steeper. With dips at 20° to 30°, resulting in progressively younger strata occurring at outcrop over relatively short distance northwards away from the core of the anticline.

2.4.2.4 The local strata form an almost unbroken sequence, divided by an unconformable contact between the Greensand Formation and underlying Wealden Formation, this boundary being present several kilometres to the north of the Site.

2.4.2.5 A complete description of the geological sequence in proximity to the Site is provided alongside a geological discussion within the main H&HIA. Summary details are provided below, where relevant to definition of the Conceptual Hydrogeological Model for the HRA.

Kimmeridge Clay Formation

2.4.2.6 The oldest strata of the area are Jurassic Kimmeridge Clays which locally outcrop across the lower sections of Quarry Combe and Westhill Combe at the coast, to the south-west of the Site.

2.4.2.7 A combination of mineral evaluation and deeper BGS drilling information suggests the upper surface of the Kimmeridge Clay resides at some 30maOD in proximity to the existing Site, within Quarry Combe - some 45maOD within the northern section and some 55maOD in the southern section and some 82maOD in Westhill Combe.

2.4.2.8 The drilling and outcrop data indicate a southeastern secondary component of dip, superimposed onto the more regional southerly dip of strata, towards the coast. Outcrop is not recorded along the coastline to the southeast of the Site (unlike the coast to the west at Quarry Combe and around Encombe Estate), with the upper surface of the Kimmeridge Clay occurring below sea-level in this area.

2.4.2.9 The Kimmeridge Clay is described as a sequence of up to 465m of (calcareous or kerogen-rich or silty or sandy) mudstones; thin siltstones and cementstone beds and which can locally contain sands and silts.

Portland Sand Formation

2.4.2.10 The Kimmeridge Clay is conformably overlain by the Jurassic Portland Sand Formation, the lower part of the Portland Group.

2.4.2.11 The Portland Sand is described by the BGS⁸ as a sequence between 20m and 50m thickness, the lower part comprises mixed siliciclastic and carbonate sediments, including bioturbated clay-rich siltstones, fine-grained sandstones and silty mudstones with variable amounts of calcite and dolomite, some beds being shell-rich especially with oysters.

2.4.2.12 The upper part of the formation is described to comprise purer carbonate lithologies, including finely crystalline, bioturbated dolomite (usually described as sandstone in lithological accounts).

2.4.2.13 The Portland Sand is subdivided into sandstone in the upper section, with siltstone/fine grained sandstone beds towards the mid/base. These are referred to as the St Albans Head Marl and Emmit Hill Marl.

2.4.2.14 Investigative drilling has been undertaken in proximity to the Northern Extension and this has enabled definition of the underlying geological units. Logs for the 6-no. boreholes drilled at the Site (BH10 & 2019-series) are presented with the main H&HIA¹.

2.4.2.15 Where investigative drilling has been extended into the Portland Sand, these indicate an initial thickness of fine-grained sandstone at the top of the unit, of between 10.2 and 15m thickness, before giving way to a siltstone unit, presumed to be the St Albans Head Marl. This latter unit was not fully penetrated but recorded in thickness between 7 – 19.8m.

2.4.2.16 The aforementioned drilling data has been used to prepare a contour plot depicting the upper surface of the Portland Sand (*figure 5*). This indicates the upper surface to vary from some 94 – 103maOD beneath the northern section of the Northern Extension area, to some 95maOD in the southern section and some 85maOD at the upper section of Quarry Combe.

2.4.2.17 The deeper BGS drilling data for the locality⁹ indicates a full thickness of the Portland Sand of some 39.1m. Applying this depth to the aforementioned upper surface information, indicates a range in levels for base of the Portland Sand from some 44.9 - 53.9maOD beneath the northern section of the Northern Extension, to some 45.9maOD in proximity to the upper section of Quarry Combe.

⁸ Lexicon of named Rock units (<https://www.bgs.ac.uk/Lexicon/>).

⁹ H&HIA – RGGE Swanworth Borehole No. 1.

Portland Stone Formation

- 2.4.2.18 The Portland Sand is conformably overlain by the Portland Stone Formation, the upper part of the Portland Group and the economic mineral of the Site operations.
- 2.4.2.19 The Portland Stone Formation comprises a lower Portland Chert Member (BGS: 15m to 22m thick) and an upper Portland Freestone Member (BGS: 10m to 15m thick).
- 2.4.2.20 Logs for the 6-no. boreholes drilled at the Site (BH10 & 2019-series¹) which fully penetrate the Portland Stone record a thickness for the formation ranging between some 19.2m and 34.6m.
- 2.4.2.21 The Portland Stone faces of the existing quarry contain numerous infilled (predominantly with clay debris) solutionally enlarged discontinuities, interpreted as relict karst features.

Portland Chert Member

- 2.4.2.22 The Portland Chert is described by the BGS to comprise buff-coloured lime-packstones and lime-wackestones with extensive black nodular chert and horizons of tabular chert.
- 2.4.2.23 The lower boundary of the Portland Chert is transitional and is recognised as a conformable upward facies change from the fine-grained dolomitic limestone ("Black Sandstones") of the upper part of the underlying Portland Sand.
- 2.4.2.24 The upper boundary of the Portland Chert also occurs over a facies change; the BGS recording the transition from its chert-bearing lime-packstones and wackestones to massive ooidal grainstones of the overlying Portland Freestone.
- 2.4.2.25 The Portland Chert is seen to be heavily fractured within the existing quarry.

Portland Freestone Member

- 2.4.2.26 The Portland Freestone is described by the BGS to comprise ooidal grainstones and packstones. The uppermost bed is a massive calcilutite known as the Shrimp Bed, yielding remains of *Callianassa* (although the presence of this horizon was not identified within cored investigative drilling in proximity to the Northern Extension¹).
- 2.4.2.27 As with the underlying Portland Chert, the Portland Freestone is heavily fractured within the existing quarry, development of which has resulted in extensive fissuring.

Purbeck Group

- 2.4.2.28 The Portland Stone Formation quarried at the Site is conformably overlain by Lulworth Formation of the Purbeck Group, the oldest (hence lowest) strata of which belong to the Mupe Member.
- 2.4.2.29 The Mupe Member is mapped by the BGS to constitute outcrop beneath soils over the extreme eastern (now restored) area of the existing quarry and similarly across the extreme north-eastern part of the Northern Extension (contact at some 125maOD).
- 2.4.2.30 The Mupe is described by the BGS as a sequence of between 14m and 18m thickness, the lower part of which comprises white-weathering marls and micrites containing algal laminations and some evaporitic material with interbedded carbonaceous mudstones (caps, dirt beds) and localised brecciated limestone pockets (broken beds).

- 2.4.2.31 Limestones, particularly in the upper part of the Mupe (lower part of Cypris Freestones), are commonly Ostracod-rich micrites and sparites; detrital quartz is rare.
- 2.4.2.32 The succeeding (progressively younger) members of the Purbeck Group present locally above the Mupe are the Worbarrow Tout Member (BGS: 21m to 38m thick) and the Stair Hole Member (BGS: 8m to 40m thick).
- 2.4.2.33 These units record relatively steep dip to the north, forming the northern flank of the Purbeck Anticline and marked by the scarp slope into the valley to the north associated with the Corfe River.
- 2.4.2.34 Outcrop of the Purbeck Group is also recorded to the southwest of the existing Site, covering much of the area encompassing Worth Matravers and ground towards Swanage.

Wealden Formation

- 2.4.2.35 The Purbeck Group is overlain by the Wealden Formation, which is present at outcrop below soils c.1.2km north of the Site at an elevation of some 40maOD.
- 2.4.2.36 The BGS describe the Wealden Formation to comprise interbedded thick sandstones, siltstones, mudstones ("shales"), limestones and clay ironstones of predominantly non-marine facies.

Local Structure

- 2.4.2.37 The eastern part of the existing quarry is mapped by the BGS to straddle a north to south oriented normal fault which downthrows to the east, bringing older strata to the west into lateral juxtaposition with younger units to the east.
- 2.4.2.38 The orientation and nature of the fault corresponds with numerous north to south trending faults present along the coastline, suggesting part of a wider stress regime.
- 2.4.2.39 Although the fault strongly influences outcrop patterns at in the vicinity of the Site, its mapped influence diminishes with distance away from the quarry such that it appears to have no significant importance to the wider distribution of strata.

Mine Workings

- 2.4.2.40 Several disused stone mine workings are located upon the Purbeck Group to the east of the Site between Worth Matravers and Swanage.
- 2.4.2.41 The general method of mining involved sinking of a steeply inclined shaft of 30m depth or more, from which sub-horizontal galleries were driven along bedding planes parallel to the strike of the strata.

2.4.3 Superficial Deposits

- 2.4.3.1 Superficial deposits are almost entirely absent from the district, the only substantial deposit of drift being Head deposits mapped by the BGS to be present some 2.7km west of the quarry.
- 2.4.3.2 The combs to the southwest and southeast of the quarry are also mapped to contain narrow basal ribbons of Head deposits.

2.5 Meteorological Setting

2.5.1 Long Term Area Averages

- 2.5.1.1 Long-term monthly average data (MAFF¹⁰) indicate an annual average rainfall depth for the area of 829.5 millimetres (mm) and an average annual potential evaporation of 543mm.
- 2.5.1.2 The Standard Average Annual Rainfall for the Site area in the period 1961 to 1990 (SAAR6190) obtained from the CEH FEH13 rainfall model¹¹ is 859mm.
- 2.5.1.3 These rainfall values accord well with the annual average for the period 1981 to 2010 of 829.4mm recorded by the Meteorological Office (MO) Swanage rain-gauge.
- 2.5.1.4 Monthly average rainfall and potential evaporation statistics from the MAFF datasets (corrected to FEH13 long-term totals) and are provided at *table 4*.

Table 4 Area Long Term Average Monthly Rainfall and Potential Transpiration													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Area Average Rainfall* (mm)	90.3	66.9	67.5	53.7	49.9	47.5	48.2	47.8	66.2	109.6	108.4	102.9	859
Potential Evaporation** (mm)	4	11	32	57	82	98	97	79	47	24	9	3	543
* MAFF Corrected to FEH13 SAAR6190, ** MAFF													

- 2.5.1.5 In addition to the above data, a raingauge has been installed at the Site to record more frequent event data, with a view to aiding interpretation of groundwater level behaviour and local aquifer/surface water interaction. This is discussed further at *section 2.6.2* below.

2.5.2 Effective Rainfall

- 2.5.2.1 Corrected MAFF long-term monthly average rainfall and potential evaporation statistics have been used to derive estimates of monthly average effective rainfall¹² for the Site area.
- 2.5.2.2 Calculation has been performed to provide estimates for bare earth¹³, grass cover and open water using methods described by Grindley¹⁴ and EA R&D Handbook W6-043/HB¹⁵, the process of calculation and subsequent effective rainfall depths are provided at *table 5*.

¹⁰ "Climate & Drainage", Technical Bulletin No.34, Ministry of Agriculture Fisheries & Food (MAFF), September 1976: MAFF Rainfall Area 46.

¹¹ Centre for Ecology & Hydrology Flood Estimation Handbook Web Service, FEH13 Rainfall Model (<https://fehweb.ceh.ac.uk/>), July 2019.

¹² The proportion of rainfall available for runoff and groundwater recharge accounting for evapotranspiration and soil moisture deficit.

¹³ Taken to be analogous a quarried surface.

¹⁴ "The Calculation of Actual Evaporation and Soil Moisture Deficit over Specified Catchment Areas", Grindley J, November 1969, Hydrological Memorandum 38, Meteorological Office, Bracknell, UK.

¹⁵ "Estimation of Open Water Evaporation, Guidance for EA Practitioners", R&D Handbook W6-043/HB, J W Finch and R L Hall, October 2001.

Table 5 Derivation of Effective Rainfall for Differing Surfaces

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
rf-Pe	86.3	55.9	35.5	-3.3	-32.1	-50.5	-48.8	-31.2	19.2	85.6	99.4	99.9	316.0
Bare earth (rc = 0mm)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
dPsm	0.0	0.0	0.0	3.3	32.1	50.5	48.8	31.2	-19.2	-18.8	0.0	0.0	
dAsm	0.0	0.0	0.0	3.3	25.7	10.0	1.0	-2.0	-19.2	-18.8	0.0	0.0	
Asm	0.0	0.0	0.0	3.3	35.4	79.5	87.8	71.2	18.8	0.0	0.0	0.0	295.9
Psm	0.0	0.0	0.0	3.3	29.0	39.0	40.0	38.0	18.8	0.0	0.0	0.0	168.1
Ae	4.0	11.0	32.0	57.0	75.6	57.5	49.2	45.8	47.0	24.0	9.0	3.0	415.2
ERF	86.3	55.9	35.5	0.0	0.0	0.0	0.0	0.0	0.0	66.8	99.4	99.9	443.8
Permanent Grassland (rc = 75mm)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
dPsm	0.0	0.0	0.0	3.3	32.1	50.5	48.8	31.2	-19.2	-85.6	-9.2	0.0	
dAsm	0.0	0.0	0.0	3.3	32.1	50.5	26.1	2.0	-19.2	-85.6	-9.2	0.0	
Asm	0.0	0.0	0.0	3.3	35.4	85.9	134.7	143.2	94.8	9.2	0.0	0.0	506.4
Psm	0.0	0.0	0.0	3.3	35.4	85.9	112.0	114.0	94.8	9.2	0.0	0.0	454.6
Ae	4.0	11.0	32.0	57.0	82.0	98.0	74.3	49.8	47.0	24.0	9.0	3.0	491.1
ERF	86.3	55.9	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.2	99.9	367.9
Cereal Crops (rc = 140mm)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
dPsm	0.0	0.0	0.0	3.3	32.1	50.5	48.8	31.2	-19.2	-85.6	-61.1	0.0	
dAsm	0.0	0.0	0.0	3.3	32.0	50.5	48.8	31.2	-19.2	-85.6	-61.1	0.0	
Asm	0.0	0.0	0.0	3.3	35.3	85.8	134.7	165.8	146.6	61.1	0.0	0.0	632.6
Psm	0.0	0.0	0.0	3.3	35.3	85.8	134.7	165.8	146.6	61.1	0.0	0.0	632.6
Ae	4.0	11.0	32.0	57.0	81.9	98.0	97.0	79.0	47.0	24.0	9.0	3.0	543.0
ERF	86.3	55.9	35.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.3	99.9	316.0
Open Water													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Correction Constants	1.4	1.1	0.9	1.0	0.9	1.0	1.2	1.4	1.5	2.0	2.3	2.0	
Ae	5.7	12.5	29.4	54.2	74.6	100.0	120.3	108.2	69.1	47.8	20.6	5.9	648.3
ERF	84.6	54.4	38.1	-0.4	-24.7	-52.4	-72.1	-60.4	-2.9	61.8	87.8	97.1	210.8

rc: Root Constant, Rf: Rainfall, Pe: Potential Evaporation, Psm: Potential Soil Moisture Deficit, Asm: Actual Soil Moisture Deficit, Ae: Actual Evaporation, ERF: Effective Rainfall. All units other than correction constants are millimetres.

2.6 Hydrological Setting

2.6.1 Background

2.6.1.1 Information concerning the hydrology for the locality encompassing the Northern Extension has been obtained from:

- Ordnance Survey digital mapping data.
- EA and CEH flow datasets.
- Report upon the private water supply network operated by the adjoining Encombe Estate.
- Spot flow gauging undertaken by BCL between February and November 2019, and;
- Water Features Survey and Site Reconnaissance Survey made by BCL, various, 2016 to 2021.
- Quarry Combe flow monitoring and rainfall assessment undertaken November 2020 – March 2021.

2.6.2 Surface Watercourses

Major Surface Watercourses

- 2.6.2.1 The region is part of the Water Framework Directive (WFD) South West River Basin District, the entirety of the Site being located within the EA's West Dorset Rivers Operational Catchment.
- 2.6.2.2 Of the 11-no. waterbodies draining this operational catchment, all were judged during the EA's 2016 Cycle 2 review period to be of "good" chemical status, 3-no. of "good" ecological status, 5-no. of "moderate" ecological status and 3-no. of "poor" ecological status.
- 2.6.2.3 None of the 24-no. reasons for failure to achieve objective status included mining, quarrying or waste treatment and disposal activities, the majority being attributed instead to agriculture, rural land management and the water industry.
- 2.6.2.4 The Corfe River and Swan River functional catchments lie to the north and east of the Site respectively (*figure 7*).
- 2.6.2.5 The EA do not define any functional catchment for the area of the Site itself; this is presumed to be due to the permeable nature of the strata and consequent absence of well-developed surface watercourses along the coastal fringe within which the Site is located.

Minor Surface Watercourses

- 2.6.2.6 There are no surface watercourses within the boundaries of either the existing quarry or Northern Extension, neither are there any mature perennial watercourses upon the Purbeck plateau.
- 2.6.2.7 The lack of well-developed surface drainage characteristic of the plateau reflects the efficiency of percolation drainage facilitated by the absence of low permeability superficial cover and preponderance of free-draining solid strata.
- 2.6.2.8 Drainage along the coastal fringe of the Isle of Purbeck peninsula occurs mainly within a series of independent, short and steeply incised valleys (combes) opening out to the English Channel.
- 2.6.2.9 Of this series of combes, Quarry Combe (referred to as Coombe Bottom and Hill Bottom in the upper and lower reaches respectively) and Westhill Combe are located to the southwest and west of the Site, whilst Winspit Bottom and Seacombe Bottom are located to the southeast.

Entrance Stream

- 2.6.2.10 A minor stream which drains lands directly underlain by the Mupe member (Lulworth Formation) to the east of the Site is culverted westward beneath the public highway immediately adjacent the quarry entrance spur.

- 2.6.2.11 This stream (unnamed by OS mapping is referred to here as the “Entrance Stream”) is shown by FEH mapping¹⁶ to drain a surface water catchment that is underlain by low permeability Purbeck deposits of some 26.5ha areal extent.
- 2.6.2.12 The Entrance Stream sinks to ground in the area of the faulted contact between the Mupe member and the Portland Freestone within the very upper reaches of Quarry Combe, some 100m to the north of the quarry weighbridge and administrative offices.
- 2.6.2.13 Applying estimates of effective rainfall presented at *table 6*, along with a catchment area of 26.5ha and an anticipated runoff coefficient of 15%¹⁰, indicates an average discharge rate for the Entrance Stream where it sinks to ground of some 0.2 litres per second (l/s) - equating to 16.5 cubic metres per day (m³/d).
- 2.6.2.14 This calculated estimate average flow accords closely with observations made on several occasions during monitoring visits made to the Site between 2016 and present day. During wetter periods, flows can be more significant, with up to 5l/s observed during the aforementioned period.

Quarry Combe Stream

- 2.6.2.15 The upper reaches of Quarry Combe pass alongside the northwest, west and southwest boundaries of the existing consented area. This section of the valley, below the area where the Entrance Stream sinks to ground, have been recorded as dry during the period of monitoring undertaken to gather baseline information for this assessment (2019 – 2021).
- 2.6.2.16 OS mapping and survey works completed in preparation of the H&HIA and this HRA indicate that perennial spring-fed flow conditions within the combe initiate around NGR ³9636, ⁰7786, some 390m south of the Site boundary, at an elevation of some 64maOD.
- 2.6.2.17 BGS mapping shows that the area of perennial streamflow coalesces mid-way up the outcrop of the Portland Sand that forms the flanks of the combe in this area.
- 2.6.2.18 As described above, the upstream section of the combe comprises a dry stream channel, with flows only expected to be recorded in this section only sporadically.
- 2.6.2.19 Quarry Combe Stream flows south-westwards from its spring-fed headwaters at around 64maOD (c. NGR ³9636, ⁰7786) over a course of some 1.2km, to meet the coast at Chapman’s Pool (NGR: ³95613, ⁰7706).
- 2.6.2.20 A series of spot flow gaugings have been made within Quarry Combe Stream between March 2019 and September 2021 (at NGR: ³96356, ⁰77825 immediately downstream of where the watercourse passes through a culvert beneath the public road leading to Hill Bottom hamlets). These are taken downstream of the catchment chamber and abstraction for supply to the Encombe Estate Reticulation system (see *section 2.8.5*).
- 2.6.2.21 Spot flow measurements have been made using a Valeport turbine Model 002 current meter allied to an Archer field-PC running Hydrologic’s Gauger data capture software. The measured flow rates are presented at *table 6*.

¹⁶ <https://fehweb.ceh.ac.uk/GB/map>

Table 6 Flow Gauging Data for Quarry Combe Stream

Date	01/03/2019	18/03/2019	01/04/2019	22/05/2019	24/06/2019	30/07/2019	14/11/2019
Flow Rate (l/s)	9.9	9	5.1	8	7.5	8.1	9.6
Date	07/06/2020	02/11/20	22/12/20	15/01/21	11/02/21	11/03/21	19/04/21
Flow Rate (l/s)	3.0	1.0	12.3	2.6	9.5	4.1	1.3
Date	07/06/21	19/07/21	20/09/21				
Flow Rate (l/s)	2.5	2.0	0.5				

- 2.6.2.22 In order to more fully elucidate the nature of flows within Quarry Combe and the potential response to rainfall events and groundwater input, a temporary flow monitoring structure (V-notch weir and datalogger) was installed within the Quarry Combe watercourse for the period 2nd Nov 2020 – 19th April 2021. The collected flow data is shown in graphical form at *figure 6*).
- 2.6.2.23 The flow data has been compared with rainfall recorded at the quarry raingauge, to enable a hydrograph analysis exercise to be completed. This exercise is seeking to provide an enhanced understanding of the local water system, looking to divide out water movement as overland rapid runoff flow, and as quick/slow groundwater movement components through the aquifer system.
- 2.6.2.24 The surface water monitoring point was installed through the winter period to minimise any evapotranspiration losses and hence simplify the mass input/output through the local water system. Flows during the monitoring period occurred between just less than 1l/s to a maximum of more than 140l/s. The graphs are capped at 140l/s as at this point the V notch weir would have overtopped, making measurement inaccurate.
- 2.6.2.25 The stream hydrograph records a 'peaky' response to rainfall events in the locality, rising and falling rapidly, from/to the baseflow level within the watercourse.
- 2.6.2.26 An estimate of the minimum rainfall runoff catchment for the area upstream of the monitoring point has been defined using the boundary of the steeply incised combe. Due to the steep gradients forming the flanks of the combe, rainfall falling within this area would be expected to move rapidly within the catchment area and into the downstream watercourse. On this basis, the well constrained catchment area upstream of the monitoring point equates to some 27.6ha (see *figure 7*).
- 2.6.2.27 For the hydrograph analysis exercise, a section of the stream flow data has been chosen between 27th January and 3rd February 2021 (*figure 6*). For this relatively wet period, a number of discrete flow peaks were recorded, during a period of generally saturated ground conditions.
- 2.6.2.28 The results of the conducted hydrograph assessment are provided at *table 7*. The results of analysis are discussed below.
- 2.6.2.29 A breakdown of the flows recorded at the monitoring point has been initially divided into total volume per day. The baseflow (generally interpreted as slower release from groundwater) is estimated for each given day from the graphical plots. The volume of flow attributable to baseflow is calculated for each day, including allowance for water taken into supply via the Encombe spring catchment system (located above the monitoring point in Quarry Combe). The latter component has been estimated during water features surveys completed in the locality as some 1.3l/s.

Table 7 Examination of flows within Quarry Combe

Date	Total flow measured at weir (m3)	Estimated baseflow from hydrograph (l/s)	Baseflow inc. 1.3 l/s allowance for estate abstraction (m3)	Difference between total flow and flow attributable to baseflow - expected as rainfall runoff or rapid groundwater throughflow (m3)	Measured rainfall (mm)	Catchment required to generate rainfall event (ha)	Comments
27/01/2021	451	4.4	492	-41	3.1	-	
28/01/2021	991	4.9	536	455	19.6	-	
29/01/2021	1386	8.8	873	513	1.0	4.7	Two days combined
30/01/2021	3581	8.8	873	2709	27.9	9.7	V high rainfall and weir overtopped
31/01/2021	1029	8.8	873	156	5.6	-	
01/02/2021	781	7.9	795	-14	2.0	-	
02/02/2021	1506	8.9	881	624	10.2	6.1	Considered most representative

2.6.2.30 The difference is then calculated between the total flow recorded over the monitoring point and the expected baseflow volume attributable to slower release i.e. that expected from groundwater. Note that this calculation has thrown up some negative numbers, suggesting either the volume of water taken into supply was less than the aforementioned 1.3l/s at the time being examined, or the level of general baseflow has been marginally overestimated from the hydrograph. In either case, because the numbers are relatively small, these are not considered critical in terms of overall understanding of water movements being examined.

2.6.2.31 The resultant totals, which are attributable to either rainfall runoff or as more rapid groundwater throughflow, have then been compared to the daily rainfall volumes recorded during the test period. The rainfall totals have been used to calculate the catchment area that would be required to generate the aforementioned 'rapid flow' volumes. For the period examined, the calculated catchment areas that would be theoretically contributing to the peak flow events within Quarry Combe, equates to between 5 and 10 ha.

2.6.2.32 The relatively modest calculated catchment areas are significantly less than the estimated runoff catchment for the combe area upstream of the monitoring point (calculated as some 27.6ha – see figure 7). This suggests that the majority of flow recorded during the peak events would result from overland flow/rainfall runoff from within the incised combe, with minimal expected contribution as groundwater throughflow from the wider locality.

2.6.2.33 If rapid groundwater transfer was contributing more significantly to the recorded surface flow within Quarry Combe, we would expect to see higher flows over the monitoring point, in turn pointing to a larger required catchment area than the maximum 10 ha described above. As the 10 ha catchment can readily be accommodated within the incised valley section upstream of the monitoring point, this suggests that rapid transfer of groundwater to the upstream section of the combe is not significant.

Westhill Combe Stream

2.6.2.34 Westhill Combe contains a small stream which coalesces around NGR: ³9538, ⁰7762, at an elevation of some 61maOD, to flow south-eastwards for 570m before converging with Quarry Combe Stream approximately 120m before outfall to the sea.

2.6.2.35 Unlike Quarry Combe Stream, which originates within lands underlain by Portland Sand, Westhill Combe Stream flows entirely upon lands directly underlain by Kimmeridge Clay (overlain in the base of the valley by Head deposits).

2.6.2.36 Flow gaugings made within Westhill Combe Stream (at NGR: ³95373, ⁰77516 immediately downstream of the footbridge crossing) between March 2020 and September 2021 record flows of between zero – 3.6 l/s. Note – these are taken downstream of the collection chamber for supply to the Encombe Estate Reticulation system (see *section 2.8.5*) and hence are reflective of excess water, not collected by abstraction. The volume of water captured for supply to the reticulation system from within Westhill Combe was measured during September 2021 as 1.4l/s, with zero flow being recorded within the downstream watercourse.

Winspit Bottom

2.6.2.37 Winspit Bottom holds a stream that originates from a spring located within Worth Matravers (NGR: ³9735, ⁰7736) which is augmented by flow from a smaller spring rising at NGR: ³9757, ⁰7661.

2.6.2.38 Winspit Bottom Stream flows over the majority of the length of the valley but is reported¹⁷ to sink, near Winspit Cottage at NGR: ³9757, ⁰7618, where BGS mapping shows the area to be underlain by limestone of the Portland Stone Formation.

2.6.2.39 From here downwards, the channel becomes less well defined. Field survey conducted as part of this investigation indicates this lower section of watercourse to be ephemeral, with flow only occurring following extended wet periods.

Seacombe Bottom

2.6.2.40 The head of Seacombe Bottom is highly dendritic, with 5 or 6-no. springs draining from a number of minor valleys reportedly¹⁷ contributing to aggregate flow within the main stream draining the combe.

2.6.2.41 As with Winspit Bottom Stream, Seacombe Bottom Stream sinks towards the mouth of the valley at NGR: ³9722, ⁰7689 where BGS mapping shows the area to be underlain by limestone of the Portland Stone Formation.

Other watercourses

2.6.2.42 A series of watercourses are shown on OS mapping data to be present to the north of the B3069, directing flow down the northern scarp slope towards the Corfe River e.g. ditch shown at Kingston Barn NGR ³96106 ⁰79497. These are shown to arise on areas underlain by Mupe Member strata and are reflective of the expected lower permeability nature of the geological unit. Survey of these waterfeatures indicates ephemeral features, being fed by runoff from adjacent land.

¹⁷ "An Assessment of the Impact of the Proposed Additional Extraction and restoration on the Existing Hydrology and Hydrogeology in the vicinity of Swanworth Quarry, Dorset", Leake CC, Principal Hydrogeologist, Tarmac Quarry Products Limited, for Tarmac Roadstone (Southern) Limited, August 1993.

2.6.3 Surface Waterbodies

- 2.6.3.1 There are no surface waterbodies within the boundaries of either the existing consented quarry or Northern Extension, the closest sizable water bodies being 2-no. lakes situated in the grounds of Encombe House at some 2.1km and 1.95m respectively.
- 2.6.3.2 Three ponds are identified to the north of the B3069, these being located in areas underlain by the aforementioned lower permeability Mupe Member, with any water presence being maintained by runoff from adjacent ground.

2.6.4 Springs and Seepages

- 2.6.4.1 The location of springs identified in proximity to the Northern Extension are presented at *figure 7*.
- 2.6.4.2 A total of 5 springs/seepage areas have been identified in the vicinity. These arise within the lower elevation valley features to the south (Quarry Combe) and southwest (Westhill Combe) of the Northern Extension.
- 2.6.4.3 Details of the status and nature of identified features are provided at *table 7.1, figure 7*.
- 2.6.4.4 Of primary interest to the HRA are the features recorded within Quarry Coombe and Westhill Combe. These comprise a series of springs/seepages feeding into a collector system operated by Encombe Estate. Collected water is added to a 'reticulation' (water supply) system, used for private water supply to various estate properties and as an amenity supply, to maintain levels within the lake at the main Encombe Estate House.
- 2.6.4.5 A second spring is located at Hill Bottom, which is used to provide a source of supply to the adjacent hamlet properties. Excess water is piped to the watercourse flowing through Quarry Combe.
- 2.6.4.6 Further afield, springs are identified in proximity to Worth Matravers (*section 2.6.2*), feeding the watercourse within Winspit Bottom and Seacombe Bottom. These arise at around 105 - 110maOD, in areas underlain by the Worbarrow Tout Member of the (Purbeck Group) and as such are expected to be hydraulically separated from the Northern Extension by the micritic, lower permeability Mupe Member.

2.7 Hydrogeological Setting

2.7.1 Background

- 2.7.1.1 Information concerning the Hydrogeology of the study area has been obtained from:
- Review of published geological and hydrogeological data.
 - Review of hydrogeological study reports prepared in support of planning applications for quarrying and water resource developments in the area.
 - Review of published and site-specific geological data including mineral evaluation borehole and piezometer borehole logs;
 - Survey of local groundwater dependent features such as springs and streams;
 - Groundwater and surface water level measurements (manual and logged) made at monitoring points located within the Northern Extension and surrounding locality (February 2019 – present).

- Field (hydraulic) testing of installed monitoring points.
- Field and laboratory measured water quality sampling from piezometer boreholes and local springs undertaken by BCL between February and July 2021.
- Experience and assessment of similar hydrogeological terrains elsewhere within the UK.

2.7.2 Aquifer Classification

- 2.7.2.1 The Portland Freestone and Portland Chert (together comprising the Portland Stone) which constitute the economic mineral of the Site are designated by the EA as a "Principal Bedrock Aquifer".
- 2.7.2.2 This designation is both economic and environmental and is intended to encompass strata that have "...high intergranular and / or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer."
- 2.7.2.3 The Purbeck Group and Portland Sandstone which respectively overlie and underlie the economic mineral are designated by the EA as a "Secondary A Bedrock Aquifer".
- 2.7.2.4 This designation is intended to include strata that have "...permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers."
- 2.7.2.5 The Portland Sandstone is underlain by the Kimmeridge Clay strata which is regarded as non-aquifer ("unproductive strata" under the EA classification scheme). The Kimmeridge Clay is expected to act as a barrier to groundwater flow and as such forms the base of the local hydrogeological sequence.

2.7.3 Aquifer Recharge

- 2.7.3.1 The outcrop area of the Portland Stone limestone occupies an elevated position in the local landscape. The Portland Stone and underlying Portland Sand present in the vicinity of the Site are considered to constitute a single unconfined aquifer unit, with recharge fed primarily through incident rainfall across the outcrop area.
- 2.7.3.2 In addition to the above autogenic recharge, allogenic recharge to the local aquifer is also identified to occur from the Entrance Stream. As described above, the Entrance Stream drains from the area of Mupe outcrop to the northeast of the Site, flowing onto the Portland Stone outcrop area downstream of the main quarry entrance. Under normal flow conditions the watercourse subsequently loses all flow to ground, close to this contact.
- 2.7.3.3 Calculation, corroborated by field observation, indicates generally low rates of flow for the Entrance Stream (and hence recharge), which are likely to average in the order of 0.2l/s. This has however been recorded to flow during more extreme rainfall events at up to 5l/s (spot observation).

2.7.4 Groundwater Flow Mechanism

- 2.7.4.1 The Portland Stone Formation possesses both low primary porosity and permeability. The occurrence of groundwater within the unit occurs as secondary permeability, held within the network of secondary fractures prevalent within the strata.
- 2.7.4.2 The ability for transmission of flow through the aquifer is therefore dependent upon the degree of interconnectivity between the network of fractures, joints and bedding planes formed through the unit. The vertical movement of rainfall through the sequence is expected to be rapid in the area encompassing the Northern Extension, reflecting the absence of surface water features on the higher elevation Portland Stone outcrop areas.
- 2.7.4.3 The Portland Sand Formation that underlies the limestones of the Portland Stone comprise silty sands with interbedded marl horizons. Field assessment suggests the primary porosity of this unit is also expected to be low (for sandstone), with permeability again expected to be dependent on the presence and interconnectivity of the secondary fracturing.
- 2.7.4.4 The hydrograph analysis for the Quarry Combe watercourse conducted at *section 2.6.2* suggests that rapid movement of water through the Portland Sand as interconnected fracture flow is not particularly prevalent for the area encompassing the Northern Extension (the watercourse reacting to rainfall runoff from within the combe catchment area, as opposed to rapid transmission through aquifer from further afield). Aside from the runoff peaks, the hydrograph records a steady baseflow release from the catchment, indicating a more delayed release of groundwater from storage (considered most likely from the relatively poorly interconnected secondary porosity).

2.7.5 Monitoring points

- 2.7.5.1 Site specific information used to define groundwater levels, aquifer properties and the local groundwater regime has been collected from:
- Groundwater level data for 8-no. piezometers installed in proximity to the Northern Extension and within the existing quarry site (H&HIA, *appendix 3*).
 - Elevation and flow data for surface water features (points of discharge from the local aquifer system).
- 2.7.5.2 The locations for the aforementioned installed monitoring points are shown on *figure 10* and summary details are provided at *table 8*.

Table 8 Swanworth Quarry - Groundwater monitoring points and range in measured levels

Name	Easting	Northing	Depth (m)	Maximum Groundwater Elevation (maOD)	Minimum Groundwater Elevation (maOD)	Range (m)
PZ1/19	396534	79169	52	82.44	79.07	3.37
PZ2/19	396542	78637	60	91.03	77.11*	13.92
PZ3/19	396367	78212	62	77.78	72.53	5.25
PZ4/19	396230	79090	52.7	93.37	89.54	3.83
PZ5/19	396924	78197	18	72.23	61.54*	10.69
PZ1/20	396778	78316	34	79.00	73.63	5.38
PZ2/20	396977	78294	34.5	75.81	69.73	6.08
PZ3/20	397225	78459	34	69.26	64.46	4.80

*Reading taken after bailing for water sample.

- 2.7.5.3 All piezometer locations have been accurately surveyed to facilitate reduction of collected groundwater data to Ordnance Datum (OD).
- 2.7.5.4 Monitoring has been undertaken in proximity to the Northern Extension since 2019 (PZ1/19 – PZ5/19). The monitoring program has been expanded, with the most recent addition of three piezometers installed within and around the existing quarry site (2020: PZ1/20 - PZ3/20). The purpose of the latter installations being to set the Northern Extension in a wider context and to provide detail on groundwater levels in the area to the southeast of Quarry Combe i.e. the opposite (down hydraulic gradient) side of the combe to the Northern Extension.
- 2.7.5.5 In addition to the site piezometer network, surface water level observations have been made for springs occurring within the Quarry Combe as part of the regular monitoring program.
- 2.7.5.6 As part of this assessment a small temporary sump has also been excavated into the base of the existing quarry. This was excavated to some 4mbgl, exposing the watertable within the basal 0.5m.
- 2.7.5.7 The sump was excavated in January 2021 at the request of the EA, to: a. provide exposure of the contact between the Portland Stone and underlying Portland Sand unit *and* b. to enable a small-scale pump exercise to assess response of the aquifer to removal of water.
- 2.7.5.8 A datalogger was installed within the quarry sump soon after excavation, with levels monitored on an hourly basis since. The sump was pumped out on the 1st March 2021 and remained dry until a rainfall event on the 12th March. This restored the water level in the base of the sump (some 0.5m).
- 2.7.5.9 Water was then recorded as being present throughout the remainder of the monitoring period, although this largely appeared perched within the base, with little response to rainfall and/or groundwater recovery.

Groundwater Levels and Flow Direction

- 2.7.5.10 The collected groundwater data (and aforementioned sump level) are presented as a series of hydrographs at *figure 8*. The data are collected by dataloggers installed within seven of the eight monitoring points, with readings taken at hourly interval.
- 2.7.5.11 The recorded data are corroborated by manual dip readings and show a generally subdued variation in groundwater levels across four of the five no. 2019 monitoring installations (PZ1-19 and PZ3-19 to PZ5-19). The remaining 2019 installation (PZ2/19) and the 2020 installations record a larger variation.
- 2.7.5.12 The 2019 piezometers installed in proximity to the Northern Extension record a natural seasonal variation of around 1m. The 2020 piezometers record a more variable system, with levels varying by some 5-6m seasonally.
- 2.7.5.13 Water samples have been taken from the monitoring points to provide necessary baseline data for the HRA. These bailed samples are clearly seen on the 2019 monitoring point hydrographs, as a series of sudden declines followed by relatively slow recovery (measured in days to weeks).

- 2.7.5.14 Of the 2019 series monitoring points, only data from piezometer PZ5/19 indicates any marked response of groundwater level to variations in rainfall, these being several short-lived spikes in groundwater level, ranging between 0.25 and 3m, persisting for up to 24-hours following very heavy rainfall.
- 2.7.5.15 Rainfall response is also recorded within the 2020 piezometers. Both the 2020 installations and PZ5/19 are each installed within the active working area in the existing quarry. In this area the depth to groundwater is much reduced (3 – 7m) in comparison to the other 2019 piezometers (40 – 50m) and the overlying Portland Stone sequence has been largely removed, with the water level residing close to the top of the Portland Sand.
- 2.7.5.16 The collected groundwater data has been used to prepare a series of contour plots to depict groundwater levels through the study area, under maximum and minimum groundwater elevation conditions. Based on the collected datasets, an interpolated contour plot is provided at *figures 9 and 10*.
- 2.7.5.17 The interpolated data indicate a piezometric gradient of some 0.019 from northwest to southeast, beneath the Northern Extension and existing site.
- 2.7.5.18 Under maximum groundwater elevation conditions, elevations in proximity to the Northern Extension fall from some 93maOD upon the north-western boundary to some 78maOD in the area to the southeast of Quarry Combe. Groundwater levels continue to decline to the south/southeast beneath the existing Site, decreasing to some 69-68maOD towards the southeastern boundary.
- 2.7.5.19 Under minimum conditions groundwater elevations are recorded as 93maOD upon the northwestern boundary of the Northern Extension, reducing to some 76maOD in the area to the southeast of Quarry Combe. Groundwater levels continue to decline to the southeast beneath the existing Site, decreasing to some 65maOD towards the southeastern boundary.

Unsaturated Thickness (depth to groundwater)

- 2.7.5.20 The depth to groundwater within the Northern Extension varies between some 40-45m, with groundwater levels residing beneath the Portland Stone, within the Portland Sand unit. Comparison of groundwater elevations with the base of the Portland Stone indicates groundwater levels to reside some 5 - 15m below this contact. In this regard, the Portland Stone (and hence the proposed infill) will reside permanently above the watertable.

Saturated Thickness

- 2.7.5.21 The effective base of the aquifer units beneath the Northern Extension is the Kimmeridge Clay. Based on drilling local to the Site, these are expected to reside some 39m below the top of the Portland Stone/Portland Sand contact. In this regard, the effective saturated thickness of the Portland Sand aquifer varies from some 24 - 34m in proximity to the Site.

2.7.6 Local Groundwater and Surface Water Interaction

- 2.7.6.1 The basal section of Quarry Combe to the south of the Northern Extension varies from some 60maOD at Hill Bottom, rising to the northeast, to attain an elevation of some 90maOD at Coombe Bottom (alongside the northern flank of the existing site).

- 2.7.6.2 Comparison of the groundwater elevation plots (*figures 9 and 10*) with the basal elevation of Quarry Combe, indicates the southern section of the valley resides below the piezometric surface and hence is likely to receive at least a component of groundwater flow from the area encompassing the Northern Extension.
- 2.7.6.3 Field investigation undertaken during minimum groundwater elevation conditions has recorded some 1.3l/s captured within the spring collector system installed within Quarry Combe and some 0.5l/s being recorded as additional flow within the adjacent watercourse at Hill Bottom i.e. a total springflow into Quarry Combe of some 1.8l/s for the section downstream of the Northern Extension.
- 2.7.6.4 The piezometric surface for the area to the southeast of Quarry Combe suggests a continued gradient to the southeast and onwards to the coast (some 1.75km distant).
- 2.7.6.5 Although there are springs identified within the area to the southeast of the existing site, these are located at elevation too high to be in continuity with groundwater held within the Portland Sand beneath the existing site. These springs arise at some 105maOD (Worth Matravers and Seacombe), which occurs significantly above the elevation of groundwater recorded in proximity to the existing Site (some 68maOD).
- 2.7.6.6 The area between the Site and the coast to the southeast is underlain by the Worbarrow Tout and Mupe Members of the Purbeck Formation (which sit stratigraphically above the units at the Site). It is therefore expected that the aforementioned spring flows are maintained by incident rainfall feeding as runoff and/or intra-flow to these higher elevation springs.
- 2.7.6.7 Extrapolation of the groundwater gradient in proximity to the Site suggests any groundwater movement through the aquifer in this direction would be expected to pass beneath the aforementioned units, emerging at the coast, at or close to, sea level.

2.7.7 Aquifer Parameters

- 2.7.7.1 Aquifer parameters describe the rate at which groundwater may be transmitted through a rock body (hydraulic conductivity / transmissivity) and the water storage potential of the system (storage).
- 2.7.7.2 The H&HIA conducted for the Site collated a series of aquifer parameter details from both desk study and field test sources. The values derived (alongside other published values for aquifer characteristics) for the strata in the locality are presented at *table 9*.

Table 9 Aquifer permeability values		
Geological unit	Hydraulic Conductivity (metres/day)	Porosity (%)
Lower Purbeck Group	0.005*	15.2 (Range 1 – 34.5)**
Portland Stone Formation	0.018 (interquartile range 3.1×10^{-4} to 0.702)*	16.4 (Interquartile range 13.5 to 18)*
Portland Sand Formation	2.1×10^{-5} (interquartile range 3.2×10^{-6} to 1.2×10^{-4})**	13.2 (Interquartile range 3.3 – 23.5)**
* The value presented values are considered representative of non-fissured/poorly interconnected matrix permeability.		
+ Values for weathered Portland Stone (BGS The physical properties of major aquifers in England and Wales).		
++ Values for Portland Sand inc. borehole tests (BGS The physical properties of minor aquifers in England and Wales).		

- 2.7.7.3 Following on from the above data collation exercise, additional falling head tests have been conducted on the Site piezometers. These have been undertaken to a. provide further site-specific permeability values and b. to assess the piezometer response to water input (recharge). The latter point is also considered alongside the monitoring point response to

effects of water removal following the routine sampling program (in effect a rising head test).

2.7.7.4

Full details of the piezometer tests are provided at *appendix 5*. A summary of the test results are provided at *table 10* below.

Table 10 Site monitoring points – Hydraulic testing	
Value	Portland Sand Formation permeability (metres/day)
Minimum	0.02
Maximum	0.40
Average	0.15
* Note the figures presented represent the early gradient data from testing and thus the maximum values recorded during testing.	

2.7.7.5

The piezometer responses generally recorded an initial relatively rapid decline, followed by an extremely slow tail off. The values presented above are representative of the peak 'early' gradients and thus present maximum values of hydraulic conductivity, in order to present a worst-case scenario for subsequent assessment in terms of transmission of pollutants etc through the aquifer.

2.7.7.6

The aforementioned values are considered representative of the initial movement of water into the secondary porosity of the surrounding aquifer. The slower tail-off is then considered representative of the wider ability for water to be transmitted through the aquifer, once the secondary porosity has been saturated. This is clearly much reduced, taking PZ3_19 as an example, the later data indicates a permeability value approximately one order of magnitude lower (some 0.02m/d) than that derived from the 'early time' data (some 0.4m/d).

2.8 Water Resources Setting

2.8.1 Background

2.8.1.1

Information concerning the water resources of the area encompassing the Site has been obtained from:

- EA Dorset: Abstraction Licensing Strategy, March 2020.
- EA radial search of abstraction licence database.
- Radial search of the Private Water Supply database held by Dorset Unitary Authority.

2.8.2 Source Protection Zones

2.8.2.1

Data on the locations and forms of groundwater Source Protection Zones (SPZs) in the region have been obtained from the EA which confirms that the entirety of the Site lies outside any EA defined SPZ.

2.8.3 Drinking Water Protected Areas & Safeguarding Zones

2.8.3.1

Both the existing quarry and the Proposed Extension reside outside any designated Drinking Water Safeguarding Zones for groundwater (DWSZgw).

2.8.4 Catchment Abstraction Management Strategy

Overview

- 2.8.4.1 The EA classify the water resource status of the local strata as "restricted water available for licensing".
- 2.8.4.2 This status is applied as the EA's groundwater unit balance indicates that more water is currently licensed for abstraction than the amount available from the groundwater unit but that recent actual abstractions are lower than the amount available.
- 2.8.4.3 In restricted groundwater units no new consumptive licences will be granted although licence trading is permitted.

2.8.5 Water Abstractions

Licensed Abstractions

- 2.8.5.1 Information concerning licensed abstractions for the locality has been obtained from the EA licence database. Details of licensed abstractions within the area encompassing the Site are shown at *table 11*. The locations of all abstractions are shown in *figure 11*.

Map Code	Licence No	Holder Name	Licence name	Licensed volume*	Distance from site**
L1a	13/44/003/S/012	Encombe Limited, Encombe House, Corfe Castle, Wareham, DORSET BH20 5LW	Spring #1	6,8191.1m3/a* 272.76m3/d	405
L1b			Spring #2		530
L1c			Spring #3		725
L1d			Spring #5		915
L1e			Spring #6		985
L1f			Spring #7		1,095
L1g			Spring #4		1,170
L2	SW/044/0003/005		Borehole	Unknown	1,475

* - These are combined figures for all 7-no. collection points which are piped under gravity to a pumping station at Encombe House from where water is distributed to various storage tanks and properties by means of 2-no. pumps of 9.09m3/hr and 2.27m3/h capacity.

** - at shortest distance between the Northern Extension boundaries and the abstraction.

- 2.8.5.2 Licensed abstractions L1a – L1g comprise input water to a private water supply and distribution system operated by Encombe Estate (the "reticulation system"). An in depth explanation of the system is provided within the H&HIA. Of primary interest to the HRA are the abstraction points made at L1a – L1c, which capture springflows arising within Quarry Combe.
- 2.8.5.3 The aforementioned springs are gathered into a catchment tank (point L1c) and directed into a 9-inch pipeline that runs under gravity around the southern flank of the combe and into a second storage chamber at Westhill Combe. A second series of catchment tanks have been installed along the basal section within Westhill Combe and these also link into the Westhill storage chamber.
- 2.8.5.4 A hand-dug tunnel then conveys water under gravity from the Westhill storage chamber, some 820m to the north-northwest, feeding into the series of lakes created to the south of the main Encombe Estate House. Water is taken from the supply system upstream of the lakes, to feed the wider water distribution system.

2.8.5.5 Recent flow assessment data collected during expected minimum flow conditions (September 2021) indicates the Quarry Combe catchment to provide some 1.3l/s into the Westhill storage tank, whilst the Westhill catchment system contributes a further 1.4l/s i.e. a total of some 2.7l/s.

2.8.5.6 The reticulation system provides a supply of water to a number of properties located on the wider Encombe Estate (locations D2a – D2q – *table 12*) as well as the fire hydrant network around the main house and cattle drinking troughs around the estate.

De-regulated Abstractions

2.8.5.7 Data has been obtained from Dorset Unitary Authority (DUA), summarising deregulated abstractions located in the vicinity of the Site. Excluding those properties listed as part of the Encombe reticulation system, a total of eight additional locations are identified. These are locations D1a – D1f, which are supplied by a single spring collector at Down Valley/Hill Bottom hamlet.

2.8.5.8 Location D3 relates to a hand dug well located above the Northern Extension within an area underlain by Lulworth Formation, (Mupe Member). The recorded waterlevel within the well is at around 145maOD, some 30m above the piezometric surface recorded within the underlying aquifer.

2.8.5.9 Location D4 relates to an abstraction taken from a spring collector at Hill Bottom, providing an amenity supply to Haysom's Quarry.

Map Code	Status	Location	Distance from site (km)*
D1a	Bramble Cottage	Properties supplied by a single spring collector at Down Valley / Hill Bottom Hamlet – Deregulated abstraction.	740 (740)
D1b	Mermaid Cottage		750 (740)
D1c	Bake House Cottage		750 (740)
D1d	Honeysuckle Cottage		775 (740)
D1e	Rose Cottage		785 (740)
D1f	Primrose Cottage		835 (740)
D2a	Woodside, West Street Kingston	Properties supplied by Encombe Estate Reticulation System. This system takes its water source from Springs L1a to L1g located within Quarry Combe and Westhill Combe (Abstraction Licence No. 13/44/003/S/012), and from a borehole (L2) located above Encombe House (Abstraction Licence No. SW/044/0003/005).	705 (405)
D2b	13 South Street, Kingston		725 (405)
D2c	2 West Street Kingston		740 (405)
D2d	3 West Street Kingston		760 (405)
D2e	5 South Street, Kingston		765 (405)
D2f	2 South Street, Kingston		790 (405)
D2g	14 West Street Kingston		810 (405)
D2h	2 Hoots, Lower Scoles Farm		820 (405)
D2i	18 West Street Kingston		830 (405)
D2j	20 West Street Kingston		835 (405)
D2j	5 The Lane, Kingston		860 (405)
D2l	West Hill Cottage, Kingston		1,165 (405)
D2m	West Lynch Cottage, Kingston		1,295 (405)
D2n	Blashenwell Farm, Corfe Castle		1,605 (405)
D2o	Encombe House		1,830 (405)
D2p	The Garden House, Kingston		1,930 (405)
D2q	The Stable House, Kingston		1,975 (405)

D3	Messrs Fry, Kingston	Hand-dug well feeding cattle drinkers under gravity	345
D4	Encombe Estate	Pump house at spring collector delivering to Haysom's quarry.	850
*- at shortest distance between the Proposed Extension boundaries and the abstraction. Note that the information upon deregulated supplies is assumed to identify point of use rather than location of source. The first distance quoted is that between the Northern Extension and the point of use, followed by a distance given in brackets which is that between the Northern Extension and the nearest potential supplying spring source (i.e. L1a within Quarry Combe).			

2.8.6 Source Protection Zones

- 2.8.6.1 Data on the locations and forms of groundwater Source Protection Zones (SPZs) in the region have been obtained from the EA and these confirm that the entirety of the Northern Extension (and existing Site) lies outside any defined SPZ.
- 2.8.6.2 This notwithstanding, the R25 notice has requested detail on the flow paths and velocity to the licensed spring valley outfalls in Hill Bottom (Quarry Combe). These comprise the three licensed locations - L1a to L1c. As presented at *section 2.7.6*, combined groundwater emergence within this section of the Combe during September 2021 was recorded at 1.8l/s.
- 2.8.6.3 Source Protection Zones are normally defined by travel time to the point of abstraction, SPZ1 being the 50-day travel time and SPZ2 being the 400-day travel time. For a spring catchment, the travel time distances can be calculated using the velocity equation derived from Darcy's Law¹⁸.
- 2.8.6.4 Using the highest permeability value derived from field testing (some 0.4m/d) and applying a worst-case configuration for defined catchment (see *appendix 6*) the above calculations suggest the 50-day travel radius would extend 24m from the spring and the 400-day travel radius would extend some 184m from the spring.
- 2.8.6.5 The closest spring to the infill area is L1a, which is located in the northeastern section of Quarry Combe. This is situated some 400m from the closest section of infill (the narrow neck connecting the existing Site to the Northern Extension) and more than 550m from the main area of infill to the north. On this basis it is clear that the infill area would reside outside any SPZ1/SPZ2 areas should these be defined for the licences.
- 2.8.6.6 An estimate of the total catchment for the aforementioned licenced abstractions has been defined based on the recorded flow emergent at the spring collector system (*section 2.7.6* – 1.3l/s) and back calculating the area required to sustain the measured flow from rainfall input. Taking the effective rainfall for the locality based on existing land use for the up hydraulic gradient catchment (*table 6* – crop production : 316mm/a), the aforementioned emergent flow suggests an area of some 13 ha would be required to maintain the aforementioned flow at the spring.
- 2.8.6.7 The groundwater contour plots indicate the catchment area for the spring is likely to extend across a proportion of the area of ground to the north of Hill Bottom, towards the proposed Northern Extension (an overall area of some 26 ha).

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"Manual for production of groundwater source protection zones", Environment Agency, March 2019.

2.8.7 Potential Sources of Pre-existing Contamination

Landfill Sites

2.8.7.1 Data supplied by the EA confirms that there are no operational or recorded historic landfills within either the existing permission or planned extension boundaries of the Site.

2.8.7.2 Summary details of known historic and currently authorised landfills in the area of the Site are tabulated below with locations and boundaries established from the EA's Public Register illustrated at *figure 12*.

Site Name	Licence Holder	Status	Wastes	EA Ref's.	Operational	Distance* (m) & Direction
Gallow Gore Landers Quarry	Landers' Quarries	Historic: Licensed Surrendered	Inert: Largely non Biodegradable / putrescible	EAHLD08946 WDL/77/009 WML/91/130 1200/0109	1977-1994	1km E
Downs Quarry	Harden Bros	Historic: Licensed	Inert, Industrial	EAHLD08867 WDL/91/152 1200/0114	1977 - **	1.3km E
Gallow Gore Quarry	Landers' Quarries	Historic: Licensed Surrendered	Inert, Industrial	WML/91/130	1977-1994	1.6km E
Acton Quarries No.1	The National Trust	Historic: Licensed Surrendered	Inert	EAHLD08868 WDL/91/130,009 1200/0110	1990-1991	1.6km E
Acton Quarries No.2				EAHLD08916 WDL/90/115,116 1200/0112	1989-1992	1.67km E
Acton Quarries No. 3				EAHLD08917 WDL/90/116,115 1200/0113	1991-1993	2.2km E
Downs Quarry	D & P Lovell Quarries	Authorised: In Closure	A05: Non-Biodegradable Wastes	EA/EPR/QP3597 HZ/A001	1991-**	1.3km E
*-at shortest distance between the closest boundaries of the landfills and the Proposed Extension						
**-unspecified by EA database						

2.8.7.3 All sites identified from the EA's Public Register are historic, with the closest being situated some 1km to the east of the Northern Extension area at Landers' Quarries. It is of note that no landfill sites are located up groundwater gradient of the Northern Extension.

2.8.7.4 The deposit for recovery operation undertaken at the existing site is not included within the EA database. The placement of material (completed under Environmental Permit No. EPR/CB3030RQ) to facilitate the site restoration has so far been placed on the eastern and southeastern flanks of the Site. This is located down hydraulic gradient of the Northern Extension.

2.8.8 Groundwater Quality

2.8.8.1 Groundwater quality data for the Portland Sand aquifer underlying both the Northern Extension and existing operation has been obtained from the Site piezometers. Laboratory analysis of water samples collected over 16-no. sampling rounds completed between February 2019 and July 2021, has been undertaken.

2.8.8.2 The full dataset of groundwater quality data for samples obtained under the above program are provided at *appendix 7*.

2.8.8.3 Table 14 below shows average and maximum concentrations for a selected number of representative chemical species established from the aforementioned Site groundwater quality data.

2.8.8.4 Average and maximum Site values for each species are also expressed as a percentage of the most relevant regulatory water quality standard (RWQS) to provide a visual comparison on general water quality.

Monitoring point	pH (pH units) [WSLM3]				
	Mean	Max.	RWQS – UK DWS		
			Minimum	Maximum	
PZ1_19	7.5	7.7	6	9	
PZ2_19	7.6	7.8			
PZ3_19	7.7	8.0			
PZ4_19	7.7	8.0			
PZ5_19	7.8	8.0			
PZ1_20	7.7	7.8			
PZ2_20	7.7	7.9			
PZ3_20	7.9	8.3			
Monitoring point	Electrical Conductivity (SEC) µS/cm (WSLM2)				
	Mean	Max.	RWQS – UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	869	993	2,500	35%	40%
PZ2_19	790	952		32%	38%
PZ3_19	1096	1600		44%	64%
PZ4_19	726	949		29%	38%
PZ5_19	515	738		21%	30%
PZ1_20	893	999		36%	40%
PZ2_20	652	792		26%	32%
PZ3_20	488	556		20%	22%
Monitoring point	Total Alkalinity (CaCO3) mg/l (WSLM12)				
	Mean	Max.	RWQS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	271	529	NS	NS	
PZ2_19	268	296			
PZ3_19	294	344			
PZ4_19	269	301			
PZ5_19	136	201			
PZ1_20	215	237			
PZ2_20	151	203			
PZ3_20	114	138			

Monitoring point	Arsenic (As) mg/l (ICPMSW)				
	Mean ⁺	Max.	RWQS UKTAG	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	<0.001	0.002	0.005	0%	40%
PZ2_19	<0.001	0.000		0%	0%
PZ3_19	<0.001	0.000		0%	0%
PZ4_19	<0.001	0.000		0%	0%
PZ5_19	<0.001	0.000		0%	0%
PZ1_20	<0.001	0.000		0%	0%
PZ2_20	<0.001	0.000		0%	0%
PZ3_20	<0.001	0.001		0%	20%
Monitoring point	Cadmium (Cd) mg/l (ICPMSW)				
	Mean ⁺	Max.	RWQS UKDWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.00004	0.00006	0.005	1%	1%
PZ2_19	0.00005	0.00015		1%	3%
PZ3_19	0.00006	0.00009		1%	2%
PZ4_19	0.00005	0.00010		1%	2%
PZ5_19	0.00005	0.00009		1%	2%
PZ1_20	0.00004	0.00005		1%	1%
PZ2_20	0.00003	0.00003		1%	1%
PZ3_20	0.00003	0.00003		1%	1%
Monitoring point	Calcium (Ca) mg/l (ICPWATVAR)				
	Mean	Max.	RWQS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	148	193	NS	NS	
PZ2_19	135	149			
PZ3_19	106	141			
PZ4_19	74	99			
PZ5_19	48	57			
PZ1_20	111	134			
PZ2_20	68	84			
PZ3_20	26	43			
Monitoring point	Lead (Pb) mg/l (ICPMSW)				
	Mean	Max.	RWQS EA - MRV	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	<0.001	<0.001	0.01	All samples below detection limit	
PZ2_19	<0.001	<0.001			
PZ3_19	<0.001	<0.001			
PZ4_19	<0.001	0.002		-	20%
PZ5_19	<0.001	<0.001		All samples below detection limit	
PZ1_20	<0.001	<0.001			
PZ2_20	<0.001	<0.001			
PZ3_20	<0.001	<0.001			

Monitoring point	Magnesium (Mg) mg/l (ICPWATVAR)				
	Mean	Max.	RWQS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	19	25	NS	NS	
PZ2_19	12	21			
PZ3_19	61	97			
PZ4_19	30	35			
PZ5_19	17	31			
PZ1_20	31	45			
PZ2_20	17	27			
PZ3_20	7	9			
Monitoring point	Manganese (Mn) mg/l (ICPMSW)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.070	0.200	0.05	140%	400%
PZ2_19	0.011	0.027		22%	54%
PZ3_19	0.030	0.114		60%	228%
PZ4_19	0.036	0.089		73%	178%
PZ5_19	0.015	0.048		30%	96%
PZ1_20	0.009	0.016		18%	32%
PZ2_20	0.009	0.015		18%	30%
PZ3_20	0.010	0.023		19%	46%
Monitoring point	Mercury (Hg) mg/l (ICPMSW)				
	Mean	Max.	RWQS EA - MRV	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	<0.0001	<0.0001	0.00001	All samples below laboratory detection limit	
PZ2_19	<0.0001	<0.0001			
PZ3_19	<0.0001	<0.0001			
PZ4_19	<0.0001	<0.0001			
PZ5_19	<0.0001	<0.0001			
PZ1_20	<0.0001	<0.0001			
PZ2_20	<0.0001	<0.0001			
PZ3_20	<0.0001	<0.0001			
Monitoring point	Nickel (Ni) mg/l (ICPMSW)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.006	0.009	0.02	29%	45%
PZ2_19	0.002	0.005		12%	25%
PZ3_19	0.012	0.026		58%	130%
PZ4_19	0.004	0.005		18%	25%
PZ5_19	0.002	0.005		12%	25%
PZ1_20	0.007	0.009		33%	45%
PZ2_20	0.003	0.007		17%	35%
PZ3_20	0.001	0.002		7%	10%

Monitoring point	Potassium (K) mg/l (ICPWATVAR)				
	Mean	Max.	RWQS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	3.3	6.0	NS	NS	
PZ2_19	2.0	5.0			
PZ3_19	4.8	8.0			
PZ4_19	6.9	45.0			
PZ5_19	2.7	6.0			
PZ1_20	4.3	6.0			
PZ2_20	3.3	5.0			
PZ3_20	2.3	3.0			
Monitoring point	Zinc (Zn) mg/l (ICPSW)				
	Mean	Max.	RWQS LFTGN02	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.08	0.22	3	3%	7%
PZ2_19	0.02	0.04		1%	1%
PZ3_19	0.02	0.08		1%	3%
PZ4_19	0.04	0.16		1%	5%
PZ5_19	0.02	0.16		1%	5%
PZ1_20	0.49	2.85		16%	95%
PZ2_20	0.60	2.99		20%	100%
PZ3_20	0.25	1.45		8%	48%
Monitoring point	Chloride (Cl) mg/l (KONENS)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	56	61	250	22%	24%
PZ2_19	48	107		19%	43%
PZ3_19	46	67		18%	27%
PZ4_19	36	78		15%	31%
PZ5_19	30	38		12%	15%
PZ1_20	30	36		12%	14%
PZ2_20	37	40		15%	16%
PZ3_20	15	18		6%	7%
Monitoring point	Ammoniacal Nitrogen (as N) mg/l (KONENS)				
	Mean	Max.	RWQS See notes	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.08	0.20	0.39*	22%	51%
PZ2_19	0.20	1.00		52%	256%
PZ3_19	0.67	1.90		171%	487%
PZ4_19	0.38	0.90		97%	231%
PZ5_19	0.31	0.90		78%	231%
PZ1_20	0.69	1.00		176%	256%
PZ2_20	0.30	0.90		76%	231%
PZ3_20	0.33	0.60		85%	154%

Monitoring point	Nitrate (N) mg/l (KONENS)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	1.6	3.1	50	3%	6%
PZ2_19	11.7	12.8		23%	26%
PZ3_19	4.9	10.4		9%	21%
PZ4_19	3.2	9.0		6%	18%
PZ5_19	2.2	4.2		4%	8%
PZ1_20	17.3	20.3		35%	41%
PZ2_20	2.0	3.8		4%	8%
PZ3_20	2.0	3.3		4%	7%
Monitoring point	Nitrite (N02) mg/l (KONENS)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	0.08	0.30	0.5	16%	60%
PZ2_19	0.04	0.08		8%	16%
PZ3_19	0.55	2.59		111%	518%
PZ4_19	0.44	1.51		88%	302%
PZ5_19	0.07	0.27		15%	54%
PZ1_20	0.68	1.26		136%	252%
PZ2_20	0.10	0.31		20%	62%
PZ3_20	0.17	0.41		33%	82%
Monitoring point	Sulphate (SO4) mg/l (ICPWATVAR)				
	Mean	Max.	RWQS UK DWS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	120	198	250	48%	79%
PZ2_19	25	30		10%	12%
PZ3_19	222	597		89%	239%
PZ4_19	52	72		21%	29%
PZ5_19	77	168		31%	67%
PZ1_20	145	184		58%	74%
PZ2_20	119	142		47%	57%
PZ3_20	105	124		42%	50%
Monitoring point	Total Petroleum Hydrocarbons (TPH) mg/l (TPHFID)				
	Mean ⁺	Max.	RWQS	PZ Mean as %'age of RWQS	PZ Max. as %'age of RWQS
PZ1_19	1.11	7.57	NS	NS	NS
PZ2_19	0.07	0.36			
PZ3_19	0.08	0.24			
PZ4_19	0.05	0.11			
PZ5_19	0.05	0.10			
PZ1_20	0.03	0.06			
PZ2_20	0.03	0.05			
PZ3_20	0.03	0.06			

UK_DWS: Water Supply (Water Quality) Regulations 2000.
 SW-PDW: Surface Waters (Abstraction for Drinking Water) Regulations 1996,
 SW-PAL: EU Dangerous Substances Directive; Protection of Surface Water for the Protection of Aquatic Life.
 WHO: World Health Organisation Guideline Values for water intended for human consumption.
 LFTGN02: EA Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water. Minimum reporting value required by LFTGN02, Table 6.6
 EA – MRV: Hazardous substances to groundwater: minimum reporting values. www.gov.uk. Jan 2017
 * - equivalent to 0.5mg/l NH4+.
 NS: No standard. RWQS: Regulatory Water Quality Standard.
 + - where laboratory analysis determined below the LOD, these have been excluded from calculation of mean data.

Comparison of Site groundwater quality with regulatory water quality standards

- 2.8.8.5 The Site groundwater quality data has been screened against a hierarchy of regulatory water quality standards (RWQS) to determine instances and magnitudes of exceedance, full results of which are included at *appendix 7*.
- 2.8.8.6 Considering the Northern Extension area (4 piezometers – PZ1_19 to PZ4_19) and existing site (4 piezometers – PZ5_19 and PZ1_20 to PZ3_20) separately, average concentrations established using all data do not record an exceedance of RWQS for either area, with the exception of ammoniacal nitrogen, nitrite and manganese. It is of note that no standards are available for calcium, potassium, magnesium, alkalinity or Total Petroleum Hydrocarbons (TPH).
- 2.8.8.7 Looking at the peak concentrations recorded, exceedance of the RWQS has occurred as discrete values for manganese, nickel, sulphate, ammoniacal nitrogen and nitrite within the Northern Extension samples and for zinc, ammoniacal nitrogen and nitrite within the existing site area samples.
- 2.8.8.8 Aside from the increase in zinc concentration, each of the assessed determinands record lower concentrations within the existing site samples, when compared to the Northern Extension samples.

Spatial distribution of species concentrations

- 2.8.8.9 Of the 4-no. Northern Extension piezometers, the groundwater elevation data shows PZ2_19 to be located directly down hydraulic gradient of the infill area and PZ3_19 to be located obliquely down gradient. PZ1_20 is also located down gradient, on the upstream flank of the existing site.
- 2.8.8.10 The upstream monitoring points for the proposed infill area (PZ1_19 and PZ4_19) record relatively elevated levels of species concentration including manganese, nitrite and ammoniacal nitrogen. Of these chemical species, both nitrite and ammoniacal nitrogen are also reflected as elevated within the down gradient monitoring points, in particular PZ1_20. Manganese is recorded in reduced concentration in the down gradient monitoring points in proximity to the existing Site.

2.9 Conceptual Hydrogeological Model

- 2.9.1.1 In accordance with guidance for conducting Hydrogeological Risk Assessments, the aforementioned baseline data has been used to develop a Conceptual Hydrogeological Model (CHM) to explain the local interrelation of the surface and sub-surface components of the water environment and the proposed inert infill operation.

- 2.9.1.2 A schematic drawing representing the Conceptual Hydrogeological Model (CHM) for the locality is presented at *figure 13* and an accompanying summary is provided below.
- 2.9.1.3 The Portland Stone Formation (together the Portland Freestone and underlying Portland Chert members), comprise a Principal Bedrock aquifer under the EA classification. The unit is formed by interbedded limestone, with siltstones and dolomite beds.
- 2.9.1.4 In proximity to the Site the watertable resides between some 5-15m below the base of the Portland Stone aquifer unit, within the underlying Portland Sand Formation. The Portland Sand comprises fractured and interbedded sandstone, marls and siltstones, the secondary fracturing providing the aquifer storage and means for groundwater movement.
- 2.9.1.5 The Portland Stone Formation comprises the economic mineral within the Northern Extension and extraction will be limited to within this unit. The Portland Stone is highly fractured, allowing percolation of incident rainfall to pass rapidly (and efficiently) to the underlying Portland Sand, and hence recording an absence of surface water features in the locality.
- 2.9.1.6 The Site is located close to the top of the local groundwater catchment, with recharge to the secondary porosity of the Portland Sand aquifer primarily occurring through percolation of incident rainfall through the Portland Stone, with a limited secondary input from the outcrop area of lower permeability Purbeck Formation strata to the northeast.
- 2.9.1.7 The base of extraction (and hence subsequent infill) will remain within the Portland Stone (above the contact with the Portland Sand) and hence a minimum standoff of some 9-18m above the extant watertable within the underlying aquifer.
- 2.9.1.8 The piezometer data installed both adjacent to the Northern Extension and in proximity to the existing Site record a strong northwest-southeast piezometric gradient within the Portland Sand aquifer, this being generally concordant with the local dip of strata.
- 2.9.1.9 Extrapolation of the piezometric surface derived from the data for the area encompassing the Northern Extension shows an implied groundwater level closely coinciding with the level of springs arising within the deeply incised valley of Quarry Combe (at Coombe Bottom – points (shown as L1a, L1b & L1c at *table 11*). This currently forms part of the supply to the Encombe Reticulation System, with any water not abstracted/collected providing baseflow to the Quarry Combe Stream.
- 2.9.1.10 The level of piezometric surface in comparison to that of the springs, strongly suggests they are likely to be fed from groundwater held within the Portland Sand and moving within the secondary porosity (fractures) of the aquifer beneath the Northern Extension.
- 2.9.1.11 Similar springs identified further down the Quarry Combe valley (Hill Bottom – D1a to D1f at *table 12*) are similarly expected to be fed by rainfall incident on the outcrop area (and groundwater held within the Portland Sand aquifer) from areas further to the west and southwest of the Northern Extension.
- 2.9.1.12 Assessment of flows and abstraction volumes within the upper section of Quarry Combe suggests that under minimum conditions the majority of emergent flow is abstracted into the Encombe Estate Reticulation System (some 1.3l/s into Encombe supply and 0.5l/s remaining as flow within the downstream adjacent watercourse).

- 2.9.1.13 Other springs identified as emerging to the southeast of the site (at Worth Matravers and Seacombe), arise at elevation above the watertable recorded in proximity to the existing site. These arise from areas underlain by Purbeck Formation strata and are expected to be maintained by runoff and/or intraflow from these generally lower permeability outcrop areas.
- 2.9.1.14 Extrapolation of the piezometric surface recorded within the Portland Sand aquifer beneath the existing site suggests a continued gradient to the southeast, with groundwater movement expected to occur beneath the near surface Purbeck strata to emerge at or close to sea level at the coast.
- 2.9.1.15 The water quality data collected in proximity to the Northern Extension record generally good water quality, but with some elevated levels of manganese and ammoniacal nitrogen (alongside chloride, zinc and nitrite). These are together expected to reflect the intensive arable activity undertaken in the locality, with associated application of fertilisers.

3 THE PLANNED INFILL

3.1 Overview

3.1.1.1 The planned infill will be placed within the extraction landform, seeking to return ground levels to prevailing (predevelopment) elevations.

3.1.1.2 The infill will be placed concurrent to extraction, over three phases of operation. The overall extraction and restoration program is expected to take around 23 years and will include a total infill placement of some 884,500m³ of inert material. The infill material will comprise some 313,000m³ of site derived overburden/processed quarry waste stone and some 571,500m³ of imported inert waste.

3.1.1.3 The imported infill material used to facilitate the restoration landform will comprise classified inert wastes from sources similar to the operation currently consented for the existing Site. These will include wastes resultant from the Site mineral processing operation and imported waste soils, inert demolition wastes and other inert waste materials incapable of producing potentially contaminating leachate.

3.1.2 Lining system

3.1.2.1 The infilling operation will include both basal and sidewall lining using appropriately selected waste materials. These will be compacted to form the base and sidewalls for the inert infill area providing an attenuating effect equivalent to a barrier of permeability 1×10^{-7} metres per second (m/s) at 1m thickness¹⁹.

3.1.3 Depth and elevation of infilling

3.1.3.1 The extraction within the Northern Extension will comprise removal of Portland Stone strata to a level of some 99 – 102maOD. This will leave a standoff of some 2-4m from the top of the underlying Portland Sand strata and remain a minimum of some 9m above the watertable (increasing to some 18m in the area to the south of the main extraction area. No dewatering will be required for the proposed extraction and restoration operations.

3.1.3.2 The infill will be placed from the base of mineral extraction, remaining above the extant watertable within the underlying Portland Sand aquifer.

3.1.3.3 The depth of infill material will vary across the extension area, from a minimum 17m within the southern section, increasing to some 28m in the northern area.

3.1.4 Waste types

3.1.4.1 It is envisaged that the Site will be permitted to accept inert wastes that are incapable of producing potentially contaminating leachate, from waste streams established for supply to the existing Site.

3.1.4.2 On the foregoing basis, the list of wastes sought by the application is given below at *table 15*.

¹⁹ Landfill Directive (1999/31/EC) for inert waste.

Table 15 Proposed Wastes Permitted for Recovery for Use in Quarry Restoration

EWC	Description	EWC	Description
01 04 08	Waste gravel and crushed rocks other than those mentioned in 01 04 07*	17 01 02	Bricks
01 04 09	Waste sands and clays	17 01 03	Tiles and ceramics
01 04 13	Wastes from stone cutting and sawing, other than those mentioned in 01 04 12**	17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06***
10 12 08	Waste ceramics, bricks, tiles and construction products (after thermal processing)	17 05 04	Soil and stones. Excluding topsoil, peat; excluding soil and stones from contaminated sites
17 01 01	Concrete	19 12 09	Minerals (for example, sand, stones)

*01 04 07: wastes containing dangerous substances from physical and chemical processing on non-metalliferous minerals.

**01 04 12: tailings and other wastes from washing and cleaning of minerals.

***17 01 06: mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances.

3.1.5 Capping

3.1.5.1 In accordance with normal procedures for inert waste placement, other than emplacement of soil cover, no engineered capping system is envisaged for the infill area.

3.1.6 Leachate management

3.1.6.1 Assuming full implementation of control and compliance procedures that will be established by HRA and which will subsequently be mandated by EA Environmental Permit, the materials for infilling will be appropriately classified inert and incapable of producing potentially contaminating leachate. A program for formal leachate management will therefore not be required.

4 CONCEPTUAL SITE MODEL

4.1 Background

4.1.1 In order to undertake the required Hydrogeological Risk Assessment, it is first a requirement to define a Conceptual Site Model (CSM). The CSM sets out the principal elements of the planned infill operation and the local hydrogeological setting, which together comprise the Source-Pathway-Receptor model. These elements are described below.

4.2 Source

4.2.1 The anticipated source water quality (referred to herein as leachate – but essentially eluate sourced from rainfall percolation through the placed inert waste mass) is represented in the HRA by 7-no. chemical species which have been selected from the EA's 18-no. (leaching test specific²⁰) determinand Waste Acceptance Criteria (WAC) schedule for inert wastes²¹ and for which baseline groundwater sample data is available. The selected chemical species are listed at *table 16*.

Table 16 Source term concentrations adopted by HRA

Chemical	Existing operation – imported material WAC test maximum leachate concentrations (mg/l)	HRA Leachate concentration (maximum permissible level assuming compliance with WAC testing [mg/l]) ⁺
Arsenic	0.02	0.05
Chloride	3.76	80
Lead	<0.004	0.05
Mercury	<0.0001	0.001
Nickel	0.0017	0.04
Sulphate	81.54	100
Zinc	0.007	0.4

All units are mg/l.

+ For all determinands these concentrations have been set at the maximum result from WAC limits permissible for inert waste as specified by regulation. The WAC testing data and maximum permissible concentrations specified by regulation are stated in units of mg/kg for solid phase samples obtained using a 10:1 liquid to solid ratio, in an eluate of 10l, as specified by BSEN 12457-2-2002. HRA leachate concentrations have therefore been established in units of mg/l by dividing the WAC concentrations by a factor of 10.

4.2.2 In addition to the aforementioned chemical species, it would be normal practice to include ammoniacal nitrogen for assessment within the HRA. Given the inert nature of waste to be deposited, ammoniacal nitrogen would not be expected to be generated by the infill material but is normally used for assessment of general water quality adjacent to infill operations. However, for the setting under assessment, the levels of ammoniacal nitrogen are already significantly elevated within the baseline water quality recorded. As such ammoniacal nitrogen is not considered appropriate for selection in this instance.

4.2.3 For the selected chemical species, the source term concentrations have been derived from recent WAC results of materials tested as part of the inert infill operation at the existing Site (representative WAC test certificates provided at *appendix 3*). The material placed as

²⁰ BS EN 12457.

²¹ As transposed from Council Decision annex 2003/33/EC.

infill within the existing Site is expected to provide a good representation of material and waste streams that will be used within the Northern Extension.

- 4.2.4 Concentrations for the source term species selected for HRA have been ascribed by reference to the relevant statutory maximum WAC limits. The concentration limit is therefore considered to implicitly represent a worst-case approach to assessment, as WAC testing associated with the infill operation will prohibit the importation of materials capable of producing leachates in greater concentrations than the WAC limit.
- 4.2.5 Furthermore, and in reality, the bulk of the inert waste imported for infilling will contain solid species concentrations substantially below those WAC limits, as well as being mixed in with approximately one third of non-saleable, processed material, derived from within the site.
- 4.2.6 The 7-no. chemicals and associated source term concentrations selected for use within the quantitative HRA are presented at *table 16*.
- 4.2.7 In addition to the concentrations assumed above, a sensitivity analysis of the site setting with regard to possible increases in source term components, as well as the possible effect of Rogue Loads (i.e. acceptance and incorporation of material that is non-compliant with the aforementioned inert material classification) is conducted at *section 5*.

4.3 Pathway

- 4.3.1 The potential pathway for leachate to enter the water environment and processes occurring within that pathway are constituted by several elements, each of which is described in-turn below.

4.3.2 Migration pathway

- 4.3.2.1 The potential leachate migration pathway simulated by HRA is as follows:
- Vertically through the engineered clay liner (single clay layer – attenuating effect equivalent to a barrier of permeability 1×10^{-7} metres per second [m/s] at 1m thickness).
 - Vertically through the unsaturated zone to the watertable beneath the infill area (a minimum of 5m through Portland Stone strata).
 - Horizontally down the hydraulic gradient (to the southeast) within the Portland Sand aquifer - expected to first emerge at surface springs within the upper reaches of Quarry Combe.

4.3.3 Chemical retardation (Kd Values)

- 4.3.3.1 Retardation is assumed to occur in the landfill liner, and within the saturated zone of the underlying aquifer.
- 4.3.3.2 Values for partition coefficients (Kd values) of individual chemical species have been based upon those presented within the LandSim Manual³ (the “Manual Value”).
- 4.3.3.3 The selected Kd values utilised within the HRA are set at the minimum value of the range in Manual Values and thus represent a conservative approach to HRA (the lesser Kd value representing maximum mobility for a given species). This notwithstanding, a sensitivity analysis is included at *section 5* to assess the risks to the water environment with regard to varying Kd values.

4.3.3.4 The Kd values adopted by HRA are shown below at *table 17*.

Table 17 Partition coefficients (Kd Values) adopted by HRA	
Chemical	Range in Kd values
Arsenic	25 – 250
Chloride	1e-9
Lead	27 – 2.7e+5
Mercury	450 - 3835
Nickel	20 – 800
Sulphate	1e-9
Zinc	1 – 600
All units are L/kg	

4.4 Receptors

- 4.4.1 The controlled waters receptor being assessed is groundwater present within the Portland Sand (Secondary A Aquifer) immediately below the infill area. This in turn feeds the aforementioned springs emerging within Quarry Combe located to the southeast of the infill area. Emergent springflow within Quarry Combe is captured and used for supply to the water reticulation system within Encombe Estate. These are therefore considered as secondary receptors as part of this HRA.
- 4.4.2 The potential for impact on the aforementioned receptors has been assessed using the Environmental Simulations International RAM package.
- 4.4.3 A series of RAM models have been developed for the infill area to predict source leachate concentrations and subsequent groundwater quality within the underlying Portland Sand aquifer and at monitoring point PZ2_19, located immediately downstream of the infill area.
- 4.4.4 As all other receptors in continuity with the Portland Sand aquifer (i.e. Quarry Combe Springs) are located at significantly greater distance from the proposed infill area, examination of water quality beneath the site and through simulation at the site boundary will therefore provide a worst-case scenario for assessment of risks to the related water environment.
- 4.4.5 As part of the assessment process an initial model will be developed to provide a suitably considered representation of potential source term concentrations, the hydrogeological setting and subsequent water quality predictions for the closest receptors. Subsequent models have been prepared to assess the sensitivity of the local water environment to non-compliant infill operations and varying key factors in the control of water quality.

5 RISK ASSESSMENT MODEL

5.1 HRA tier selection

5.1.1 Although the proposed infill will receive only inert wastes, initial screening has indicated a requirement to conduct a Tier 3 detailed quantitative HRA for the proposed infill within the Northern Extension for the following reasons:

- The Secondary Aquifer status of the Portland Sand aquifer encompassing the infill area;
- The proximity of established licensed abstraction made in the area down hydraulic gradient of the infill area;
- The proximity of the infill to the water environment *i.e.* a known watertable within the Portland Sand aquifer beneath the Site;
- The proximity of the Site to ecologically sensitive receptors located to the south (primarily South Dorset Coast SSSI).

5.1.2 The quantitative HRA for the Northern Extension has been undertaken using RAM, a computer-based risk modelling programme developed by Environmental Simulations International.

5.1.3 The results of the modelling assessment will be used to provide quantitative detail on the potential risk relating to placement of infill within the proposed development.

5.1.2 Background

5.1.2.1 A RAM model has been developed to provide an assessment of the potential for movement of contaminant from the inert infill area, vertically through the proposed clay lining system, into the underlying Portland Sand aquifer.

5.1.2.2 The model examines contaminant concentrations at seven time slices during the lifecycle of the development. These time slices are 1, 5, 10, 25, 100, 1,000 and 10,000 years.

5.1.2.3 An initial assessment to assess the sensitivity of the lining system to build-up of leachate through rainfall ingress has also been conducted (*section 5.1.3*).

5.1.3 Assessment of head on engineered barrier system (EBS)

5.1.3.1 A mass balance has been conducted to assess the potential for build-up of incident rainfall fed recharge, within the lined infill areas.

5.1.3.2 The mass balance has calculated the potential ingress volume based on the areal extent of the infill area and the effective rainfall (*table 6*). The mass balance results are summarised at *table 18*.

5.1.3.3 The mass balance calculations only include for vertical movement from the lined landfill areas *i.e.* no loss laterally through the flanks. The results are thus considered conservative, presenting a worst case of potential build-up in leachate levels required to drive flow through the installed liner.

5.1.3.4 For the scenario presented, the infill would not be expected to result in any build-up of leachate levels within the lined area greater than approximately 0.15m.

Table 18 Mass balance assessment - waterlevels within infill area				
Parameter	Value	Justification		
Input				
Length x (m)	475	Model dimensions set to represent areal extent of infill.		
Length y (m)	215	Model dimensions set to represent areal extent of infill.		
Annual input from rainfall (m3)	32,272	Assumes Effective Rainfall for cereal crop – 315mm (table 5)		
Output				
Iteration	1	2	3	4
Head gradient [leachate level above liner, 1m thick liner] (i)	0.05	0.1	0.15	0.2
Permeability of liner (m/s)	1.00E-07	1.00E-07	1.00E-07	1.00E-07
Basal area of liner (m2)	102,125	102,125	102,125	102,125
Flow through liner (m3/d)	44	88	132	176
Annual outflow capacity (m3)	16,103	32,206	48,309	64,412
Mass balance				
Balance*	-16,168	-65	16,038	32,141
* Negative value indicates outflow exceeds ingress for given head within lined area.				

Permeability of landfill liner

5.1.3.5

The mass balance results assume a liner permeability/geological barrier equivalent to 1m thick and 1×10^{-7} m/s. Should a lower permeability liner be created, this could result in a build-up of rainfall ingress within the lined areas and mitigative action may be required to reduce the volume of rainfall ingress e.g. installing land drainage.

5.1.4 RAM model parameterisations

5.1.4.1

Input parameter values and structural assumptions adopted in the RAM model, together with justifications for their selection are given at *table 19* below.

Table 19 RAM_HRA1 Model parametrisation		
Parameter (unit)	Value	Justification
Landfill Layout		
Length x (m)	475	Model dimensions set to represent areal extent of infill.
Length y (m)	215	Model dimensions set to represent areal extent of infill.
Depth of infill (m)	8.7	Average thickness required to represent total infill volume (section 3.1).
Infiltration		
Post Infilling Infiltration (mm/yr)	315	Effective Rainfall (table 5 – 315mm/a) restoration to agricultural land for - cereal production.
Waste parameters		
Head of leachate (m)	0.2	Model dimensions set as per mass balance calculations – table 17.
Leachate inventory		
Arsenic	0.05	Conservative values ascribed as maximum allowable concentration for inert waste classification (table 15).
Chloride	80	
Lead	0.05	
Mercury	0.001	
Nickel	0.04	
Sulphate	100	
Zinc	0.4	
Clay liner		
Source	-	Selected wastes to achieve appropriate hydraulic conductivity
Liner thickness (m)	1	Specification as required under Landfill Directive.

Hydraulic conductivity (m/s)	1x10 ⁻⁷	Specification as required under Landfill Directive (min value).
Pathway Porosity (fraction)	0.2	Nominal value taken from literature review/previous assessment.
Tortuosity	10	From RAM manual, worked examples and published literature.
Unsaturated pathway		
Geological Unit	Portland Stone	
Unit thickness (m)	9	Expected minimum standoff from the watertable (section
Hydraulic conductivity (m/s)	0.018	From literature review (table 8)
Hydraulic gradient (m)	1.2	Mass balance – table 17. Maximum predicted head on liner.
Pathway Porosity (fraction)	0.18	Value taken from literature review (table 8).
Tortuosity	10	From RAM manual, worked examples and published literature.
Saturated Pathway		
Geological Unit	Portland Sand	
Aquifer Thickness (m)	39.1	Drill records for locality
Hydraulic Conductivity (m/s)	4.6x10 ⁻⁶	From Conceptual Hydrogeological Model (CHM) maximum value from field testing of site monitoring points (section 2.7.7)
Piezometric Gradient (dimensionless)	0.019	Gradient taken from collected site elevation data (figures 10 & 11).
Pathway Porosity (fraction)	0.132	Porosity value for Portland Stone maximum value from literature review.
Mixing width (m)	585	Equivalent to the width of the infill area perpendicular to groundwater flow.
Mixing Depth (m)	24	Minimum saturated thickness of the Portland Sand aquifer.
Tortuosity	10	From RAM manual, worked examples and published literature.

5.1.5 RAM Model results

5.1.5.1 Output from the RAM model prepared using the parameters set out at *table 19*, are presented as PDF summaries at *appendix 8*.

5.1.5.2 A summary of the results predicted for the immediate site boundary are provided below at *table 20*.

Table 20 RAM_HRA1: Predicted concentrations within the Portland Sand aquifer immediately below the infill area								
Time (years)	Species	Modelled concentrations (mg/l)						
		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
	RWQS mg/l	0.005	250	0.01	0.00001	0.02	250	0.01
1		0.000	31	0.00	0.00000	0.00	38	0.00
5		0.000	15	0.00	0.00000	0.00	19	0.00
10		0.000	6	0.00	0.00000	0.00	8	0.00
25		0.000	0	0.00	0.00000	0.00	1	0.00
100		0.001	0	0.00	0.00000	0.00	0	0.00
1,000		0.000	0	0.00	0.00000	0.00	0	0.00
10,000		0.000	0	0.00	0.00000	0.00	0	0.00
RWQS: Regulatory Water Quality Standard - See table 13).								

5.1.5.3 The model has been run at a relatively simple level, taking into account dilution and attenuation of any determinand concentrations as leachate migrates across the proposed landfill liner into the Portland Sand aquifer. The model predictions are made for effectively zero travel distance within the aquifer, thus being representative of water quality immediately beneath the infill area (a worst-case location in terms of water quality).

- 5.1.5.4 The model results predict concentrations for all determinands to remain in compliance with relevant RWQS. The most significant changes are recorded for chloride and sulphate, with the predicted moderate alterations in baseline chemistry, expected to return to prevailing levels within just over 10 years.
- 5.1.5.5 It is of note that for the level of assessment conducted, the model has not taken into account additional ameliorating factors that will serve to further attenuate water quality emergent from the infill area, such as the natural degradation of chemical species that will occur within the groundwater system.
- 5.1.5.6 In addition, the HRA1 model assumes all waste will generate the maximum concentrations of selected species in eluate, whilst remaining compliant as inert material (*table 16*). In reality, much of the infill material will occur below these levels, as demonstrated by the WAC certificates presented at *appendix 3*. The landform will also comprise some 35% of site derived non-saleable overburden and processed quarry stone material. This naturally occurring material would be expected to further reduce the concentrations predicted at *table 20* and hence further ameliorate any potential negative effect being recorded within the surrounding aquifer.
- 5.1.5.7 On the foregoing basis, the results of model run HRA1 are considered to present a likely worst-case with regard to groundwater quality in proximity to the proposed infill area within the Northern Extension.

5.1.6 Sensitivity analysis

RAM_SENS1: Increased leachate source concentrations

- 5.1.6.1 Sensitivity simulation has been undertaken to assess the potential risk arising from a hypothetical scenario wherein wastes are deposited in the inert infill area containing species concentrations at 2-times the upper WAC limits for the selected species.
- 5.1.6.2 The source term concentrations for infill leachate adopted by the sensitivity model (SENS1) are described below at *table 21*. All other model parameter values adopted within the SENS1 sensitivity analysis have been maintained at the values applied to the original HRA model (RAM_HRA1).

Table 21 RAM_SG1_SHRA1 model parameterisation: revised leachate inventory adopted by sensitivity analysis

Chemical	Leachate Concentration*	Chemical	Leachate Concentration*	Chemical	Leachate Concentration*
Arsenic	0.1	Mercury	0.002	Zinc	0.8
Chloride	160	Nickel	0.08		
Lead	0.1	Sulphate	200		
All units are mg/l. * 200% of maximum WAC concentrations permissible for inert waste as specified by regulation.					

- 5.1.6.3 Simulated maximum concentrations in groundwater for the Portland Sand aquifer immediately below the infill area for each chemical species subject to sensitivity analysis at SENS1 are given below at *table 22*.

Table 22 Sensitivity Analysis 1 - Source concentrations. RAM_HRA1_SENS1: Predicted concentrations within the Portland Sand Aquifer immediately below the infill area.

Time (years)	Species	Modelled concentrations (mg/l)						
		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
	RWQS mg/l	0.005	250	0.01	0.00001	0.02	250	0.01
1		0.000	61	0.00	0.00000	0.00	77	0.00
5		0.000	30	0.00	0.00000	0.00	38	0.00
10		0.000	13	0.00	0.00000	0.00	16	0.00
25		0.000	1	0.00	0.00000	0.00	1	0.00
100		0.002	0	0.00	0.00000	0.00	0	0.01
1,000		0.000	0	0.00	0.00000	0.00	0	0.00
10,000		0.000	0	0.00	0.00000	0.00	0	0.00

RWQS: Regulatory Water Quality Standard - See table 13).

5.1.6.4 The sensitivity simulation SENS1 has been devised to determine the implications of sustained and significant exceedance of WAC limits by the imported waste stream. The simulation predicts that none of the modelled species would exceed RWQS in groundwater immediately below the infill area.

5.1.6.5 For the scenario described above any marginal degradation in extant groundwater quality would furthermore be expected to return largely to prevailing condition in a little over 10 years, with a delayed marginal increase for less mobile species (represented by zinc) occurring at around 100 years.

RAM_SENS2: Aquifer permeability (reduction)

5.1.6.6 The HRA models include the effects of dilution within the saturated zone of the aquifer beneath the infill area.

5.1.6.7 The HRA1 model uses the maximum hydraulic conductivity value (k) derived from the testing of site piezometers (*table 10*). This was selected to present a likely worst-case scenario in terms of travel time for mobilisation of any contamination. This notwithstanding, using the highest k value will also provide a greater degree of dilution in the underlying aquifer. In this regard, sensitivity analysis SENS2 has been undertaken to examine the effects upon modelled simulations of reducing the hydraulic conductivity value to the minimum recorded during testing (some 0.02 - *table 10*). All other model parameter values adopted by the SENS2 sensitivity analysis have been maintained at the values applied to the original HRA1 model.

5.1.6.8 Simulated maximum concentrations in groundwater for the Portland Sand aquifer immediately beneath the infill areas for each chemical species subject to sensitivity analysis SENS2 are given below at *table 23*.

5.1.6.9 The sensitivity simulation SENS2 has been devised to determine the effect of a more constrained representation of system dilution. The simulation shows that the modelled chemical species record increased concentration, as would be expected with reduced aquifer dilution. However, none of the predicted values for the species analysed exceed RWQS within groundwater immediately below the infill area, all remaining at least an order of magnitude below the relevant assessment level.

Table 23 Sensitivity Analysis 2 – Hydraulic Conductivity. RAM_SENS2: Predicted concentrations within the Portland Sand Aquifer immediately below the infill area.

Time (years)	Species	Modelled concentrations (mg/l)						
		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
	RWQS mg/l	0.005	250	0.01	0.00001	0.02	250	0.01
1		0.000	65	0.00	0.00000	0.00	81	0.00
5		0.000	32	0.00	0.00000	0.00	40	0.00
10		0.000	13	0.00	0.00000	0.00	17	0.00
25		0.000	1	0.00	0.00000	0.00	1	0.00
100		0.001	0	0.00	0.00000	0.00	0	0.00
1,000		0.000	0	0.00	0.00000	0.00	0	0.00
10,000		0.000	0	0.00	0.00000	0.00	0	0.00

RWQS: Regulatory Water Quality Standard - See table 13).

RAM_HRA1_SENS3: Reduced aquifer mixing width

- 5.1.6.10 The HRA1 model uses dilution across the full width of aquifer perpendicular to groundwater flow. Although valid for the bulk testing of the aquifer setting, for a dual permeability system it is important to also assess the role of preferential pathways through the aquifer (fracture flow).
- 5.1.6.11 To assess this, a third sensitivity model (SENS3) has been prepared, which focuses the aquifer flow through a much-reduced width of aquifer (10m) i.e. reflective of a series of fracture/conduit routes through the system. Infill contaminant loading is then also focussed into this much reduced active pathway.
- 5.1.6.12 All other model parameter values adopted by the SENS3 sensitivity analysis have been maintained at the values applied to the original HRA1 model.
- 5.1.6.13 Simulated maximum concentrations in groundwater for the Portland Sand aquifer immediately beneath the infill areas for each chemical species subject to sensitivity analysis at SENS3 are given below at *table 24*.
- 5.1.6.14 The sensitivity simulation SENS3 has been devised to determine the effect of possible components of fracture flow in proximity to the infill area. The simulation shows that the modelled chemical species do record levels elevated above the HRA1 scenario, whilst remaining below the relevant RWQS, with the exception of zinc.
- 5.1.6.15 The model results indicate, for the scenario where all eluate flow from the Northern Extension is focussed into a very narrow section of aquifer immediately beneath the infill, the proposed attenuating geological barrier will continue to largely manage water quality, as slower release from the infill area to any more rapid transfer routes through the aquifer.
- 5.1.6.16 It is of note that the results presented at *table 24* are indicative of water quality immediately below the infill. For the points of emergence from the aquifer (springs) within Quarry Combe, these are located a minimum of 400m down hydraulic gradient. The spring flows emerging in Quarry Combe would be expected receive additional input and hence dilution from the wider aquifer, serving to further reduce the emergent concentrations.

Table 24 Sensitivity Analysis 3 – Reduced aquifer mixing width. RAM_SENS3: Predicted concentrations within the Portland Sand Aquifer immediately below the infill area.

Time (years)	Species	Modelled concentrations (mg/l)						
		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
	RWQS mg/l	0.005	250	0.01	0.00001	0.02	250	0.01
1		0.000	68	0.00	0.00000	0.00	85	0.00
5		0.000	33	0.00	0.00000	0.00	42	0.00
10		0.000	14	0.00	0.00000	0.00	17	0.00
25		0.000	1	0.00	0.00000	0.00	1	0.00
100		0.002	0	0.00	0.00000	0.00	0	0.01
1,000		0.000	0	0.00	0.00000	0.00	0	0.00
10,000		0.000	0	0.00	0.00000	0.00	0	0.00
RWQS: Regulatory Water Quality Standard - See table 13).								

5.2 Rogue Load Assessment

5.2.1 An assessment of the potential impact on the local groundwater regime that could result from Rogue Loads being accepted at the Swanworth Site has been undertaken. The original RAM model has been repeated using the peak leachate concentration values specified within Council Decision Annex 2003/33/EC²². The source concentration values utilised are presented at *table 25*.

Table 25 RAM_RL1_Rogue Loads: Source term concentrations – 'C_o' values'

Chemical	Leachate Concentration	Chemical	Leachate Concentration	Chemical	Leachate Concentration
Arsenic	0.06	Mercury	0.002	Zinc	1.2
Chloride	460	Nickel	0.12		
Lead	0.15	Sulphate	1500		
All units are mg/l.					

5.2.2 The Rogue Load assessment assumes 1 in 10 loads (10%) of the imported inert material will be deposited at the above concentrations. The remaining 9 in 10 loads (90%) of imported material is assumed as set out in HRA1 (*table 19*). In addition to the imported material, the restoration landform will utilise approximately 35% of material derived from within the existing site. It is assumed this material will be wholly inert, but for the Rogue Load assessment it is also assumed the site derived material will also result in eluate as per the imported material set out in *table 19*.

5.2.3 The resultant concentrations as used for the Rogue Load assessment are presented at *table 26*.

Table 26 RAM_RL1_Rogue Loads: Model parameterisation - Source term concentrations

Chemical	Leachate Concentration	Chemical	Leachate Concentration	Chemical	Leachate Concentration
Arsenic	0.05	Mercury	0.001	Zinc	0.45
Chloride	105	Nickel	0.05		
Lead	0.06	Sulphate	193		
All units are mg/l.					

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Peak concentration values (C_o) from Section 2.1.2.1 of Council Decision Annex 2003/33/EC.

5.2.4 The results of the assessment models are included in full at *appendix 8*. Summary details are provided at *table 27*.

Table 27 Rogue Loads assessment results. RAM_RL1_Rogue Loads: Predicted concentrations within the Portland Sand Aquifer immediately below the infill area - Assuming input from Rogue Loads

Time (years)	Species	Modelled concentrations (mg/l)						
		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
	RWQS mg/l	0.005	250	0.01	0.00001	0.02	250	0.01
1		0.000	40	0.00	0.00000	0.00	74	0.00
5		0.000	20	0.00	0.00000	0.00	37	0.00
10		0.000	8	0.00	0.00000	0.00	15	0.00
25		0.000	1	0.00	0.00000	0.00	1	0.00
100		0.001	0	0.00	0.00000	0.00	0	0.01
1,000		0.000	0	0.00	0.00000	0.00	0	0.00
10,000		0.000	0	0.00	0.00000	0.00	0	0.00

RWQS: Regulatory Water Quality Standard - See table 13).

5.2.5 The model results provide an assessment of continued and sustained “Rogue-Load” deposition (1 in 10 loads of imported material falling significantly outside the inert waste criteria required for acceptance to the Site). This notwithstanding all species remain within the RWQS as set out within the HRA.

5.2.6 The Rogue Load assessment indicates the chemical species presenting the greatest risk factor of those examined is sulphate, chloride and/or zinc (although the latter is in no greater extent than previously modelled scenarios, recording a peak at 100-years). The sulphate and chloride concentrations remain significantly below the relevant RWQS, with water quality returning to baseline conditions in little over 10 years.

5.2.7 The Rogue Load assessment is considered to represent an extreme failure of management and protocol for operation of the site. Although this is not expected to be reflective of the actual infill operation, the model results do highlight the importance for appropriate WAC controls for acceptance of infill material to the site.

5.3 Model conservatism

5.3.1 The RAM models developed for this HRA are considered to be conservative (*i.e.* they produce simulations that tend toward over-estimation of likely concentrations); the principal conservative influences being summarised below at *table 28*.

5.3.2 The foregoing details notwithstanding, the proposed infill is located within the upstream catchment for a spring collector system used as part of the supply to the Encombe Estate private water supply system. This abstraction is made under EA licence.

5.3.3 Assessment has shown that the prevalence of developed fracture flow through the aquifer beneath the Northern Extension is not expected to be significant (*section 2.7.6*). However, the identified springs within Quarry Combe do arise at discrete locations along the watercourse suggesting flow is directed through fractures at a local scale.

5.3.4 The presence of fractures through the aquifer would offer a potential rapid pathway for contamination to pass from the infill area to the downstream points of discharge (springs). Because of the potential sensitivity of these locations, Suttles have reached agreement

with the licence holder to enable a change to the use for the Quarry Combe licenced abstractions, from 'potable supply' to 'amenity use', with water from Quarry Combe being instead used for maintenance of lake levels and flows in the local watercourse. In this regard, an application will be made (and alteration made to the pipework configuration) to change the permitted use of water abstracted from Quarry Combe, prior to any infilling within the Northern Extension.

Table 28 Summary Detail for Landfill in the Vicinity of the Site

Modelled Parameter	Model Representation	Comments
Leachate Source Conc.	Assumed source term concentrations have been set at the maximum permissible level for leachate testing, for infill material to remain classified as inert. These values exceed, by an order of magnitude, example WAC leaching tests undertaken on representative material used for infilling at the existing operation. Furthermore, the models have been run assuming all material placed within the restoration landform will be imported. This is not the case with around 35% of the placed material being onsite derived overburden or nonsaleable quarry waste.	The leaching test data set at the WAC limit for inert waste will inevitably over-state the total chemical loading within the modelled infill. In reality the actual species concentrations within waste accepted (such as the example certificates for the existing site) will almost always be lower than the maximum WAC limits to comply with material classification.
Assessment points	The model runs have examined water quality immediately below the base of the infill area. The water qualities have met the water quality standards as set out within the HRA. Monitoring points and springs are located further distance from the infill area..	Species entering the groundwater environment from the infill area would experience additional attenuations (dispersion, degradation etc) as water moves through the aquifer. By assessing the water quality at the base of the infill a worst case is being presented in terms of predicted water quality

6 CONTROL & COMPLIANCE MONITORING

6.1 Background

- 6.1.1 Groundwater Control Levels are site-specific assessment criteria used to determine whether a landfill is performing as designed and intended to draw attention to the development of adverse trends in the monitoring data.
- 6.1.2 Groundwater Control Levels should be regarded as an early warning system and breaches should lead to appropriate investigation or implementation of corrective measures.
- 6.1.3 Breaches of groundwater Control Levels should not, however, ordinarily be interpreted as an indication that groundwater pollution has occurred.
- 6.1.4 In more detail, the purpose for specification of groundwater Control Levels is to:
- Highlight variations between the conceptual model (including the results of quantitative risk assessment) and observed conditions;
 - Identify unambiguous adverse trends which are indicative of leachate impacts;
 - Allow for variation in natural water quality from baseline conditions, and;
 - Give sufficient time to take corrective or remedial action before Compliance Limits are breached.
- 6.1.5 In contrast, EA guidance²³ requires that groundwater Compliance Limits for potentially polluting substances be set at the point where pollution can be said to have occurred and can be detected by monitoring.
- 6.1.6 A change in groundwater quality to a concentration below the compliance limits would be acceptable, but a concentration at or above the compliance limit would be unacceptable.

6.2 Selection of monitoring points

- 6.2.1 As discussed at *section 2.7*, a program of groundwater sampling in the vicinity of the proposed infill is currently undertaken at a number of monitoring locations.
- 6.2.2 A review has been undertaken of the groundwater quality monitoring data (*table 14*), the location of Site piezometers relative to the infill area and groundwater flow direction (*figure 10*).
- 6.2.3 Review indicates that piezometers PZ2_19 and PZ1_20 constitute the most appropriate monitoring points for down-gradient groundwater Control Level and Compliance Limit surveillance to be undertaken during and following operation of the infill; Piezometer PZ4_19 also being selected as the up-gradient monitoring point.

6.3 Derivation of Control Levels and Compliance Limits

- 6.3.1 Derivation of Control Levels and Compliance Limits has involved a two-stage process involving:
- Selection of appropriate chemical species, and;

²³ "Additional guidance for hydrogeological risk assessments for landfills and the derivation of groundwater control levels and compliance limits", EA Horizontal Guidance Note H1 – Annex J3, Version 2.1, December 2011.

- Justification and enumeration of level and limit values.

6.3.2 Enumeration of level and limit values has been based upon:

- Characteristic statistics calculated from background water quality datasets compiled for each of the 2-no. selected Control Level and Compliance Limit piezometers: PZ2_19 and PZ1_20.

6.3.2 Initial discussion

6.3.2.1 Groundwater quality monitoring has been undertaken since February 2019 and has included the 7-no. chemical species utilised within the model scenarios presented at *section 5* (arsenic, chloride, lead, mercury, nickel, sulphate and zinc). With the exception of zinc and some outlier samples for chloride, these are recorded at monitoring points PZ2_19 and PZ1_20 at concentrations below the relevant RWQS and will be reviewed for potential utility in the derivation of groundwater Control Level and Compliance Limits.

6.3.3 Statistical analysis of background data

6.3.3.1 In accordance with EA guidance²⁴, statistical techniques have been applied to assess the suitability of the individual background groundwater quality datasets compiled for piezometers PZ2_19 and PZ1_20 with respect to setting groundwater Control Level and Compliance Limits.

6.3.3.2 This has involved the computation of D'Agostino's Test³⁰ to determine the distribution characteristics of the time-series data for each of the aforementioned determinands. The analyses for arsenic, lead and mercury have not been conducted in this manner, as each dataset has insufficient number of readings above the limit of detection for analysis to be meaningful. The setting of values for these species is discussed at *section 6.3.4*.

6.3.3.3 The computation is provided in full at *appendix 9* and a summary given in *table 29*, which presents:

- The characteristic statistical distribution for each chemical species for the selected piezometers;
- The mean of this data plus 2 and 3 standard deviations ($\mu + x\sigma$);
- Number of outlier data points removed to enable statistical analysis for each monitoring point, *and*;
- Whether these values exceed RWQS.

²⁴"Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final technical report P1-471, 2002.

Table 29 Summary Detail for Landfill in the Vicinity of the Site							
Monitoring Point	PZ2_19			PZ1_20			RWQS
Species	No. outlier data*	$\mu + 2\sigma$	$\mu + 3\sigma$	No. outlier data*	$\mu + 2\sigma$	$\mu + 3\sigma$	
Arsenic	Not analysed – all data below detection limit						0.005
Chloride	4	45	46	0	39	44	250
Lead	Not analysed – all data below detection limit						0.01
Mercury	Not analysed – all data below detection limit						0.00001
Nickel	**			0	0.011	0.013	0.02
Sulphate	0	30	32	0	215	250	250
Zinc	0	0.040 ⁺	0.062 ⁺	1	0.045 ⁺	0.058 ⁺	0.01

RWQS: Regulatory Water Quality Standard (See table 13).
 *: No. of outlier data indicates no of samples removed from statistical analysis and represents no. of samples that would exceed defined statistical figures within existing dataset (max of 16 rounds of sampling).
 **: Dataset for PZ2_19 Nickel is not defined as normally or log-normally distributed despite removal of outlier data.
 All values are mg/l.
 + Baseline data contains water quality already exceeding RWQS, hence limits exceed specified RWQS.

6.3.3.4 It is generally accepted that derivation of Control Level and Compliance Limit values as a function of the statistical characteristics of a groundwater quality dataset are valid when:

- That dataset is either normally or log-normally distributed, and;
- Both the $\mu + 2\sigma$ and $\mu + 3\sigma$ are below RWQS.

6.3.3.5 Where such conditions are met, the general expectation is that Control Levels and Compliance Limits may be appropriately defined at the $\mu + 2\sigma$ and $\mu + 3\sigma$ values respectively²⁵.

6.3.3.6 The statistical analysis of the background groundwater quality data is shown to conform to the data distribution criteria for chloride (with removal of some outlier data for PZ2_19), nickel, sulphate and zinc for monitoring points PZ2_19 and PZ1_20. For PZ2_19 the distribution criteria are met for chloride, sulphate and zinc. For PZ1_20 the criteria are met for chloride, nickel, sulphate and zinc.

6.3.3.7 Although the samples for nickel at PZ2_19 do not meet the statistical criteria, they do fall within the range defined by the PZ1_20 samples and at similar levels. On this basis it is proposed to apply the limits defined for PZ1_20 at both monitoring points.

6.3.3.8 For the zinc analysis, although these meet the statistical requirements, the current baseline water quality exceeds the selected RWQS making this unsuitable for further use.

6.3.4 Other analysis of background data

6.3.4.1 For each of the proposed monitoring points the presence of arsenic, mercury and lead within the background data is recorded as permanently below the limit of detection for analysis (LOD). These are each hazardous substances and as such are not permitted to

²⁵ $\mu + 2\sigma$ (two-standard deviations around the mean) = 95.45% around the mean = 97.725th percentile*.

$\mu + 3\sigma$ (three-standard deviations around the mean) = 99.73% around the mean = 99.865th percentile*.

(* - percentiles being the notation most widely used for reporting of model simulations by LandSim).

enter groundwater. On this basis, for hazardous substances the Control Level and Compliance Limit are both set at the LOD.

6.4 Enumerated Control Levels and Compliance Limits

6.4.1 The groundwater Control Level and Compliance Limits derived by model prediction, applying upper value criteria described above, are presented at *table 30* and *table 31*.

Table 30 Groundwater Control Levels

Species	Control Level		Derivation
	PZ2_19	PZ1_20	
Arsenic	0.005	0.005	Limit of detection
Chloride	45	39	Statistical analysis of baseline data (2 std. dev.)
Lead	0.001	0.001	Limit of detection
Mercury	0.00001	0.00001	Limit of detection
Nickel	0.011	0.011	Statistical analysis of baseline data (2 std. dev.)
Sulphate	30	215	Statistical analysis of baseline data (2 std. dev.)
All values are mg/l.			

Table 31 Groundwater Compliance Limits

Species	Control Level		Derivation
	PZ2_19	PZ1_20	
Arsenic	0.005	0.005	Limit of detection
Chloride	107*	44	Statistical analysis of baseline data (3 std. dev.).
Lead	0.001	0.001	Limit of detection
Mercury	0.00001	0.00001	Limit of detection
Nickel	0.013	0.013	Statistical analysis of baseline data (3 std. dev.)
Sulphate	32	250	Statistical analysis of baseline data (3 std. dev.)
All values are mg/l. *Compliance Limit set at the maximum level recorded within the dataset. This was removed as one of four other outlier points to enable statistical analysis to be completed. As values exceeding the 3 std dev. criteria are recorded in the dataset the max. baseline value is to be used for compliance monitoring.			

6.5 Routine monitoring

6.5.1 Frequency

6.5.1.1 During the operational infilling phase, groundwater level monitoring and sampling at the up-gradient piezometers (PZ4_19) and down-gradient Control and Compliance Piezometers (PZ2_19 and PZ1_20) should be undertaken quarterly.

6.5.1.2 Prior to the commencement of infilling operations, it is recommended that sampling is undertake six monthly interval to provide an expanded dataset, which will allow for review and refinement of the Control and Compliance Limits should this be required.

6.5.1.3 Post-Closure monitoring frequency should reduce to annually.

6.5.2 Determinands

Field

- 6.5.2.1 Field measurements to be made within the Control/Compliance piezometers during routine monitoring shall include: measurement of groundwater levels (recorded in units of mBGL, reduced to maOD), pH and electrical conductivity of groundwater samples.

Laboratory

- 6.5.2.2 The laboratory analysis suite and minimum reporting values to apply to groundwater collected from the Control/Compliance piezometers during routine monitoring should be as shown below at *table 32*.

Table 32 Operational & post-closure groundwater quality determinand suite				
Control & Compliance Determinands	Background Determinands			
	WAC Schedule Determinands		Others	
Arsenic (0.005)	Ammoniacal Nitrogen (0.01)	Cadmium (0.001)	Conductivity (1)	Sodium (0.1)
Chloride (0.1)	Barium (0.01)	Antimony (0.001)	Calcium (0.1)	Total Alkalinity (0.1)
Lead (0.01)	Chromium (0.001)	Selenium (0.001)	Magnesium (0.1)	
Mercury (0.00001)	Copper (0.001)	Total Dissolved Solids (1)	Manganese (0.001)	
Nickel (0.01)	Fluoride (0.1)	Phenol Index (0.05)	Potassium (0.1)	
Sulphate (0.1)	Molybdenum (0.001)	Dissolved Organic Carbon (0.2)	Nitrate (0.1)	
	Zinc (0.01)	pH	Nitrite (0.001)	
Values in brackets are required minimum reporting values (pH: N/A. Conductivity: $\mu\text{S}/\text{cm}$, all other determinands: mg/l)				

6.6 Routine quarterly assessment

- 6.6.1 Upon receipt of the quarterly laboratory data, results for the down-gradient piezometers should be compared with the prescribed groundwater Control Levels (*table 30*) and Compliance Limits (*table 31*).

6.7 Contingency monthly monitoring

- 6.7.1 In the event that either Control Levels or Compliance Limits are found to have been breached during routine quarterly monitoring and assessment, the monitoring frequency shall be increased to monthly.
- 6.7.2 Monitoring shall return to a quarterly frequency only following 2-no. consecutive monthly monitoring rounds undertaken without breach of Control Levels and / or 3-no. consecutive monitoring rounds undertaken without breach of Compliance Limits.
- 6.7.3 In the event that Control Levels are breached for 3-no. successive monthly monitoring rounds, or Compliance Limits breached for 2-no. successive monthly monitoring rounds, then the relevant Contingency Actions described at *section 6.8* shall be implemented.

6.8 Contingency Actions

- 6.8.1 The Contingency Actions that are to be taken in the event of a breach of groundwater control levels and compliance limits are described at *table 33*.

Table 33 Operational & post-closure groundwater quality determinand suite

Contingency Action	Following Breach of:	
	Control Level	Compliance Limit
Advise Site management	✓	✓
Advise the environmental manager of landfill operating company	✓	✓
Advise the Environment Agency		✓
Confirm by repeat sampling and analysis	✓	✓
Review existing monitoring information	✓	✓
Review site management and operations, and implement actions to prevent future failure of a compliance limit	✓	
Review the assumptions incorporated into the site conceptual model	✓	✓
Review existing hydrogeological risk assessment, control levels and compliance limits*	✓	✓
If risks are unacceptable set in place procedures for implementing corrective measures in consultation with or required by the Environment Agency		✓
* This should include a re-evaluation of whether the baseline conditions have changed since the last risk assessment.		

7 SUMMARY & CONCLUSIONS

- 7.1 BCL have undertaken a hydrological and hydrogeological baseline study and quantitative hydrogeological risk assessment of a planned inert waste infill operation within a Northern Extension to Swanworth Quarry, Dorset.
- 7.2 The work has involved the development of a conceptual hydrogeological model (CHM) and conceptual site model (CSM).
- 7.3 The conceptual models have informed the development of a RAM quantitative assessment model for the simulation of the likely effects of the infill operation upon the local water regime - both the underlying Portland Sand Secondary B Bedrock Aquifer and the local surface water environment.
- 7.4 In-turn, this has allowed derivation of Control Level and Compliance Limit values to be used for assessment of future groundwater quality monitoring data to determine the need for: (i) increased monitoring frequency, (ii) further assessment, (iii) changes to operational practices or (iv) remedial actions.
- 7.5 The infill operation will receive only classified inert material and has been designed to include basal and sidewall lining to provide an attenuating effect equivalent to $1\text{e-}7$ metres per second (m/s) at 1m thickness²⁶.
- 7.6 Numerical risk assessment has used selected chemical species (arsenic, chloride, lead, mercury, nickel, sulphate and zinc) to examine the risks presented by the infill operation to the local water environment. The model results have demonstrated that the proposed operation will not introduce further undue risk to groundwater quality in the locality, assuming compliance with waste acceptance procedures to ensure placement of appropriately classified waste. The model results indicate that any temporary additional chemical loading resultant from the infill will remain significantly below the relevant species RWQS, with dispersion back to baseline levels in little over 10 years.
- 7.1.1 The foregoing details notwithstanding, the proposed infill is located within the upstream catchment for a spring collector system used as part of the supply to the Encombe Estate private water supply system. This abstraction is made under EA licence.
- 7.1.2 Assessment has shown that the prevalence of developed fracture flow through the aquifer beneath the Northern Extension is not expected to be significant. However, the identified springs within Quarry Combe do arise at discrete locations along the watercourse, suggesting flow is directed through fractures at a local scale.
- 7.1.3 The presence of fractures through the aquifer would offer a potential rapid pathway for contamination to pass from the infill area to the downstream points of discharge (springs). Because of the potential sensitivity of these locations, Suttles have reached an agreement with the licence holder to change the registered use for the Quarry Combe licenced abstractions, from 'potable supply' to 'amenity use', with water from Quarry Combe being separated out for maintenance of lake levels and flows in the local watercourse. In this regard, an application will be made (and alteration made to the pipework configuration) to

²⁶ Landfill Directive (1999/31/EC) for inert waste.

change the permitted use of water abstracted from Quarry Combe, prior to any infilling within the Northern Extension.

- 7.1.4 In terms of wider water resource considerations, the development is located above the watertable and will allow the return of any incident rainfall to the underlying aquifer, both during extraction and following completion of restoration at the Site. This will ensure retention of groundwater resources within the local aquifer system and protection of extant patterns of groundwater movement in the locality.
- 7.7 Aside from the details above, it is concluded that there is no requirement for any additional control or management measures beyond the waste acceptance quality control procedures (generic to inert landfill) that will attend the Landfill Permit.
- 7.8 However, in order to comply with the requirements of the Landfill Directive it will be necessary to establish a program for monitoring of groundwater quality, for which Control Levels and Compliance Limits have been derived.
- 7.9 Statistical analysis of the collected baseline data have been used to derive groundwater Control Levels and Compliance Limits for 2-no. existing piezometers situated down-gradient upon the watertable from the infill (piezometers PZ2_19 and PZ1_20).
- 7.10 Groundwater Control Levels and Compliance Limits for each of the aforementioned chemical species have been set based upon the mean plus 2 standard deviations and 3 standard deviations, in accordance with EA guidance. For the hazardous substances (arsenic, lead and mercury) the limits are set at the limit of detection.
- 7.11 The 6-no. chemical species specified for groundwater Control Level and Compliance Limit monitoring will form part of a wider suite of 29-no. determinands included as part of monitoring programs to be implemented for both the operational and post-closure phases of the infill operation.
- 7.12 During the operational phase for the Site, sampling and analysis of species concentrations in groundwater, applying the 29-no. determinand suite, will be undertaken quarterly for the identified 1 up-gradient and two down-gradient compliance and control piezometers.
- 7.13 Monthly groundwater level monitoring will be continued for all site piezometers during the operational phase of the infill program.
- 7.14 Six-monthly collection of groundwater quality data should be maintained for the period prior to commencement of infilling operations. This will allow for review and refinement of the Control and Compliance Values should this be required.
- 7.15 Quarterly assessment of progressively acquired groundwater quality data should be made to determine for breaches of the specified Control Levels and Compliance Limits; in the event of which, monitoring will be escalated to a monthly frequency.
- 7.16 Quarterly monitoring should only be resumed once there have been 2-no. successive monthly monitoring rounds without breach of Control Levels and / or 3-no. successive monthly monitoring rounds without breach of Compliance Limits.
- 7.17 Remedial actions have been specified in accordance with EA guidance in the event of a confirmed breach of Control Levels (3-no. successive events) and / or Compliance Limits (2-no. successive events).

- 7.18 Following completion of the infill operation and closure of the Site, the frequency of groundwater sampling should reduce to six-monthly, maintaining the same determinand suite and assessment regime as for the operational phase. The contingency plans for escalated monitoring and remedial actions will remain as specified for the operational phase.
- 7.19 In relation to prevailing regulatory policy as defined in the Groundwater Directive, Water Framework Directive and the Groundwater Daughter Directive, the infill operation is not expected to result in any discernible release of hazardous substances to groundwater.
- 7.20 Furthermore, the HRA has shown the modelled release of non-hazardous substances would not lead to deterioration in the quality of groundwater and hence would not cause harm to the local groundwater environment, local protected sites (SSSI/SAC) and water dependant receptors.
- 7.21 It is therefore concluded that the infill operation will be undertaken in full compliance with relevant water resource regulations.
- 7.22 This conclusion assumes that any permit issued to allow the infill operation should be conditioned by implementation and adherence to any relevant recommendations advanced within this report and other such permit conditions that may be reasonably imposed by the Environment Agency.

8 RECOMMENDATIONS

- 8.1 Control and Compliance Values have been set following statistical analysis of the collected baseline data and computer simulation for monitoring groundwater quality in proximity to the infill areas at the Site (*table 30* and *31*).
- 8.2 These should be used for setting Control Level and Compliance Limit values for any relevant Environmental Permit conditions.
- 8.3 A program of regular monitoring has been recommended to ensure the development is operating as expected. The program includes identification of required monitoring locations, a schedule of determinands and minimum reporting values (*table 32*), alongside contingency actions should a breach of quality values be observed (*table 33*). The regular monitoring program is to be undertaken on a quarterly basis throughout the infill operation, reducing to six-monthly post closure.

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BCL Consultant Hydrogeologists Limited

December 2021



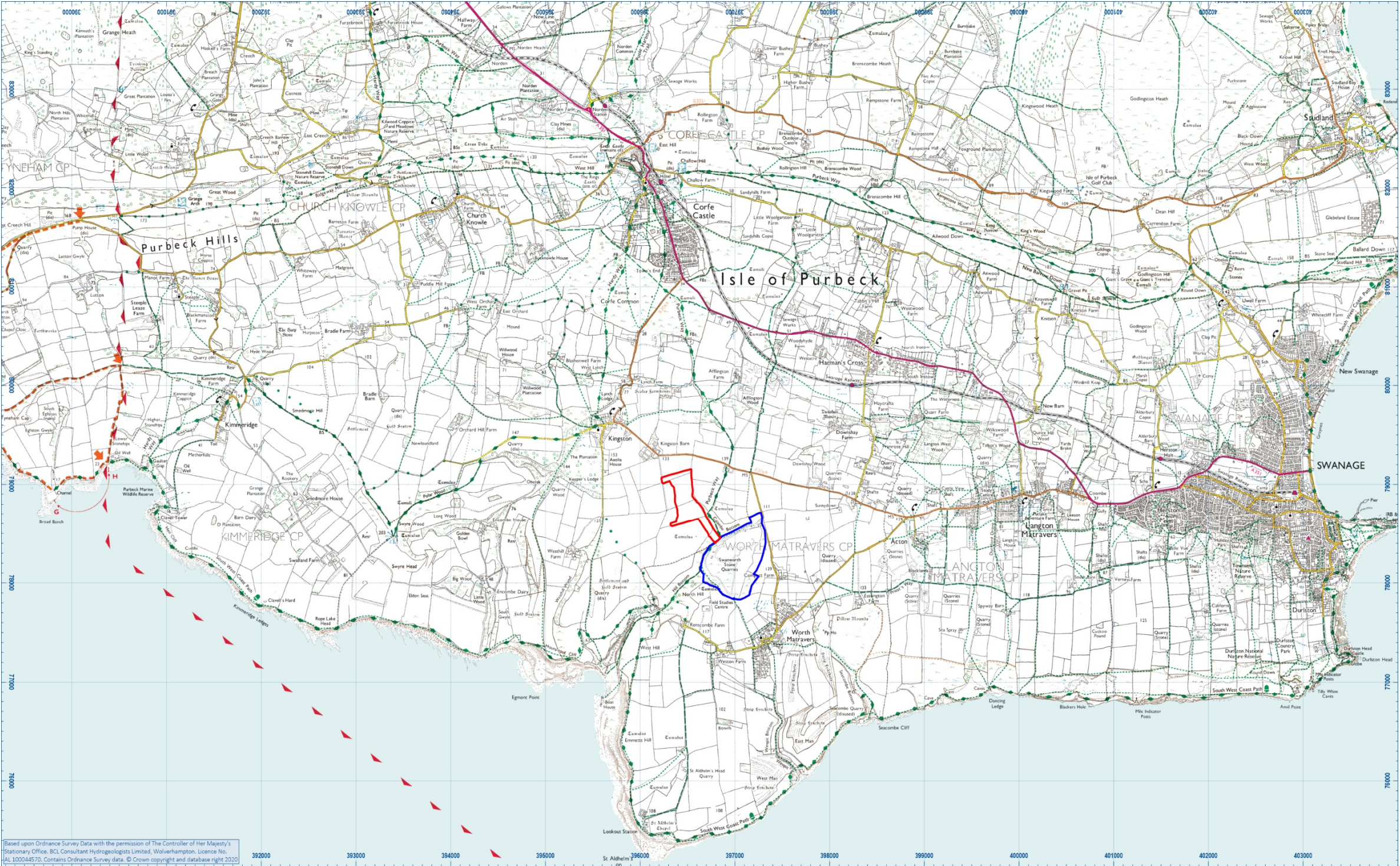
Suttles Stone Quarries
Swanworth Quarry
Worth Matravers, Dorset

**Planning Application for Northward Extension to Existing
Mineral Extraction and Restoration**

Hydrogeological Risk Assessment

Final Report
December 2021

Figures



Key

Existing Swanworth Quarry site

Northern Extension

BISL/SWTH HRA/21



Suttles Stone Quarries

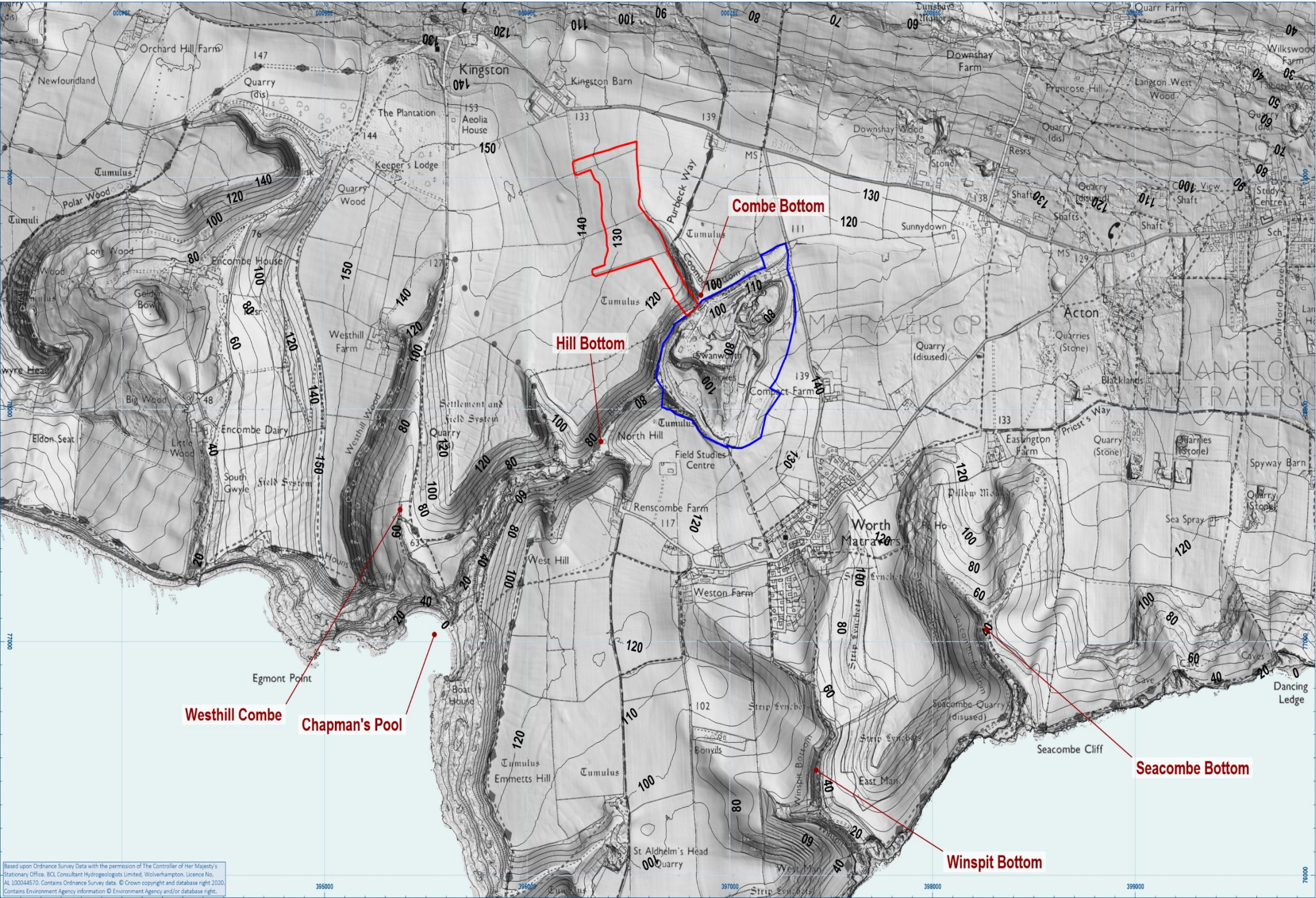
Swanworth Quarry, Worth Matravers, Dorset

Hydrogeological Risk Assessment

Final Report

Figure 1: Site location

Drawn By: PB	Scale: 1:30,000
Date: Dec 21	Format: A3L



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Key

- Existing Swanworth Quarry site
- Northern Extension
- Ground elevation contour (maOD)

BSL/SWTH HRA/21

Suttle
Stone Quarries

Suttles Stone Quarries

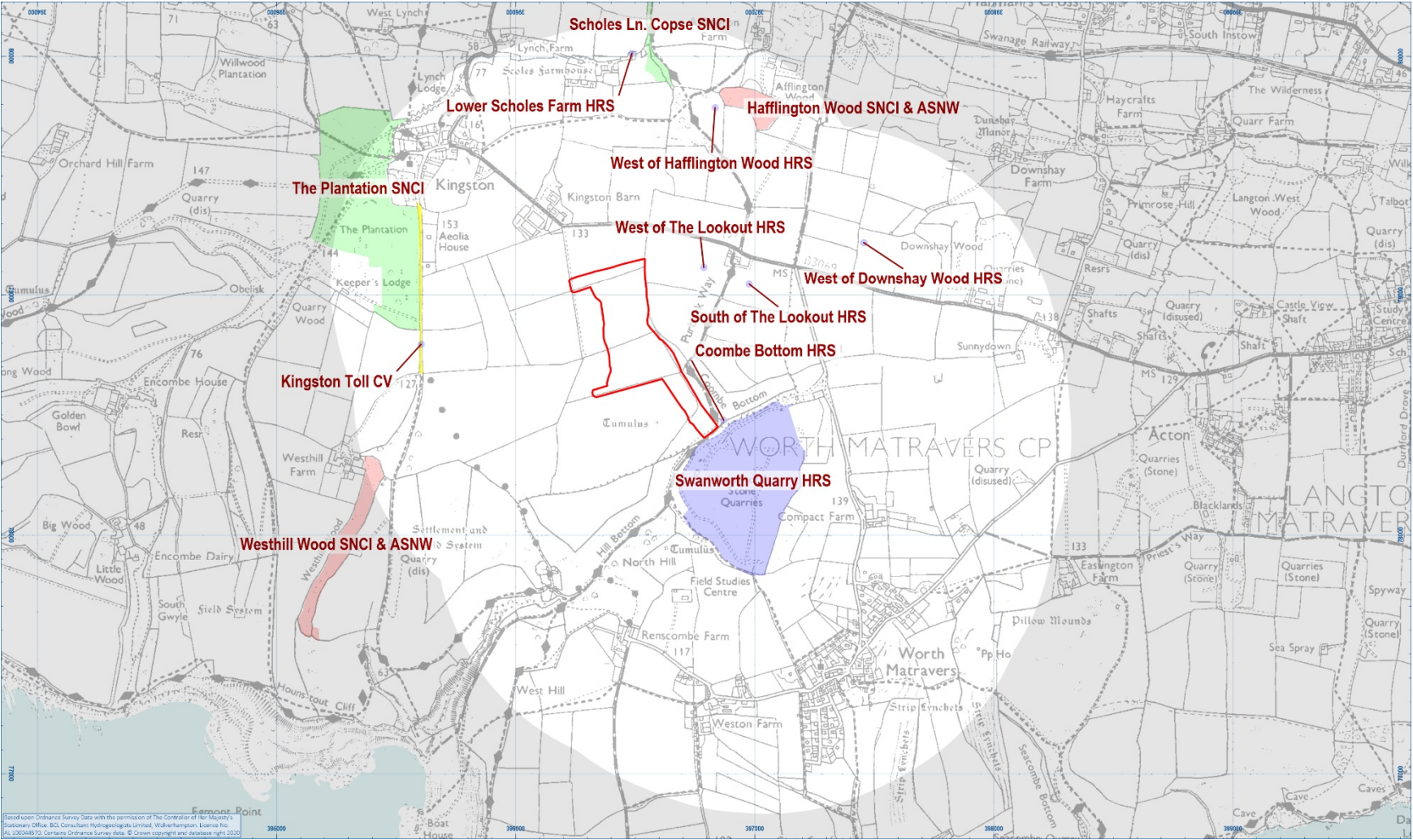
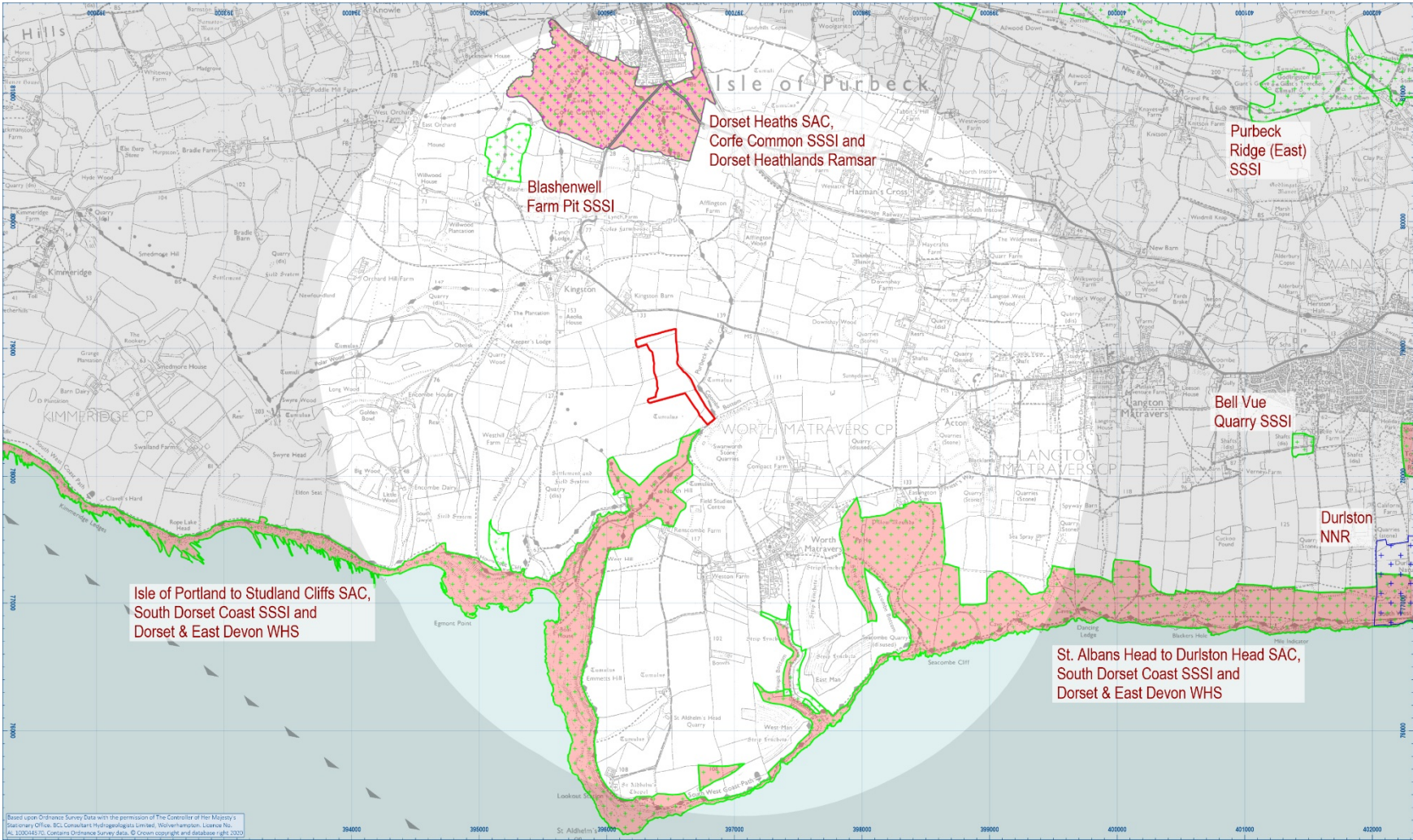
Swanworth Quarry, Worth Matravers, Dorset

Hydrogeological Risk Assessment

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Figure 2: Site survey (maOD)

Drawn By: PB	Scale: 1:6,000
Date: Dec 21	Format: A3L



Key

Northern Extension

Special Area of Conservation (SAC)

Site of Special Scientific Interest (SSSI)

RAMSAR Site

National Nature Reserve (NNR)

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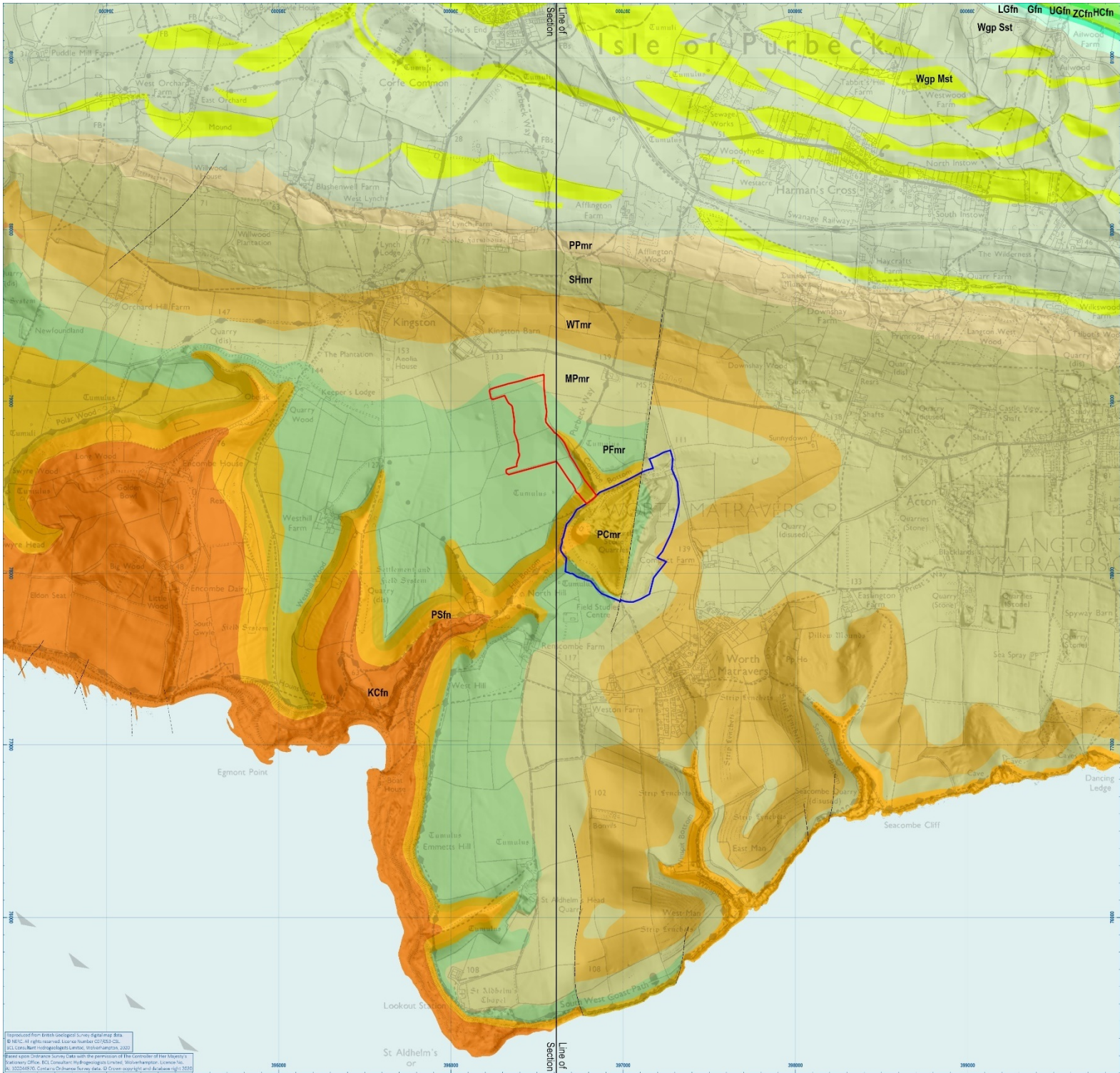
Figure 3: Sites of ecological interest

Drawn By: PB

Date: Dec 21

Scale: 1:30,000

Format: A3L



Key

Existing Swanworth Quarry Site

Northern Extension

Line of section

Key to geological units
(Extract from BGS geological units)

BISL/SWTH_HRA/21



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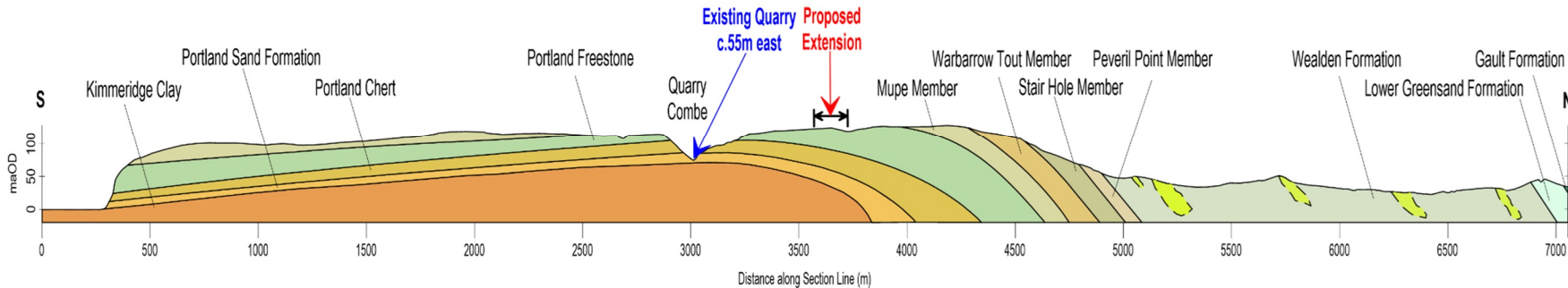
Swanworth Quarry, Worth Matravers, Dorset

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Figure 4: Regional geology

Drawn By: PB	Scale: 1:30,000
Date: Dec 21	Format: A3L





Key

Northern Extension

Contour of upper surface of Portland Sand (maOD)

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Swanworth Quarry, Worth Matravers, Dorset

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Figure 5: Contour plot depicting the upper surface of the Portland Sand (base of Portland Stone)	
Drawn By: PB	Scale: 1:60,000
Date: Dec 21	Format: A3L

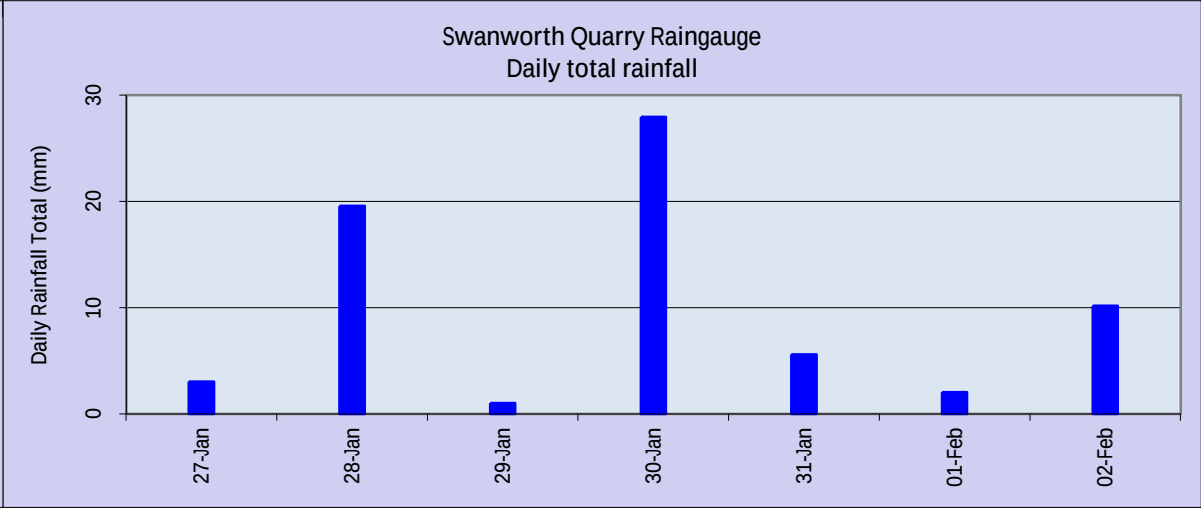
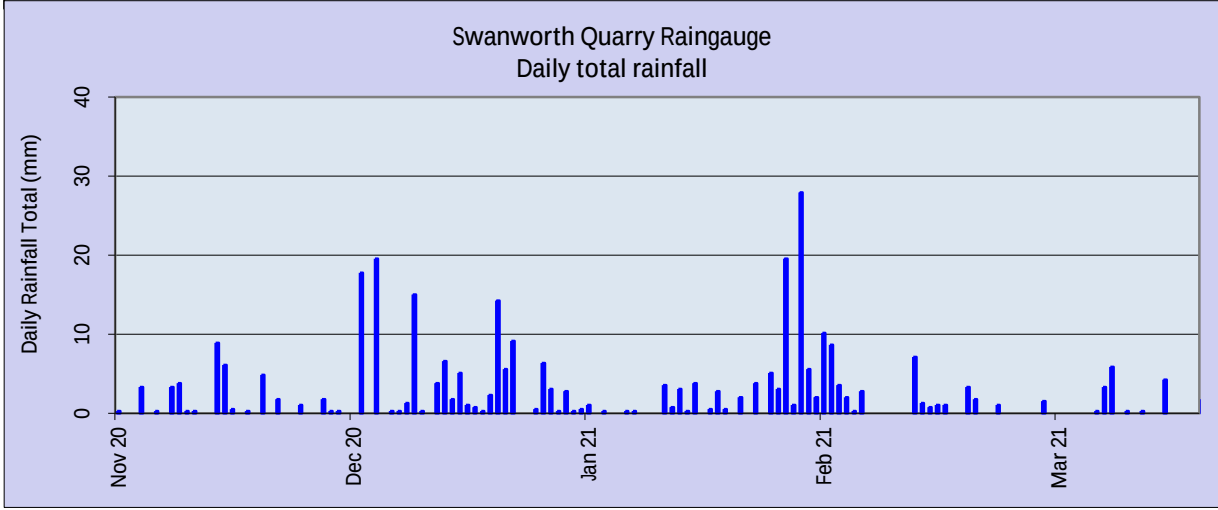
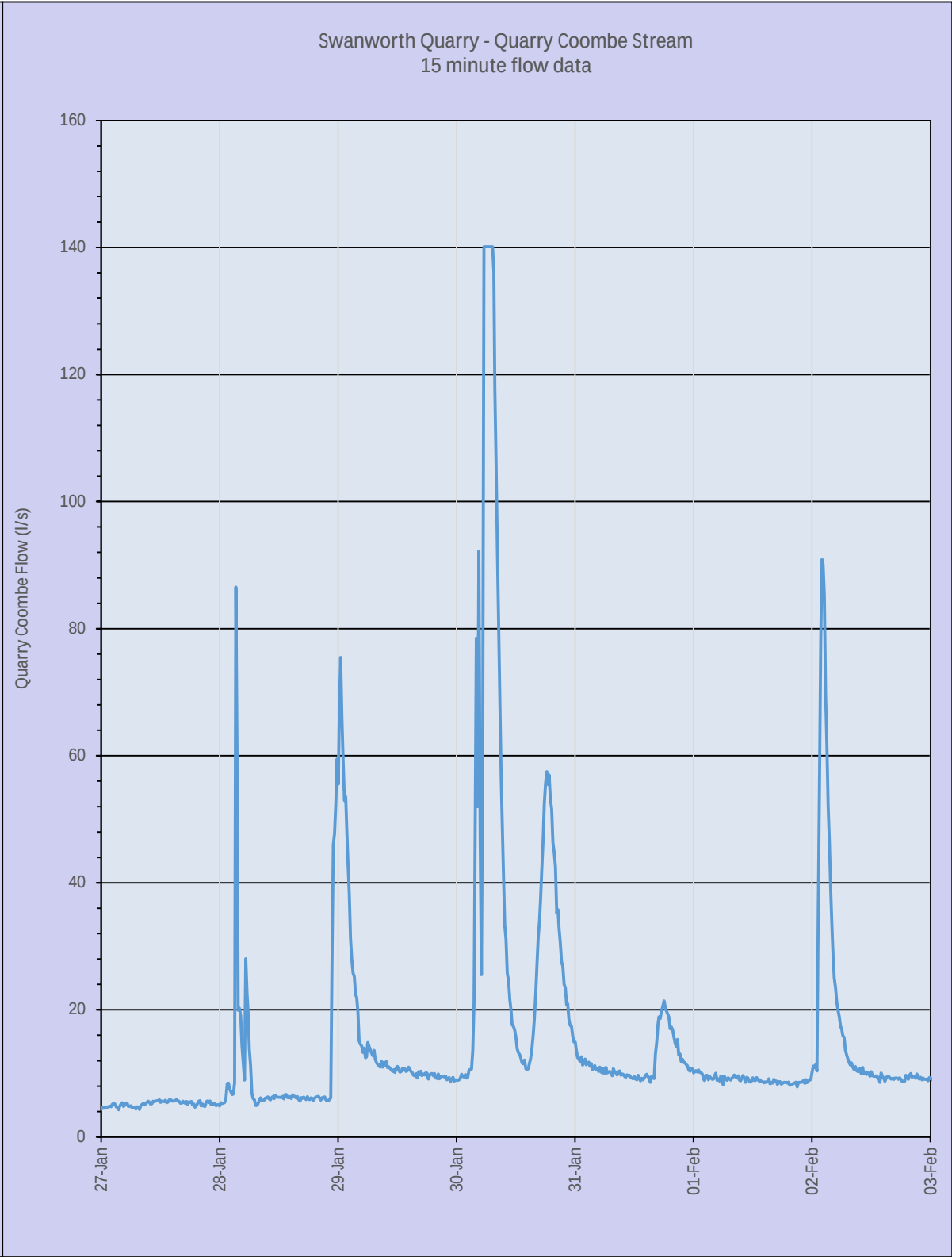
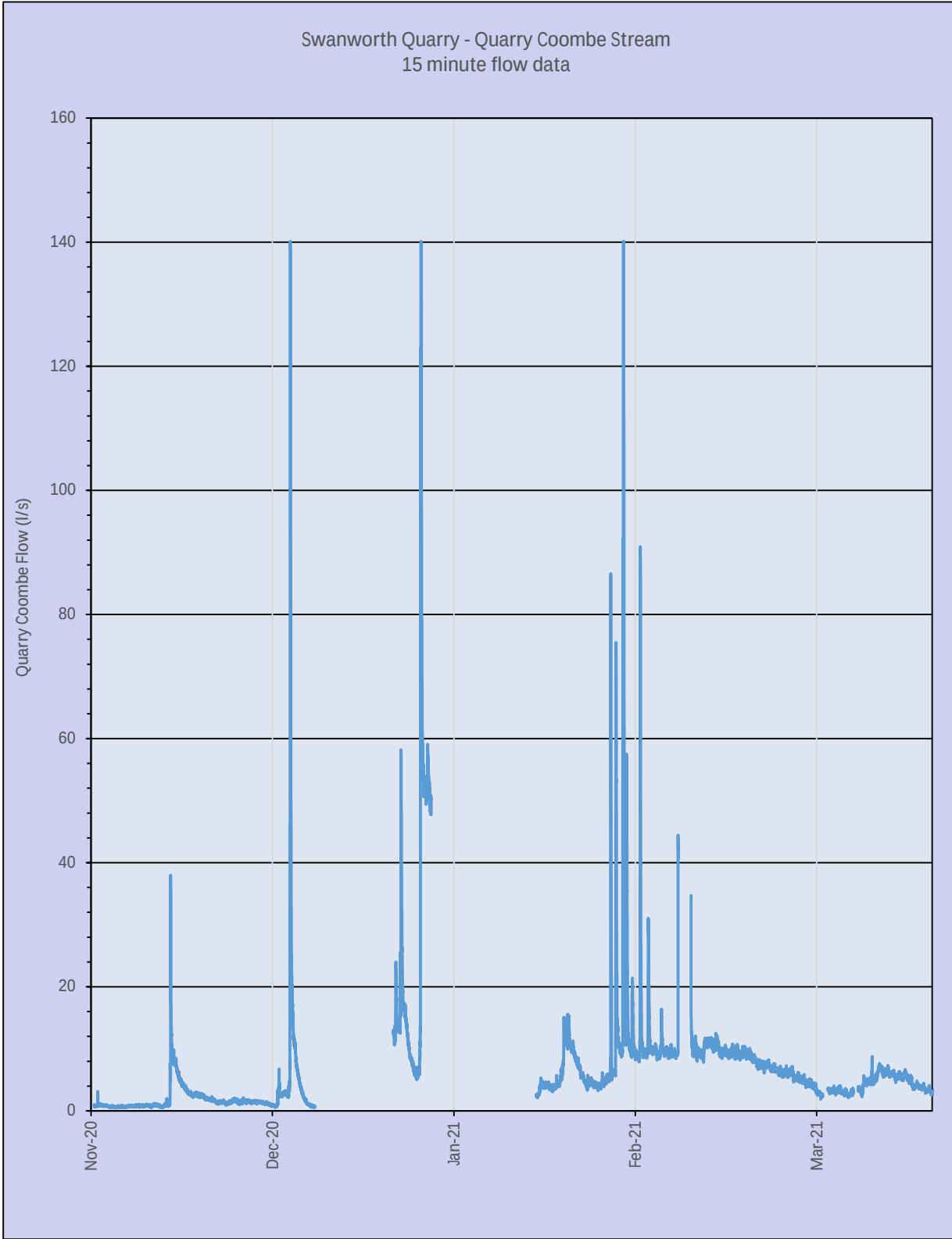
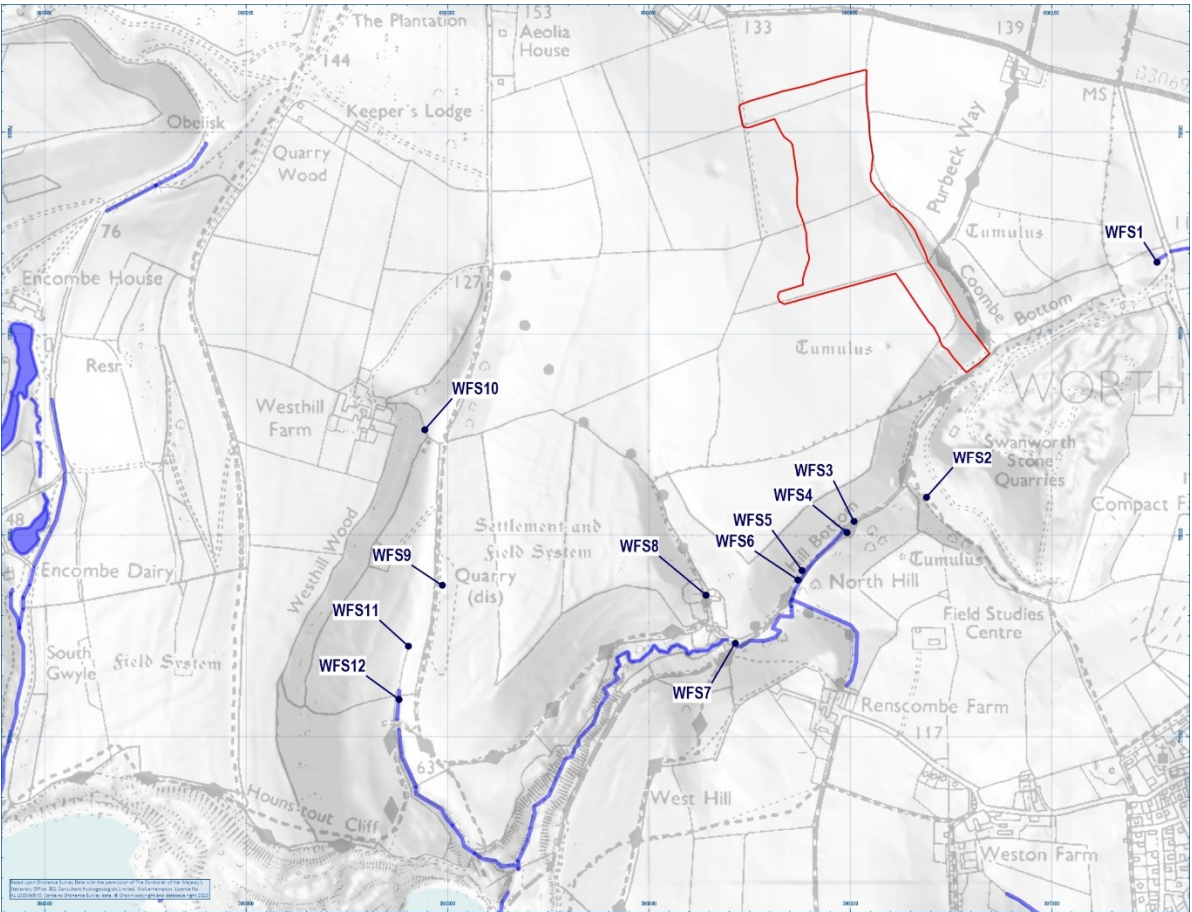
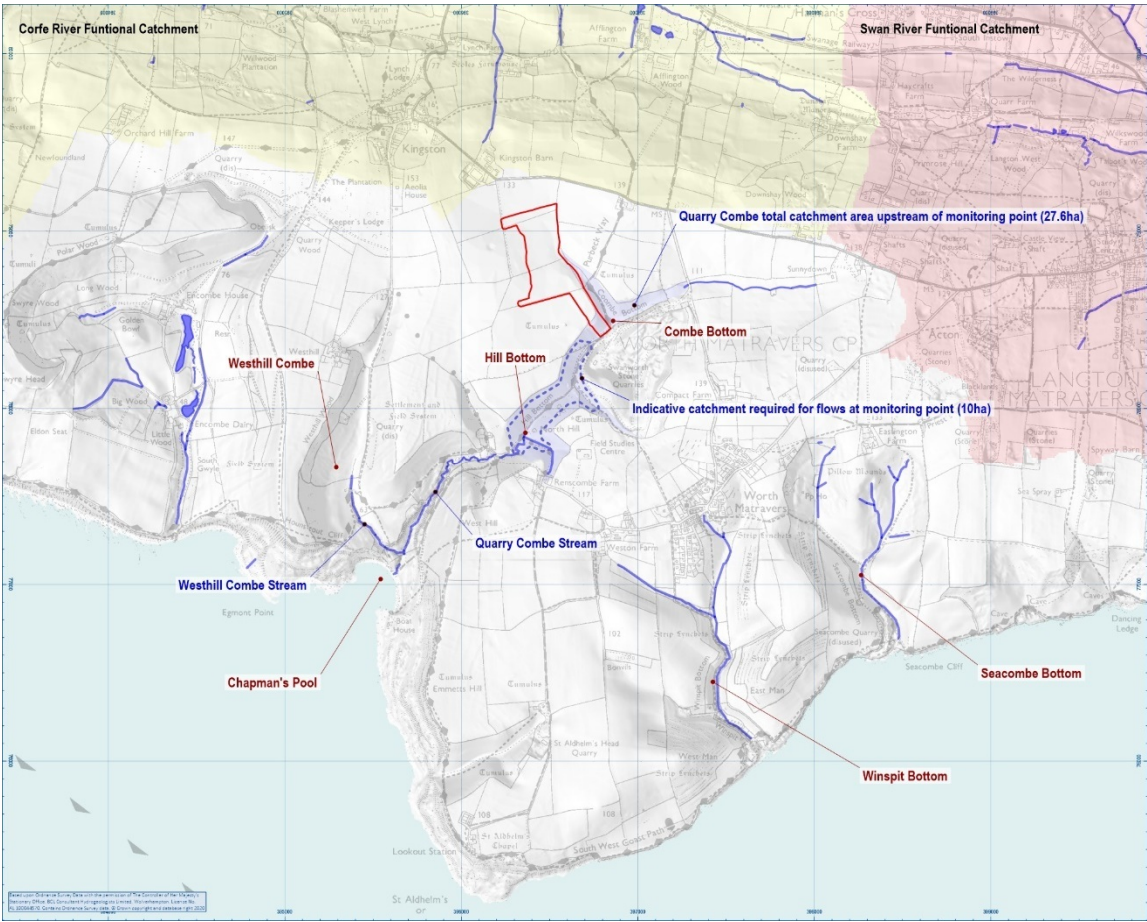


Table 7.1 Water features survey – September 2021

WFS No. (see figure below)	NGRx	NGRy	Description	Crest (m)	Base (m)	Length (m)	Water Depth (m)	Freeboard (m)	Flow (l/s)
WFS1	397261	78677	Entrance Stream - Dry						
WFS2	396689	78093	Position of head spring within Quarry Combe as indicated by Encombe Estate Reticulation plan: no evidence of spring during survey	NA	NA	NA	NA	NA	NA
WFS3	396509	78032	Formalised spring location with buried pipe work (understood to supply piped flow to WFS5).	2	2	3	0.5	2.5	NA
WFS4	396491	78005	First emergence of flow within Quarry Combe Stream (10m south of WFS3).	3	0.5	NA	0.02	0.4	0.05l/s
WFS5	396380	77911	Formalised spring location with pipe work supplying into Encombe Estate reticulation system, overflow made by pipe to Quarry Combe Stream.	2	2	3	0.2	2	1.3l/s
WFS6	396370	77888	Spring seepage across path made to Quarry Combe Stream. Very low flow but channel appears well established.	0.2	0.2	NA	0.02	0.03	damp
WFS7	396213	77731	Encombe Estate pump-house delivering from spring collector to Haysom's quarry with "waste" overflow decanting to Quarry Combe Stream.	NA	NA	NA	NA	NA	0.25l/s
WFS8	396141	77851	Outflow from formalised spring (supplies hamlet at Down Valley / Hill Bottom) Understood to be single source of supply for hamlet properties. Spring "waste" (not captured for use) piped to Quarry Combe Stream/	0.4	0.4	0.7	0.2	0.2	0.25l/s
WFS9	395486	77874	Ephemeral seepage (observed in previous survey).	1	0.5	1	NA	NA	Dry
WFS10	395443	78263	Hazel Spring: uppermost supply source within Westhill Combe, piped to catchment tank close to WFS12, where it feeds into Encombe tunnel.	0.5	1	3	0.5	0.5	>0.1l/s
WFS11	395402	77724	Westhill Combe valley floor spring source access manhole (one of several) – providing overall flow of 1.4l/s into Encombe tunnel catchment tank.	1	1	1	0.1	0.4	1.4l/s
WFS12	395374	77529	Westhill Combe Stream flowing beneath stone bridge – all flow being captured within catchment tank for supply through tunnel.	0.75	0.75	4	0.01	0.74	Dry



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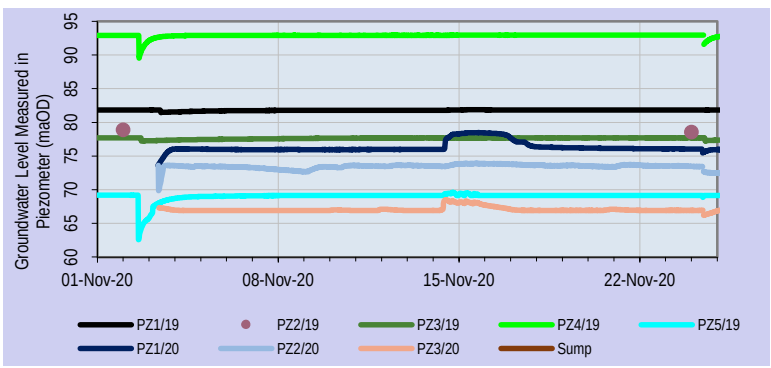
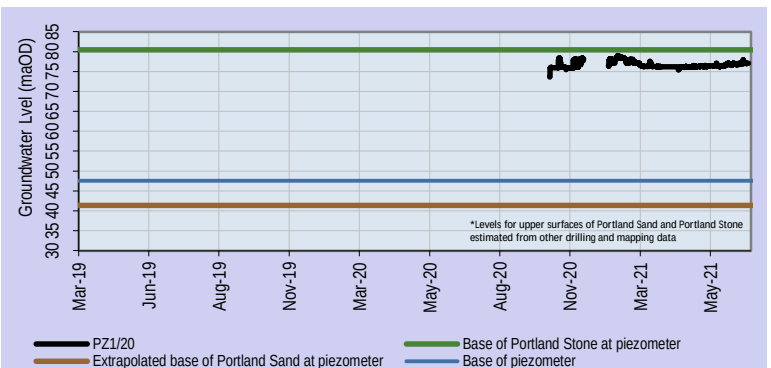
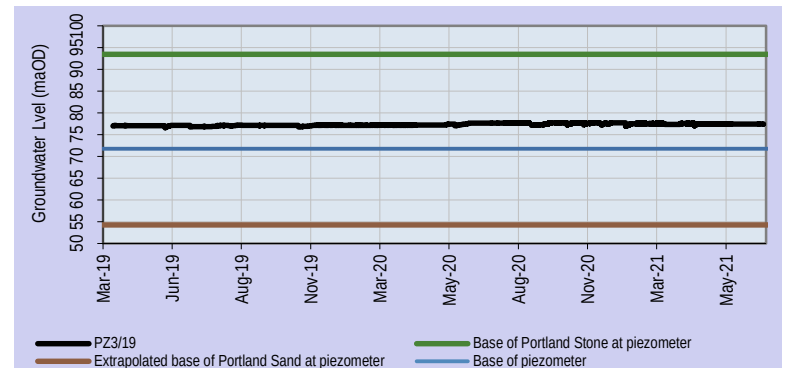
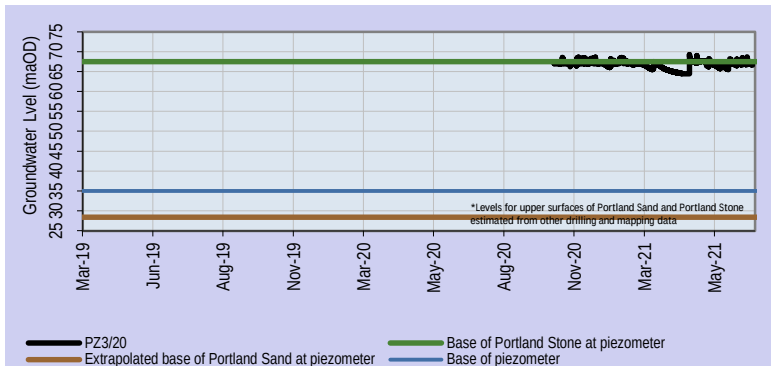
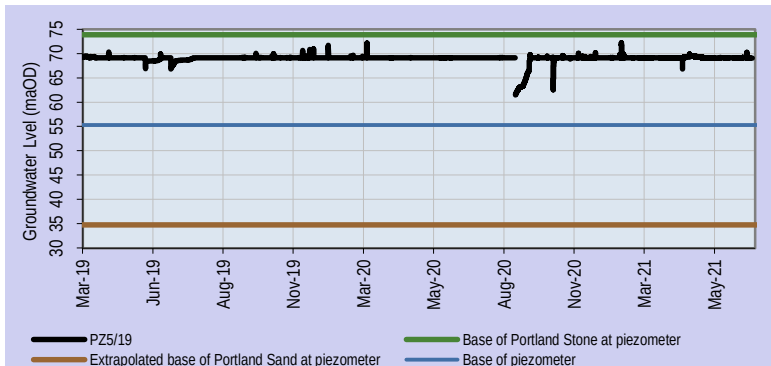
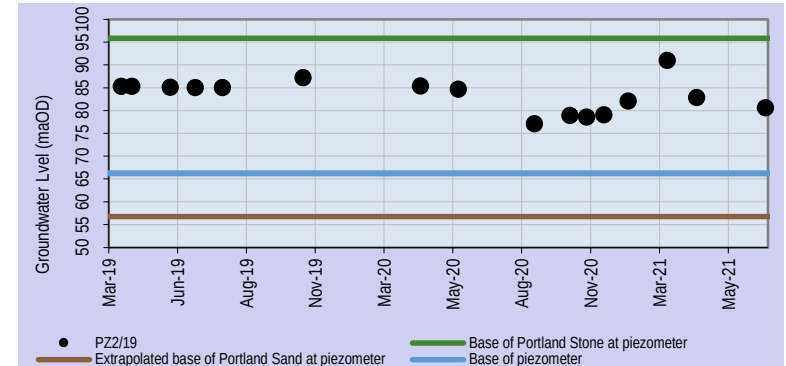
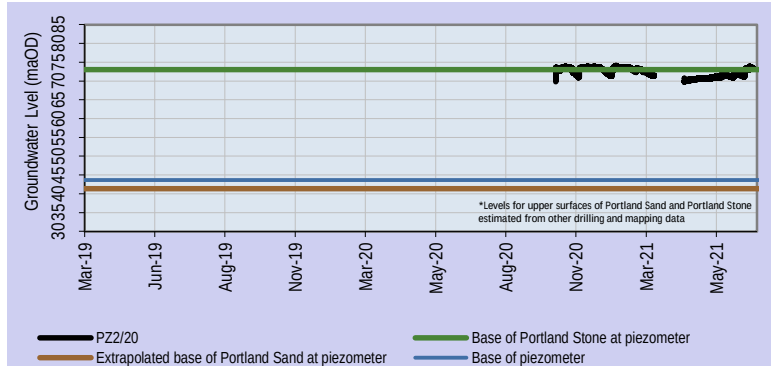
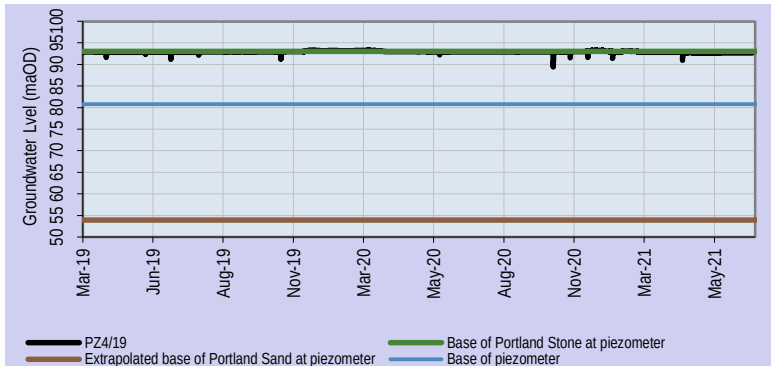
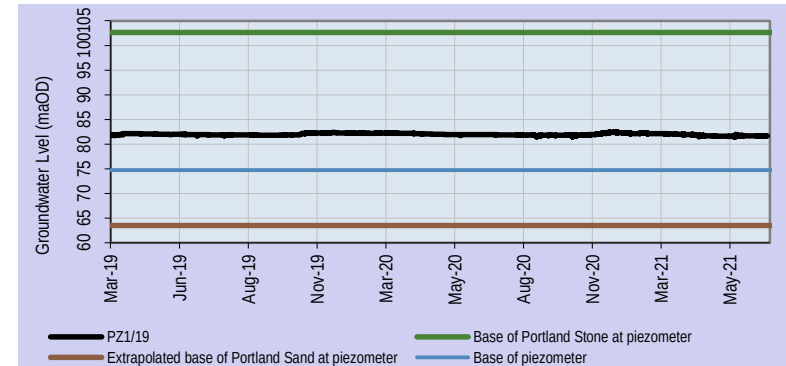
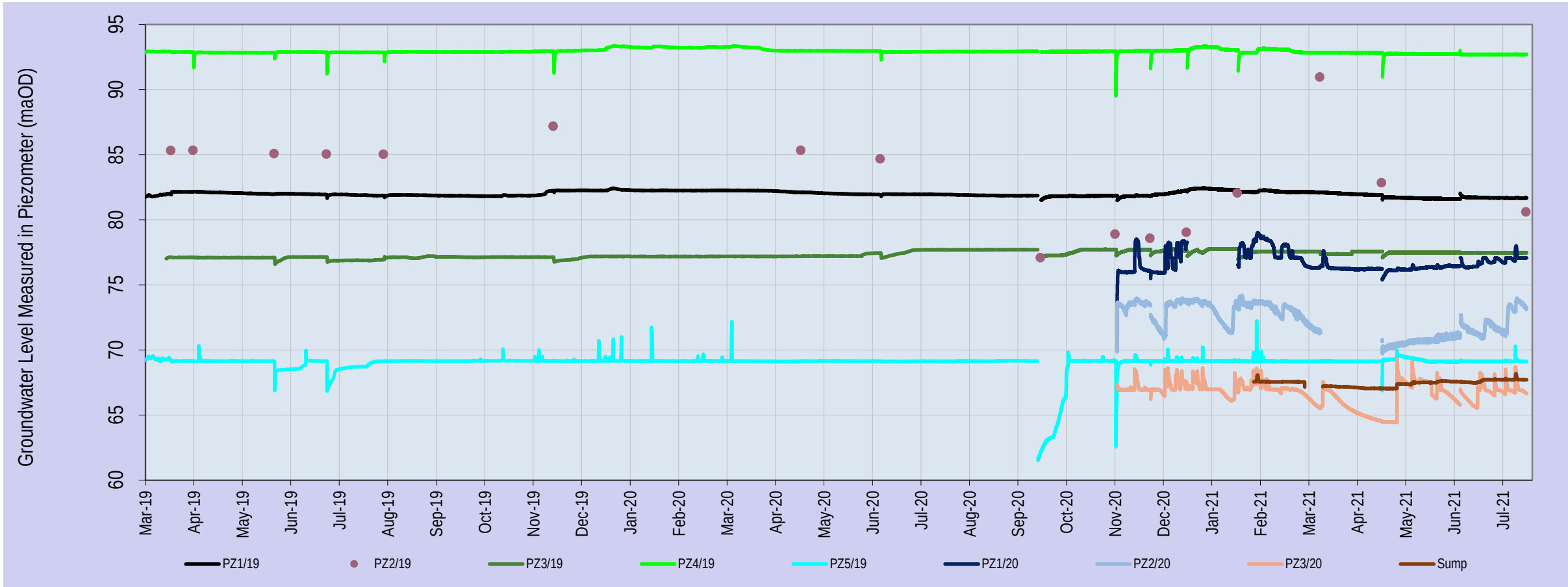
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Figure 7: Waterfeatures

Drawn By: PB
Date: Dec 21

Scale: as shown
Format: A3L



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Figure 8: Site piezometers – Groundwater hydrographs

Drawn By: PB
Date: Dec 21

Scale: n/a
Format: A3L



Key

Extension Area

Groundwater monitoring point and measured elevation (maOD)

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Figure 9: Groundwater contour plot – Maximum elevation conditions (maOD)

Drawn By: PB	Scale: 1:55,000
Date: Dec 21	Format: A3L



Key

Extension Area

Groundwater monitoring point and measured elevation (maOD)

Piezometric surface contour (maOD)

Spring and ID

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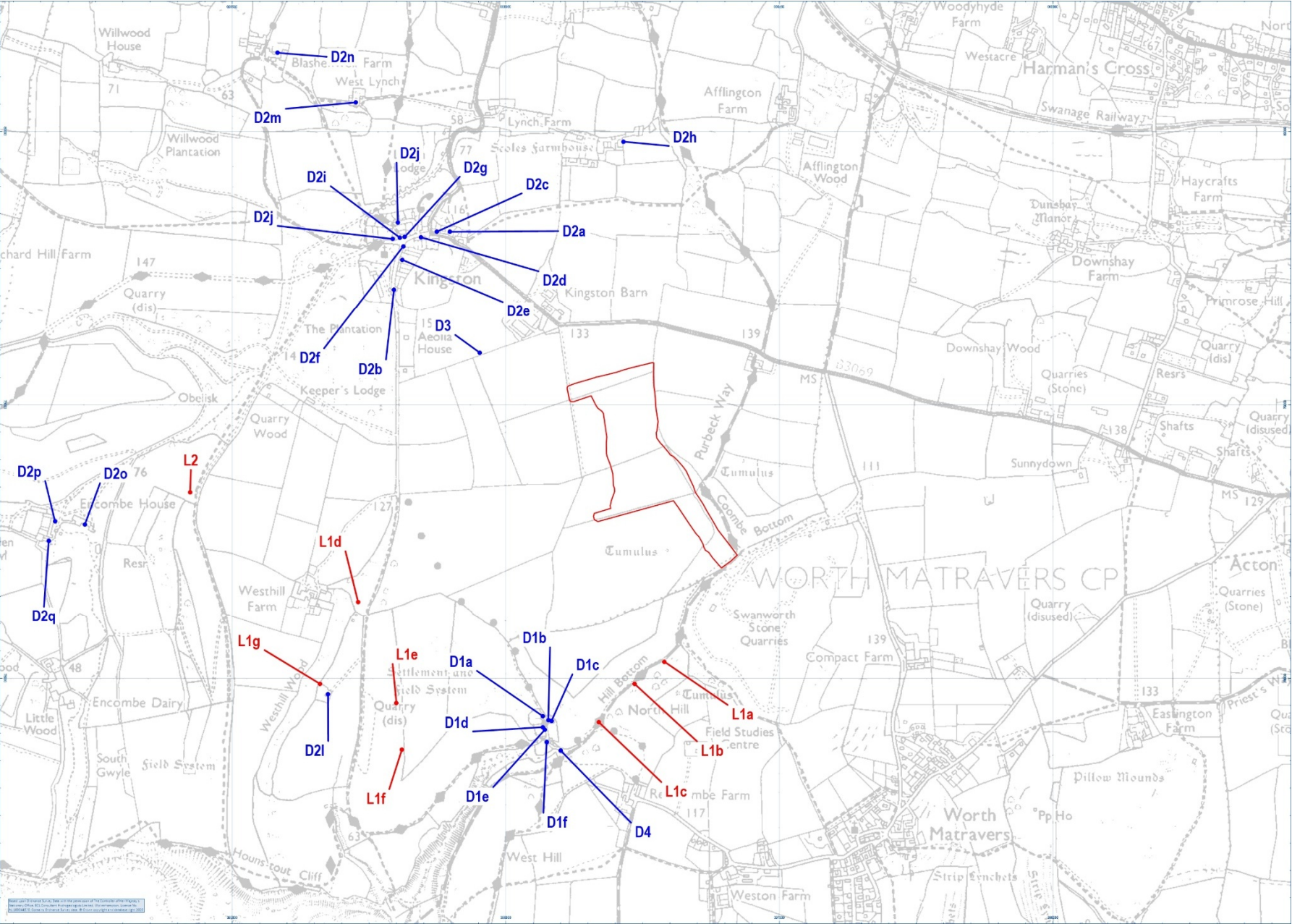
Figure 10: Groundwater contour plot – Minimum elevation conditions (maOD)

Drawn By: PB

Scale: 1:55,000

Date: Dec 21

Format: A3L



Key

Northern Extension

Abstraction and ID (tables 10&11): red denotes Licensed, blue - Private/deregulated

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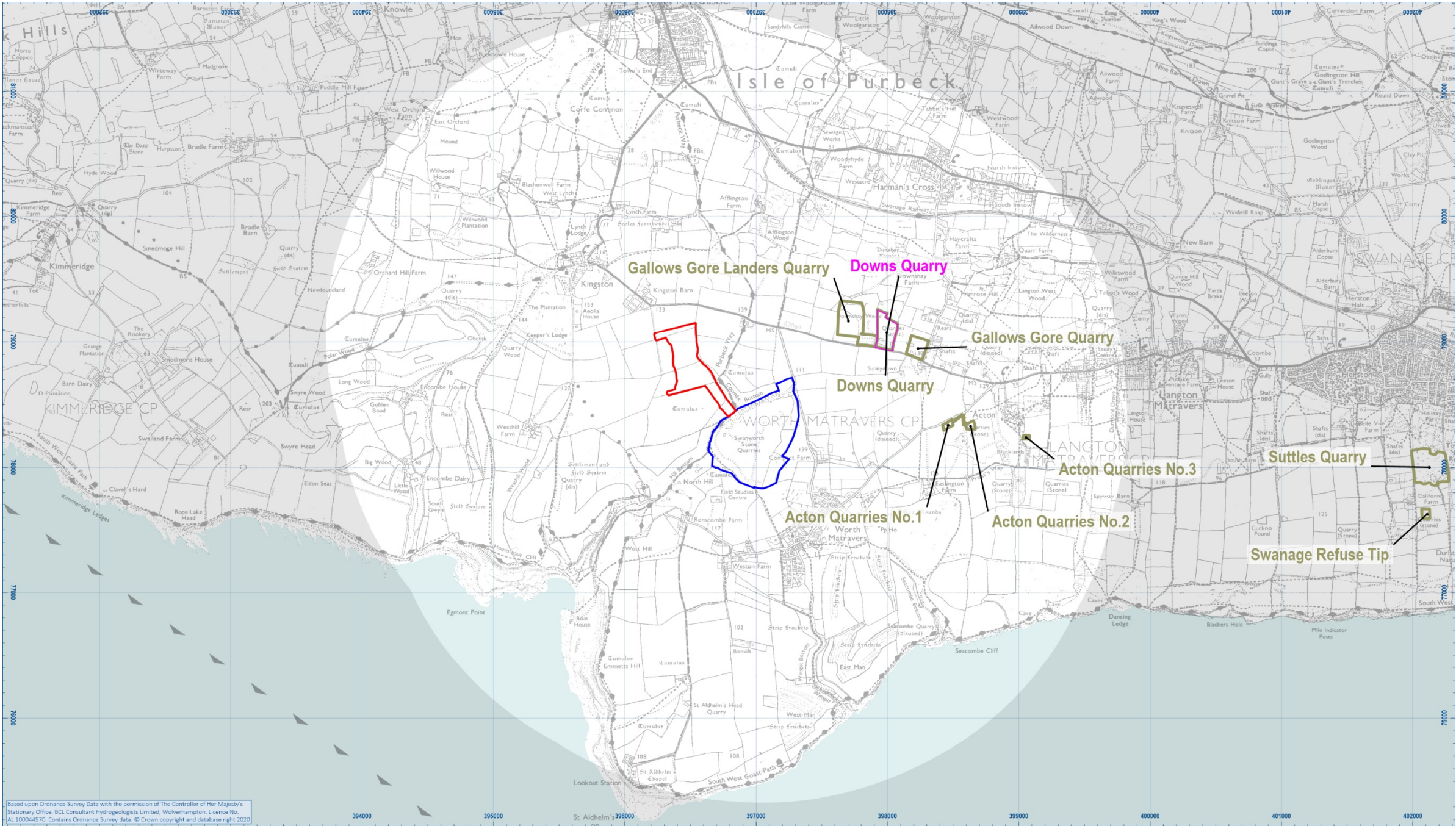
Figure 11: Abstractions

Drawn By: PB

Scale: 1:20,000

Date: Dec 21

Format: A3L



Key

- Existing Swanworth Quarry Site
- Northern Extension
- Historic Landfill
- Authorised Landfill

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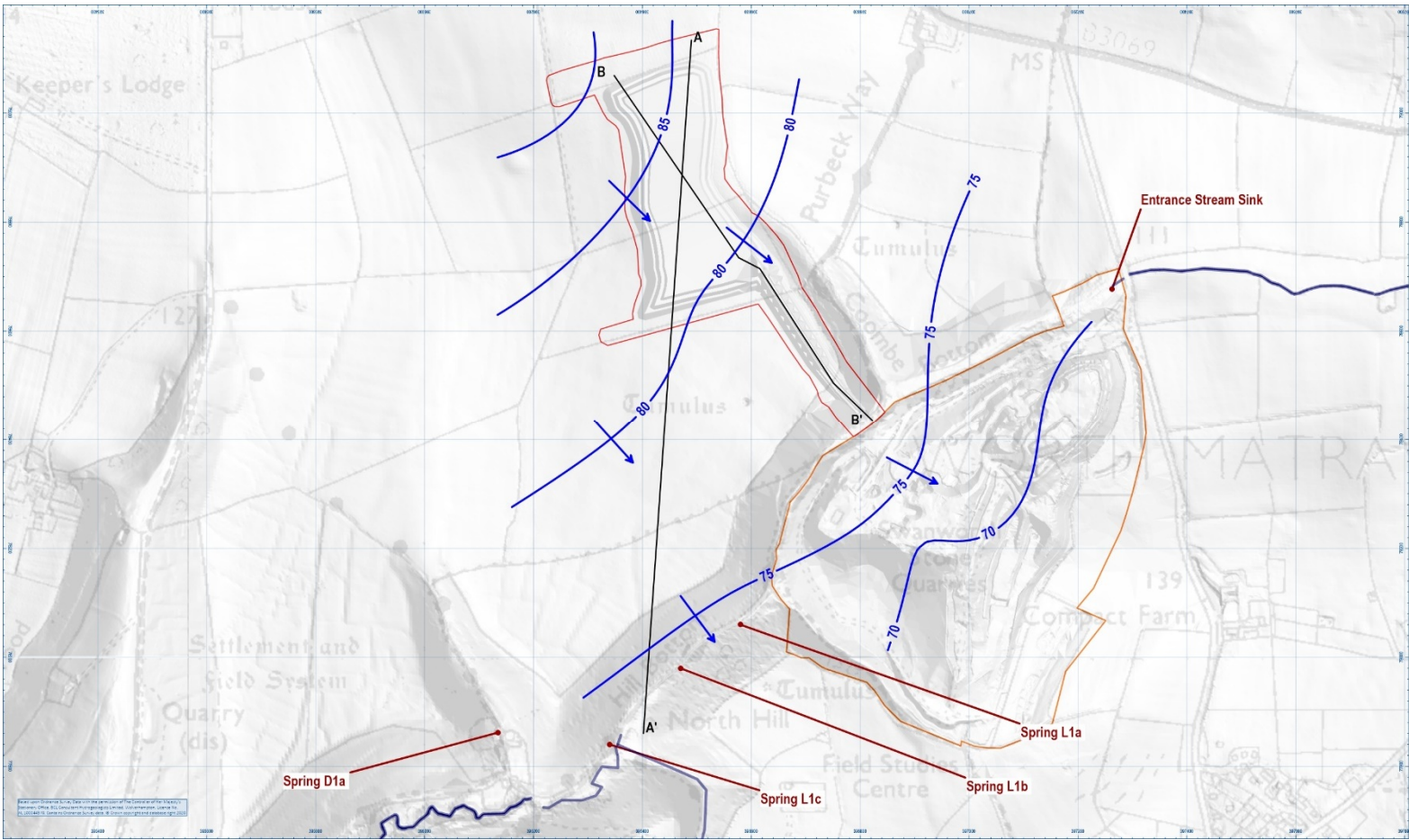
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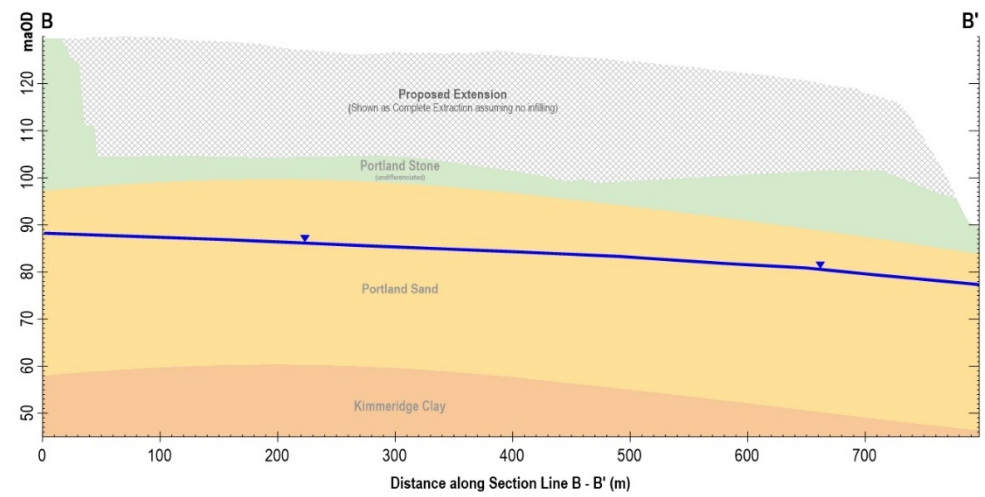
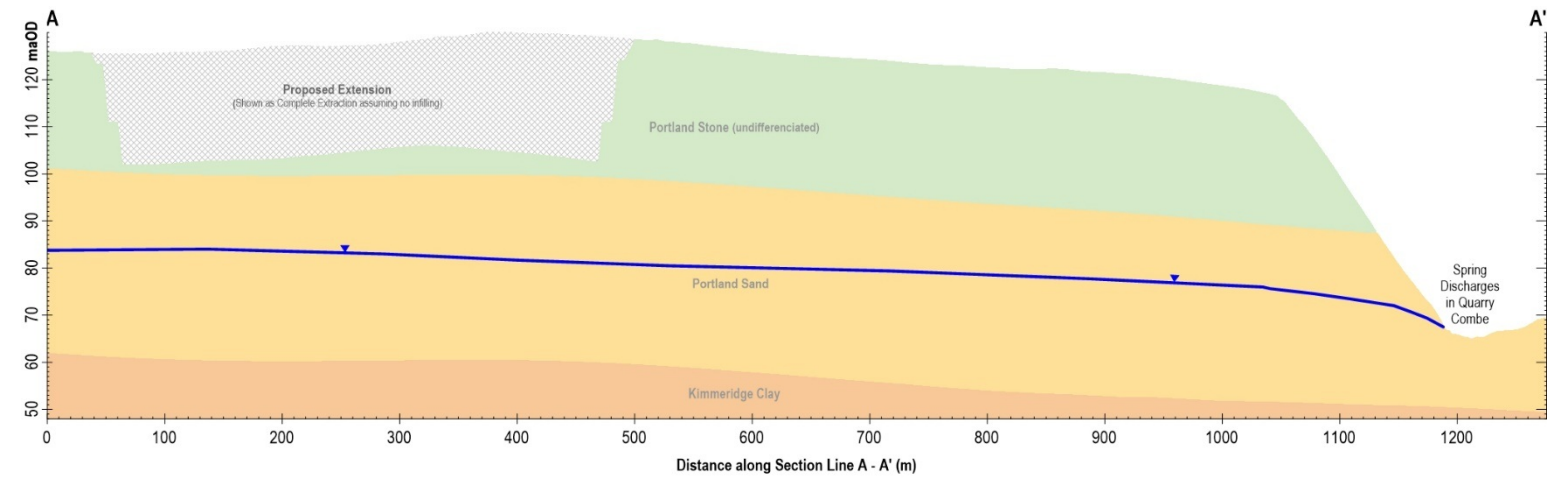
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Figure 12: Environment Agency registered landfill sites

Drawn By: PB	Scale: 1:30,000
Date: Dec 21	Format: A3L



- Key
- Existing Swanworth Quarry Site
 - Northern Extension
 - Piezometric contour (maOD)
 - Inferred direction of groundwater movement
 - Watercourse
 - Spring/seepage



Cross section scale as shown

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Figure 13: Conceptual model

Drawn By: PB
Date: Dec 21

Scale: 1:12,500
Format: A3L



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Worth Matravers, Dorset

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Appendix 1 Guidance & Information Sources

Regulatory & Industry Standard Guidance & Methodologies & Literature References

- "Hydrogeological Impact Appraisal for Dewatering Abstractions Environment Agency - Science Report (SC040020/SR1)". Water Resource Consultants for the Environment Agency, April 2007.
- "National Planning Policy Framework" (NPPF: Department for Communities and Local Government [DCLG], February 2019).
- "Planning Practice Guidance to the National Planning Policy Framework - www.gov.uk/government/collections/planning-practice-guidance" (PPG: DCLG), Launched March 2014).
- "Flood Risk and Coastal Change", Planning Practice Guidance (PPG), DCLG / Department for the Environment Food and Rural Affairs (DEFRA), above website - launched March 2014.
- "Planning Policy Statement 25 (PPS 25): Development and Flood Risk" (PPS25: DCLG, 2006)
- "Development and Flood Risk: A Practice Guide Companion to PPS25", DCLG, February 2009 (referred to herein as PPS25pg).
- "Flood Estimation Handbook CD-ROM, Version 3.0 (FEH CD-ROM No.3)", Centre for Ecology and Hydrology (CEH; formerly the Institute of Hydrology), 2009 and successor web-service.
- "The Calculation of Actual Evaporation and Soil Moisture Deficit over Specified Catchment Areas", Grindley J, November 1969, Hydrological Memorandum 38, Meteorological Office, Bracknell, UK.
- "Estimation of Open Water Evaporation, Guidance for Environment Agency Practitioners", R&D Handbook W6-043/HB, Finch JW and Hall RL, October 2001.
- "Technical Management of Water in the Coal Mining Industry", National Coal Board (NCB), 1982.
- "Some Physical Properties of Sand and Gravels", Hazen A., 1893, Massachusetts State Board of Health, 24th Annual Report.
- "Control of groundwater for temporary works", SH Somerville, 1986, Construction Industry Research and Information Association (CIRIA) report no. 113.
- "Groundwater Protection: Principles and Practice (GP3)" Version 1.1, EA, August 2013 and the superseding "Groundwater Protection - collection", DEFRA Website, January 2020.
- "Groundwater Hydrology", D K Todd, 1980.
- LandSim Release 2 Manual / Version 2.5 Addendum / Version 2.5.17 Addendum, Golder Associates / EA, EA R&D Publication 120.
- "Flood Estimation Handbook CD-ROM, Version 3.0 (FEH CD-ROM No.3)", Centre for Ecology and Hydrology (CEH; formerly the Institute of Hydrology), 2009 and successor web-service.
- Landfill Developments: Groundwater Risk Assessment for Leachate (<https://www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate>);
- "Additional guidance for hydrogeological risk assessments for landfills and the derivation of groundwater control levels and compliance limits", EA Horizontal Guidance Note H1 – Annex J3, Version 2.1, December 2011;
- "Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels" (LFTGN01), EA, March 2003 ;
- "Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water" (LFTGN02), EA, February 2003, and;
- "Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final technical report P1-471, 2002.
- "Manual for the production of Groundwater Source Protection Zones", EA March, 2019.

Published Data Sources

- Ordnance Survey (OS): Topographic maps at scales of 1:50,000 and 1:25,000.
- OS open-source digital data (Meridian 2, Panorama & Terra50 data-sets).
- British Geological Survey (BGS): Published 1:50,000 scale solid and drift geological mapping, sheet-no's. 252 (Swindon).
- BGS Geoindex, well details and borehole logs, 2017.
- Environment Agency (EA) , October 2017:
- Source Protection Zone (SPZ) spatial mapping data;
- Licensed abstractions;
- Flooding spatial mapping data;
- Register of Waste Disposal Sites;
- Local rainfall data, and;
- Water Framework Directive Catchment Mapping, Cycle 2.
- Natural England (NE): Spatial mapping & citation information for Designated Sites of ecological interest (Sites of Special Scientific Interest [SSSI's] & Special Areas of Conservancy [SAC's]);
- Geoindex, well details and borehole logs and On-line Lexicon of Named Rock Units, BGS;
- Spatial mapping & citation information for Designated Sites of ecological interest (Sites of Special Scientific Interest [SSSI's] & Special Areas of Conservancy [SAC's]), Natural England (NE);
- "The Physical Properties of Major Aquifers in England and Wales", EA & BGS, Allen D.J, Brewerton L.J, Coleby L.M, Gibbs B.R, Lewis M.A, McDonald A.M, Wagstaff S.J, Williams A.T, 1997;
- "Climate & Drainage", Technical Bulletin No. 34, Ministry of Agriculture Fisheries & Food (MAFF), September 1976.

Site Specific Data Sources

- "Swanworth Quarry, Worth Matravers, Dorset. Planning Application for a Northward Extension to Existing Mineral Extraction and Restoration. Hydrological & Hydrogeological Impact Assessment". BCL. 6th May 2020. Ref. QPL.SSQ.SWANWORTH.H&HIA20.02.
- "Swanworth Quarry Extension, Restoration Plan", David Jarvis Associates (DJA) for SSQ, January 2020, Drawing ref. LV-0011;
- Drill logs for site piezometers – installed 2019 and 2020, Suttles.
- Results of water features and reconnaissance surveys undertaken by BCL (between September 2019 and present).
- Piezometer testing and sampling, dates as above.



Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 2 Dorset Council Regulation 25 Letter

Mr Steve Lamb
Quarryplan (GB) Ltd
12A The Borough Mall
Wedmore
Somerset
BS28 4EB

Date: 25 November 2020
Ref: 6/2020/0321
☎ 01865 453747
✉ suzi.coyne@ntlworld.com

Dear Mr Lamb

Planning Application: 6/2020/0321 for Extension to Swanworth Quarry, Kingston Lane, Worth Matravers, Swanage BH19 3LE

I refer to the above planning application that was received on 17th June 2020, and our telephone conversation of 5 October 2020 in which we discussed that some of the responses to consultation in respect of this proposal had identified that there are a number of issues that have not been adequately addressed in the submission.

I am now writing to set out the outstanding matters that need to be provided before the application can be determined, and would request, in accordance with Regulation 25 of the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 and Section 62(3) of the Town and Country Planning Act 1990, that the following information is provided:

1. The description of the proposal, as given in the application forms, does not fully encompass all the aspects of the development for which, as is apparent from the supporting documents, planning permission is being sought. Please would you therefore confirm your agreement to the following amended description of the proposal:

"The winning and working of limestone through the lateral extension to Swanworth Quarry, retention of processing plant and existing infrastructure, importation of inert waste material for restoration purposes, and continued production and sale of secondary aggregates."
2. Additional information to address the concerns raised by the Environment Agency in relation to the groundwater environment and dependent local water supplies, to include:
 - a. Evidence for groundwater flow paths and velocity to the licensed spring valley outfalls in Hill Bottom from the extension and current site. Whilst new boreholes were installed for the extension area, there are no groundwater boreholes at the existing site capable of identifying the direction of groundwater flow. The work should include long term observations for the flow regime in Hill Bottom on which to demonstrate the site conceptual model, and review the likely changes to the flow regime resulting from changes to catchment recharge distribution during operation and following restoration.
 - b. Provision of a risk assessment suitable for an environmental permit application for the deposit for recovery scheme, to enable the proposed infill composition and need to use inert waste materials to achieve a final restoration profile to be considered

against the potential risk to the quantity and quality of the water environment and dependent water supplies.

- c. Review of the impacts of the development on the SSSI/SAC using the site assessment and updated conceptual model for the changes to the flow regime.
3. An updated Landscape and Visual Impact Assessment, to provide an objective re-assessment of the predicted landscape and visual effects:
 - a. against the alternative baseline of the existing quarrying activity ceasing and the site being fully restored within the short term (the next 5 years or so);
 - b. to reflect that the proposal is not for a temporary short term development, and that the duration of effect at in excess of 25 years would generally be defined as very long term; and
 - c. in light of a higher sensitivity for the receptor points of local roads which are well used by visitors wishing to experience the scenic qualities of the area.
4. Detailed drawings of the proposed screen bunds including height and treatment to assist in understanding how they would appear in the landscape and achieve the desired effect.
5. Clarification as to the proposals for the area shown shaded green on Figure 21 of the Development Guidelines in relation to Site Allocation CR1 at Appendix A of the Minerals Site Plan 2019. A plan should be provided to show how the "green land" relates to the development proposals and confirm that there would be no working within it.
6. Proposals for compensatory environmental enhancements to be provided in the event that adverse landscape and visual impacts cannot be avoided or adequately mitigated.
7. Revisions to the noise assessment to include:
 - a. Clarification that the calculation of predicted noise levels includes the use of plant and machinery associated with landfilling operations on an ongoing basis together with quarrying operations (not just as temporary operations); and
 - b. Consideration of additional measures to reduce the effects of noise levels on users of the Purbeck Way, which would be as near as 65m to the edge of extraction/landfilling operations and run within close vicinity of the development site for a length of about 500 metres.
8. A separate review of all the potential effects of the development proposals, including from changes in hydrology, displacement of recreation, species, proximity, land management and restoration measures to determine whether they would be of such significance as to be likely to adversely affect the integrity of the Isle of Portland to Studland Cliffs and St Albans Head to Durlston Head SACs and the Dorset Heaths Ramsar sites either alone or in combination with other plans or projects.
9. The proposed methods for minimising air overpressure generated by blasting at source as mentioned at paragraph 11.5 of the Assessment of Environmental Impact of Blasting (Section 4 of the Environmental Statement).

On an additional matter, I need to advise that although reminders have been sent, comments are still to be received from Natural England and the Council's Natural Environment team. I do apologise for this situation, which I gather is due to a backlog of workload arising from the

COVID-19 crisis. Should these consultation responses, once they are available, identify any outstanding issues I would need to send a further request for additional information.

Please note that the further information once satisfactorily received will need to be advertised, and only after all the requested further information has been subject to appropriate consultation will it be possible for the application to be considered by officers who will provide a recommendation to the Council's Strategic Planning Committee

Yours sincerely

A handwritten signature in blue ink, appearing to read 'Suzi Coyne', is positioned above the printed name.

Suzi Coyne
Planning Consultant to Dorset Council



Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 3 Waste Acceptance Criteria Certificates

Certificate No. 21-02201-Issue 1-Page: 2
 Site Address^ Manning Heath - Poole



ACSE Sample Number 53788
 Sample ID 562583 - 21-69431
 Clients Sample Ref.^ 0/50mm Screened Fines
 Material Source^ Mannings Heath Depot
 Location / Sample Depth (m)^ Stockpiles
 Time Sampled^
 Date Sampled^ 11/12/2021
 Sample Deviating Codes b
 Client's Sample Description^
 ACS Testing Material Description^ 0/50 Screened Fines
 Principal Matrix (as received) Gravel

LANDFILL WASTE ACCEPTANCE CRITERIA (WAC)					
TEST VALUES					
Mass of Undried Test Portion (Mw)	92.5	g	Volume of Leachant Used (L10)	0.898	litres
Mass of Dried Test Portion (Mp)	90.0	g			
Moisture Content Ratio (MC)	2.8	%	Volume of Eluate (VE10)	0.856	litres
Dry Matter Content (DR)	97.3	%			

SOLIDS ANALYSIS				
Analyte	Method	AS	Sample Condition for Analysis	Results
Total Organic Carbon (%)	MT/ACSE/102	*	As received	2.00
Loss on ignition (%)	MT/ACSE/302	*	Air dried at 30 °C	1.5
BTEX (mg/kg)	MT/ACSE/101	*b	As received	< 0.60
PCBs (7 congeners) (mg/kg)	MT/ACSE/104	*b	Air dried at 30 °C	< 1.00
Mineral oil (C10 - C40) (mg/kg)	MT/ACSE/105	*b	As received	< 50
PAHs (mg/kg)	MT/ACSE/108	*b	As received	7.19
pH (units)	MT/ACSE/301	*	Air dried at 30 °C	9.2

ELUATE ANALYSIS				
Analyte	Method	AS	Concentration in Eluate (mg/l)	Amount Leached (mg/kg)
Eluate Preparation	LP/ACSE/811			
Liquid : Solid Ratio (L/S)	LP/ACSE/101	*	L/S 10	L/S 10
pH (units)	MT/ACSE/301	*	9.5	
Temperature (°C)	MT/ACSE/301		20	
Conductivity (mS/m)	MT/ACSE/303	*	14.81	
Arsenic	MT/ACSE/205	*	< 0.007	< 0.070
Barium	MT/ACSE/205	*	0.0446	0.446
Cadmium	MT/ACSE/205	*	< 0.0008	< 0.008
Chromium (total)	MT/ACSE/205	*	0.006	0.058
Copper	MT/ACSE/205	*	< 0.008	< 0.080
Mercury	MT/ACSE/202	*	< 0.0001	< 0.0010
Molybdenum	MT/ACSE/205	*	0.0030	0.030
Nickel	MT/ACSE/205	*	0.0009	0.0089
Lead	MT/ACSE/205	*	< 0.004	< 0.040
Antimony	MT/ACSE/205	*	< 0.003	< 0.030
Selenium	MT/ACSE/205	*	< 0.006	< 0.060
Zinc	MT/ACSE/205	*	0.007	0.066
Chloride	MT/ACSE/204	*	< 3.00	< 30.00
Fluoride	MT/ACSE/204	*	0.37	3.650
Sulphate	MT/ACSE/204	*	26.10	261.0
Total dissolved solids	MT/ACSE/304	*	115	1150
Phenol index	MT/ACSE/107	*	< 0.05	< 0.50
Dissolved organic carbon	MT/ACSE/103	*	7.33	73.30

Comments: (comments are beyond the scope of UKAS accreditation)

Key (at clients request):

Individual test result exceeds the landfill waste acceptance criteria limit for inert waste.

The landfill waste acceptance criteria limits are provided for guidance only.
 Eluates prepared in accordance with BS EN 12457-3:2002*

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION		
Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
3 %	5 %	6 %
---	---	10 %
6	---	---
1	---	---
500	---	---
100	---	---
---	>6	---

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION		
BS EN 12457-2:2002 LIMIT VALUES (mg/kg) at L/S 10		
Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
0.5	2	25
20	100	300
0.04	1	5
0.5	10	70
2	50	100
0.01	0.2	2
0.5	10	30
0.4	10	40
0.5	10	50
0.06	0.7	5
0.1	0.5	7
4	50	200
800	15000	25000
10	150	500
1000	20000	50000
4000	60000	100000
1	---	---
500	800	1000

Certificate No. 20-00072-Issue 0-Page: 2

Site Address^ Mannings Heath

ACSE Sample Number 46489
 Sample ID 505169 - 20-59680
 Clients Sample Ref.^ Screened Fines 0/50mm
 Material Source^ MRH - Recycled
 Location / Sample Depth (m)^ Stockpile
 Time Sampled^ 1520
 Date Sampled^ 13/01/2020
 Sample Deviating Codes f
 Client's Sample Description^
 ACS Testing Material Description^ Screened Fines 0/50mm
 Principal Matrix (as received) GRAVEL



LANDFILL WASTE ACCEPTANCE CRITERIA (WAC)

TEST VALUES

Mass of Undried Test Portion (Mw)	91.7	g	Volume of Leachant Used (L10)	0.898	litres
Mass of Dried Test Portion (Mp)	90.0	g			
Moisture Content Ratio (MC)	1.9	%	Volume of Eluate (VE10)	0.875	litres
Dry Matter Content (DR)	98.2	%			

SOLIDS ANALYSIS

Analyte	Method	AS	Sample Condition for Analysis	Results
Total Organic Carbon (%)	MT/ACSE/102	*	As received	2.22
Loss on ignition (%)	MT/ACSE/302	*	Air dried at 30°C	2.7
BTEX (mg/kg)	MT/ACSE/101	*f	As received	< 0.60
PCBs (7 congeners) (mg/kg)	MT/ACSE/104	*	Air dried at 30°C	< 1.00
Mineral oil (C10 - C40) (mg/kg)	MT/ACSE/105	*	As received	302
PAHs (mg/kg)	MT/ACSE/108	*	As received	2.63
pH (units)	MT/ACSE/301	*f	Air dried at 30°C	8.8

ELUATE ANALYSIS

Analyte	Method	AS	Concentration in Eluate (mg/l)	Amount Leached (mg/kg)
Eluate Preparation	LP/ACSE/811			
Liquid : Solid Ratio (L/S)	LP/ACSE/101	*	L/S 10	L/S 10
pH (units)	MT/ACSE/301	*	9.5	
Temperature (°C)	MT/ACSE/301		20	
Conductivity (mS/m)	MT/ACSE/303	*	22.50	
Arsenic	MT/ACSE/205	*	0.018	0.1779
Barium	MT/ACSE/205	*	0.0669	0.669
Cadmium	MT/ACSE/205	*	< 0.0008	< 0.008
Chromium (total)	MT/ACSE/205	*	0.006	0.064
Copper	MT/ACSE/205	*	0.013	0.126
Mercury	MT/ACSE/202	*	< 0.0001	< 0.0010
Molybdenum	MT/ACSE/205	*	0.0018	0.018
Nickel	MT/ACSE/205	*	0.0017	0.017
Lead	MT/ACSE/205	*	< 0.004	< 0.040
Antimony	MT/ACSE/205	*	< 0.003	< 0.030
Selenium	MT/ACSE/205	*	< 0.006	< 0.060
Zinc	MT/ACSE/205	*	< 0.002	< 0.020
Chloride	MT/ACSE/204	*	< 3.00	< 30.00
Fluoride	MT/ACSE/204	*	0.20	1.990
Sulphate	MT/ACSE/204	*	56.96	569.6
Total dissolved solids	MT/ACSE/304	*	170	1700
Phenol index	MT/ACSE/107	*	< 0.05	< 0.50
Dissolved organic carbon	MT/ACSE/103	*	9.70	97.00

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION

Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
3 %	5 %	6 %
---	---	10 %
6	---	---
1	---	---
500	---	---
100	---	---
---	>6	---

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION

BS EN 12457-2:2002 LIMIT VALUES (mg/kg) at L/S 10		
Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
0.5	2	25
20	100	300
0.04	1	5
0.5	10	70
2	50	100
0.01	0.2	2
0.5	10	30
0.4	10	40
0.5	10	50
0.06	0.7	5
0.1	0.5	7
4	50	200
800	15000	25000
10	150	500
1000	20000	50000
4000	60000	100000
1	---	---
500	800	1000

Comments: (comments are beyond the scope of UKAS accreditation)

Key (at clients request):

 Individual test result exceeds the landfill waste acceptance criteria limit for inert waste.

The landfill waste acceptance criteria limits are provided for guidance only.
 Eluates prepared in accordance with BS EN 12457-3:2002*

Certificate No. 20-01111-Issue 1-Page: 2
 Site Address^ Manning Heath - Poole



ACSE Sample Number 49858
 Sample ID 532891 - 20-64338
 Clients Sample Ref.^ Screened Fines
 Material Source^ Mannings Heath Depot
 Location / Sample Depth (m)^ Stockpile
 Time Sampled^
 Date Sampled^ 27/07/2020
 Sample Deviating Codes bf
 Client's Sample Description^
 ACS Testing Material Description^ Screened Fines
 Principal Matrix (as received) LOAM

LANDFILL WASTE ACCEPTANCE CRITERIA (WAC)

TEST VALUES

Mass of Undried Test Portion (Mw)	90.7	g	Volume of Leachant Used (L10)	0.899	litres
Mass of Dried Test Portion (Mp)	90.0	g			
Moisture Content Ratio (MC)	0.8	%	Volume of Eluate (VE10)	0.864	litres
Dry Matter Content (DR)	99.2	%			

SOLIDS ANALYSIS

Analyte	Method	AS	Sample Condition for Analysis	Results
Total Organic Carbon (%)	MT/ACSE/102	*	As received	0.82
Loss on ignition (%)	MT/ACSE/302	*	Air dried at 30°C	1.6
BTEX (mg/kg)	MT/ACSE/101	*bf	As received	< 0.60
PCBs (7 congeners) (mg/kg)	MT/ACSE/104	*b	Air dried at 30°C	< 1.00
Mineral oil (C10 - C40) (mg/kg)	MT/ACSE/105	*#b	As received	164
PAHs (mg/kg)	MT/ACSE/108	*#b	As received	5.64
pH (units)	MT/ACSE/301	*f	Air dried at 30°C	8.7

ELUATE ANALYSIS

Analyte	Method	AS	Concentration in Eluate (mg/l)	Amount Leached (mg/kg)
Eluate Preparation	LP/ACSE/811			
Liquid : Solid Ratio (L/S)	LP/ACSE/101	*	L/S 10	L/S 10
pH (units)	MT/ACSE/301	*	8.6	
Temperature (°C)	MT/ACSE/301	*	20	
Conductivity (mS/m)	MT/ACSE/303	*	25.90	
Arsenic	MT/ACSE/205	*	0.020	0.200
Barium	MT/ACSE/205	*	0.0663	0.663
Cadmium	MT/ACSE/205	*	< 0.0008	< 0.008
Chromium (total)	MT/ACSE/205	*	0.004	0.035
Copper	MT/ACSE/205	*	< 0.008	< 0.080
Mercury	MT/ACSE/202	*	< 0.0001	< 0.0010
Molybdenum	MT/ACSE/205	*	< 0.0010	< 0.010
Nickel	MT/ACSE/205	*	0.0012	0.0122
Lead	MT/ACSE/205	*	< 0.004	< 0.040
Antimony	MT/ACSE/205	*	0.003	0.031
Selenium	MT/ACSE/205	*	< 0.006	< 0.060
Zinc	MT/ACSE/205	*	0.005	0.054
Chloride	MT/ACSE/204	*	3.76	37.56
Fluoride	MT/ACSE/204	*	0.25	2.500
Sulphate	MT/ACSE/204	*	81.54	815.4
Total dissolved solids	MT/ACSE/304	*	215	2150
Phenol index	MT/ACSE/107	*	< 0.05	< 0.50
Dissolved organic carbon	MT/ACSE/103	*	12.9	129.1

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION

Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
3 %	5 %	6 %
---	---	10 %
6	---	---
1	---	---
500	---	---
100	---	---
---	>6	---

LANDFILL WASTE ACCEPTANCE CRITERIA SPECIFICATION

BS EN 12457-2:2002 LIMIT VALUES (mg/kg) at L/S 10		
Inert Waste	Stable non-reactive hazardous waste in non-hazardous landfill	Hazardous waste
0.5	2	25
20	100	300
0.04	1	5
0.5	10	70
2	50	100
0.01	0.2	2
0.5	10	30
0.4	10	40
0.5	10	50
0.06	0.7	5
0.1	0.5	7
4	50	200
800	15000	25000
10	150	500
1000	20000	50000
4000	60000	100000
1	---	---
500	800	1000

Comments: (comments are beyond the scope of UKAS accreditation)

Key (at clients request):

Individual test result exceeds the landfill waste acceptance criteria limit for inert waste.

The landfill waste acceptance criteria limits are provided for guidance only.
 Eluates prepared in accordance with BS EN 12457-3:2002*



Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 4 Hydraulic testing of monitoring points

Bouwer-Rice Method to Determine Hydraulic Conductivity From Falling Head Tests

The hydraulic conductivity of the aquifer is estimated using the method of Bouwer and Rice²⁷. This calculation uses measured displacement of water level over the relevant time period, after water is introduced into the piezometer as a falling head test.

The equation for hydraulic conductivity, K, is:

$$K = \frac{r_c^2 \ln(R_e / r_w)}{2d} \frac{1}{t} \ln \frac{h_0}{h_t}$$

where r_c = internal radius of the piezometer casing pipe

r_w = radius over which aquifer is undisturbed

R_e = radial distance over which the difference in head is dissipated in the flow system of the aquifer

d = length of the well screen or open section of the well

h_0 = head in the well at time $t_0 = 0$

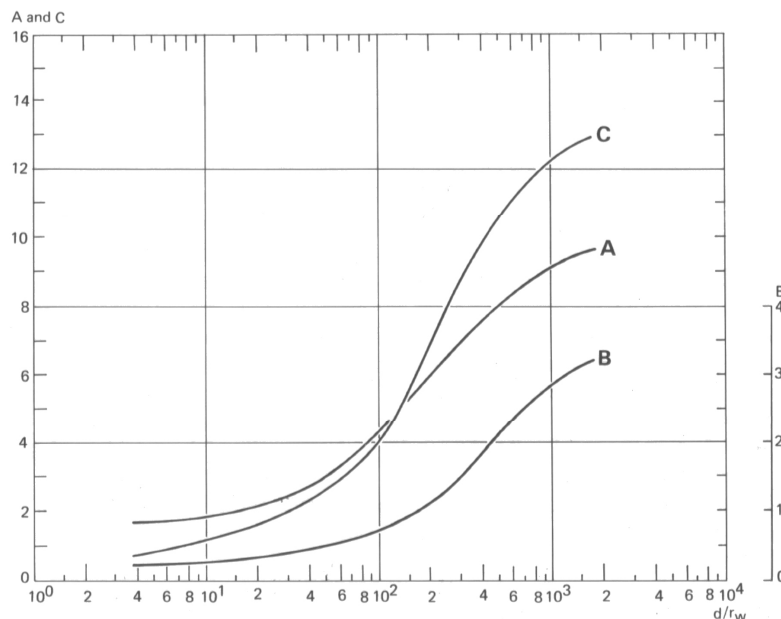
h_t = head in the well at time $t > t_0$

The value of $\frac{1}{t} \ln \frac{h_0}{h_t}$ is found for each falling head test by taking a best-fit straight line approximation to early time data on the graph of the logarithm of induced head against time.

Making the assumption that the piezometer fully penetrates to the base of the aquifer, then:

$$\ln \frac{R_e}{r_w} = \frac{1.1}{\ln(b/r_w)} + \frac{C}{d/r_w} \dot{u}^{-1}$$

where: C = function of d/r_w taken from the graph below.



Graph giving values of parameter C for use in Bouwer-Rice method¹, for fully penetrating piezometer. Taken from Kruseman and de Ridder (2000).

²⁷ Bouwer and Rice 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research 12, 423-428. Explained in Kruseman and de Ridder 2000. Analysis and Evaluation of Pumping Test Data, International Institute for Land Reclamation and Improvement.

This calculation for hydraulic conductivity assumes the following conditions:

- The aquifer is unconfined, homogeneous, isotropic, of uniform thickness over the area influenced by the test and has an apparently infinite areal extent.
- Prior to the test, the water table is approximately horizontal over the area influenced by the test.
- The head is raised instantaneously when water is introduced into the piezometer; there is negligible change in head around the well; no flow occurs above the watertable.
- Well losses are negligible
- Flow to the well is in a steady state

In practise these conditions cannot be fully met. This method does not then give accurate values but allows estimates of hydraulic conductivity to be made.

Full results of testing are provided on the following pages. A summary of the test results is provided at *table A5.1* below.

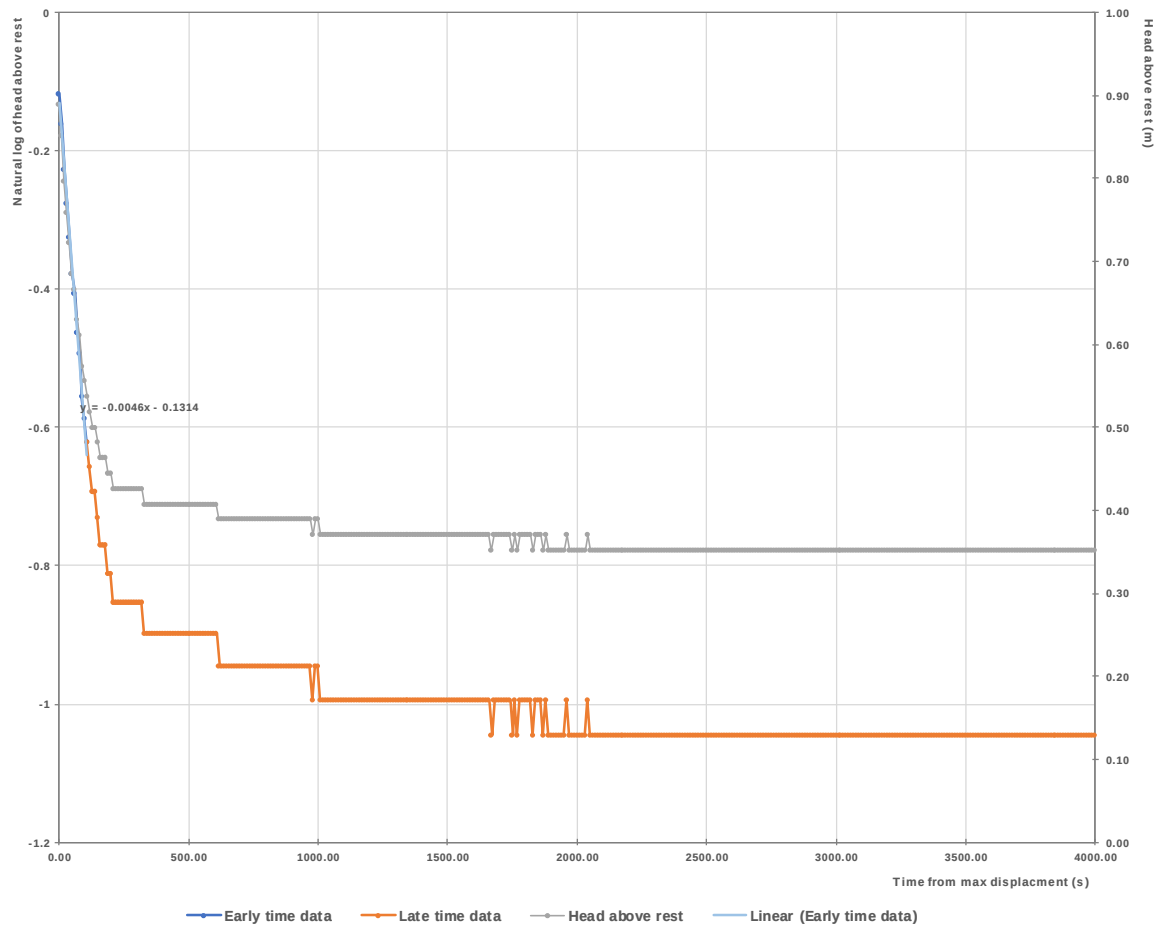
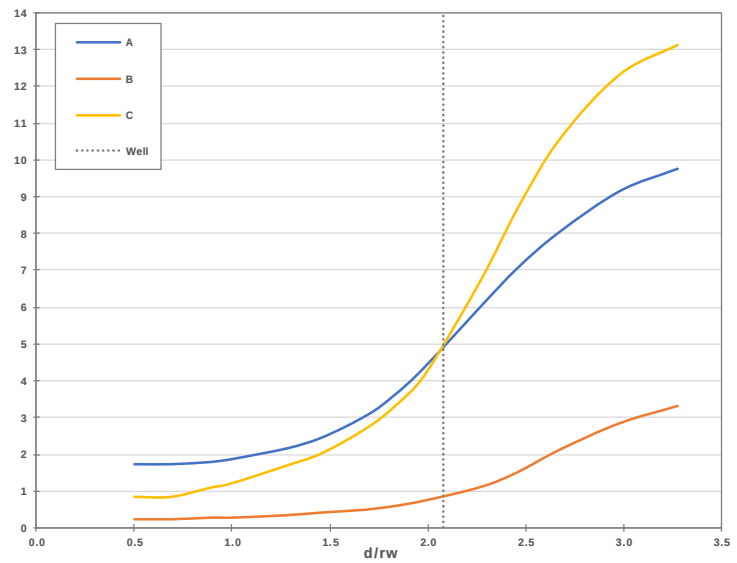
Table A5.1 – Swanworth Quarry Northern Extension. Site Piezometers.

Summary results of hydraulic testing – June 2021.

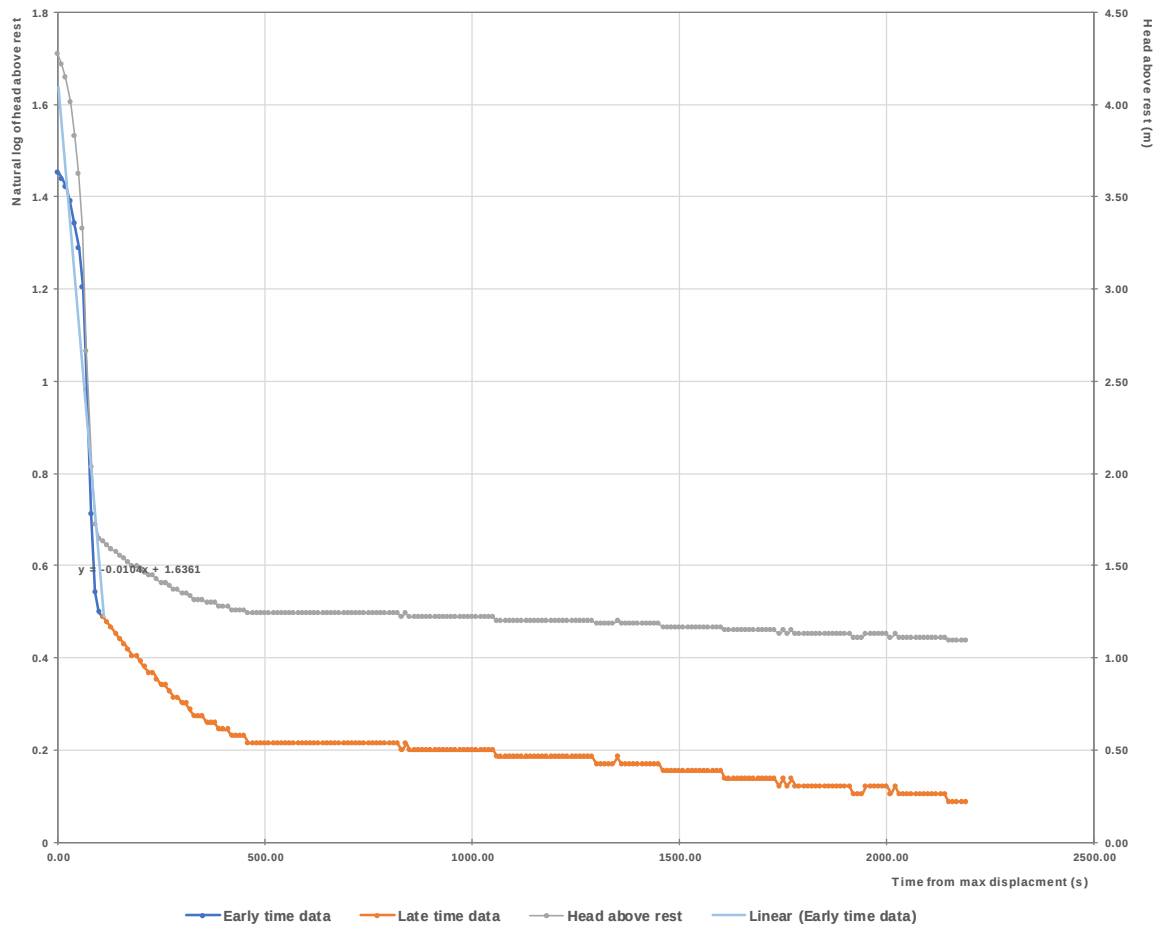
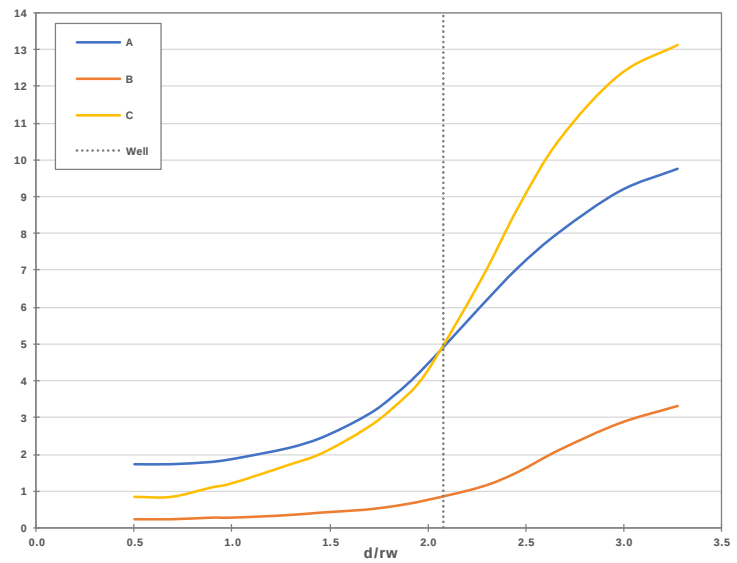
[illegible]

Assumes aquifer is unconfined, homogeneous etc.

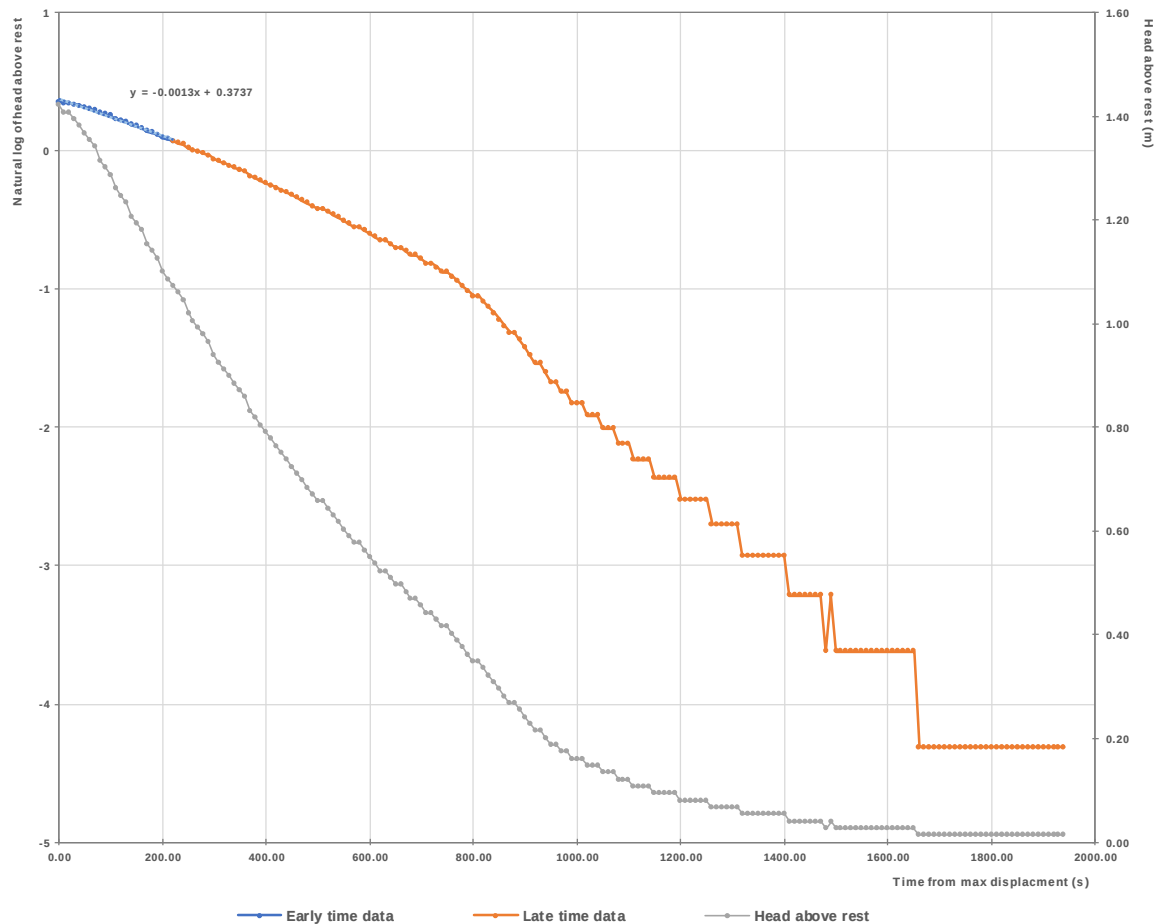
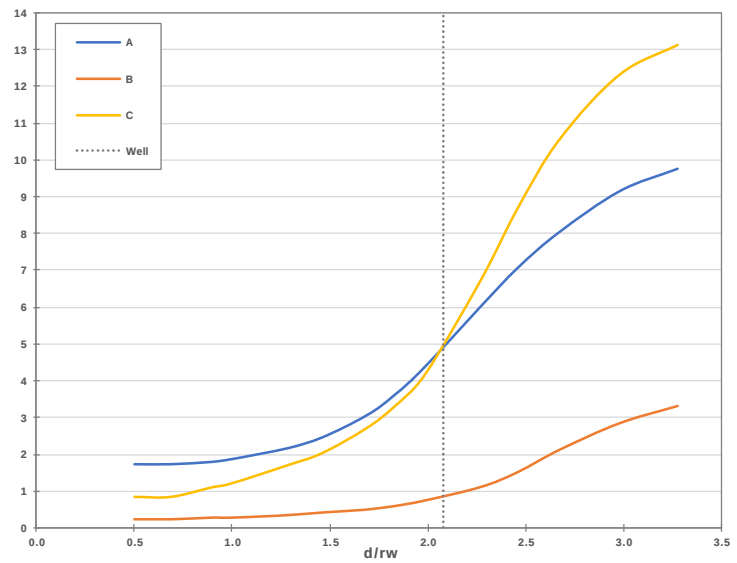
K (md ⁻¹)	=	0.0685
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Assumes aquifer is unconfined, homogeneous etc.

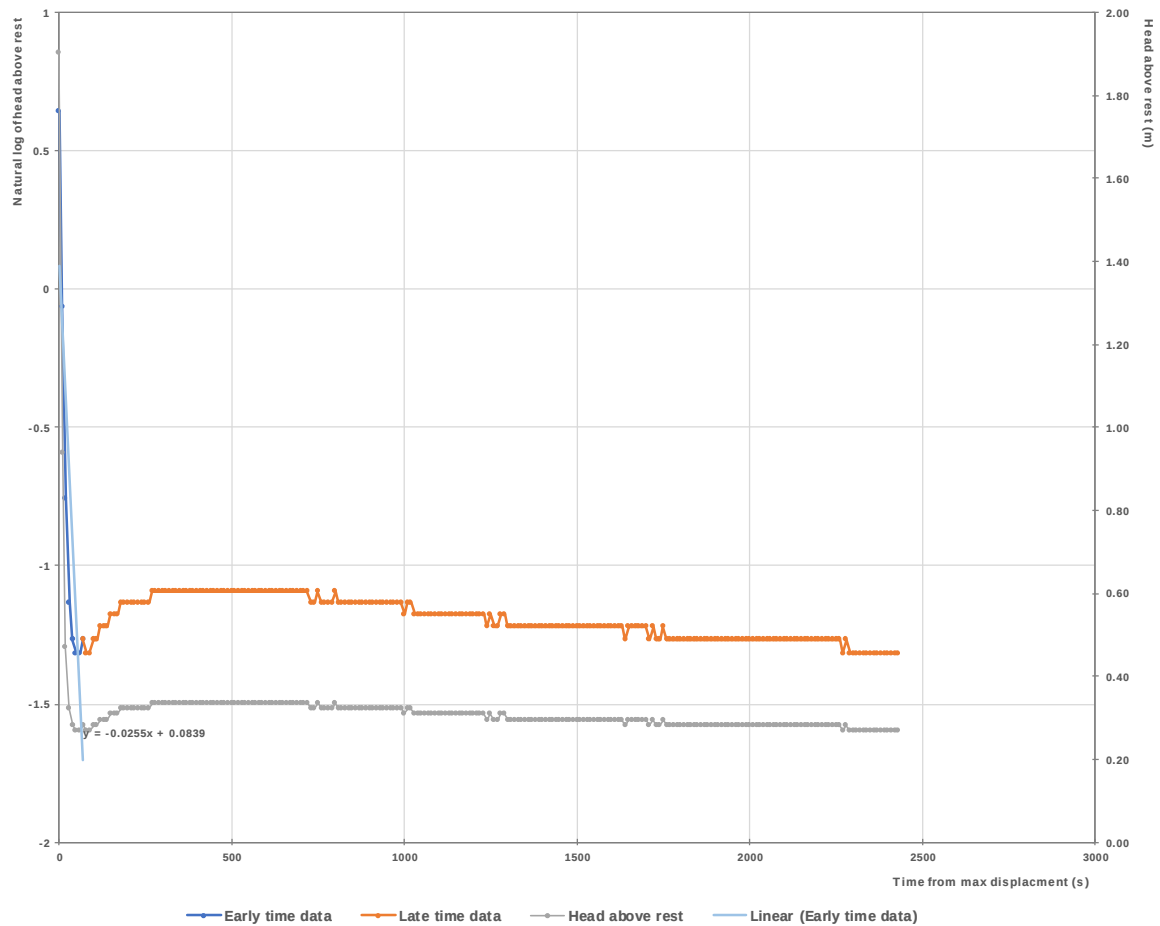
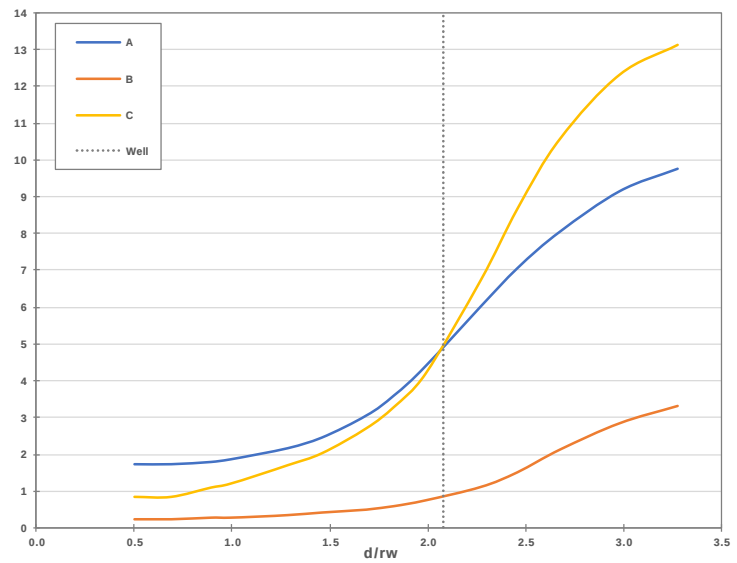


Assumes aquifer is unconfined, homogeneous etc.

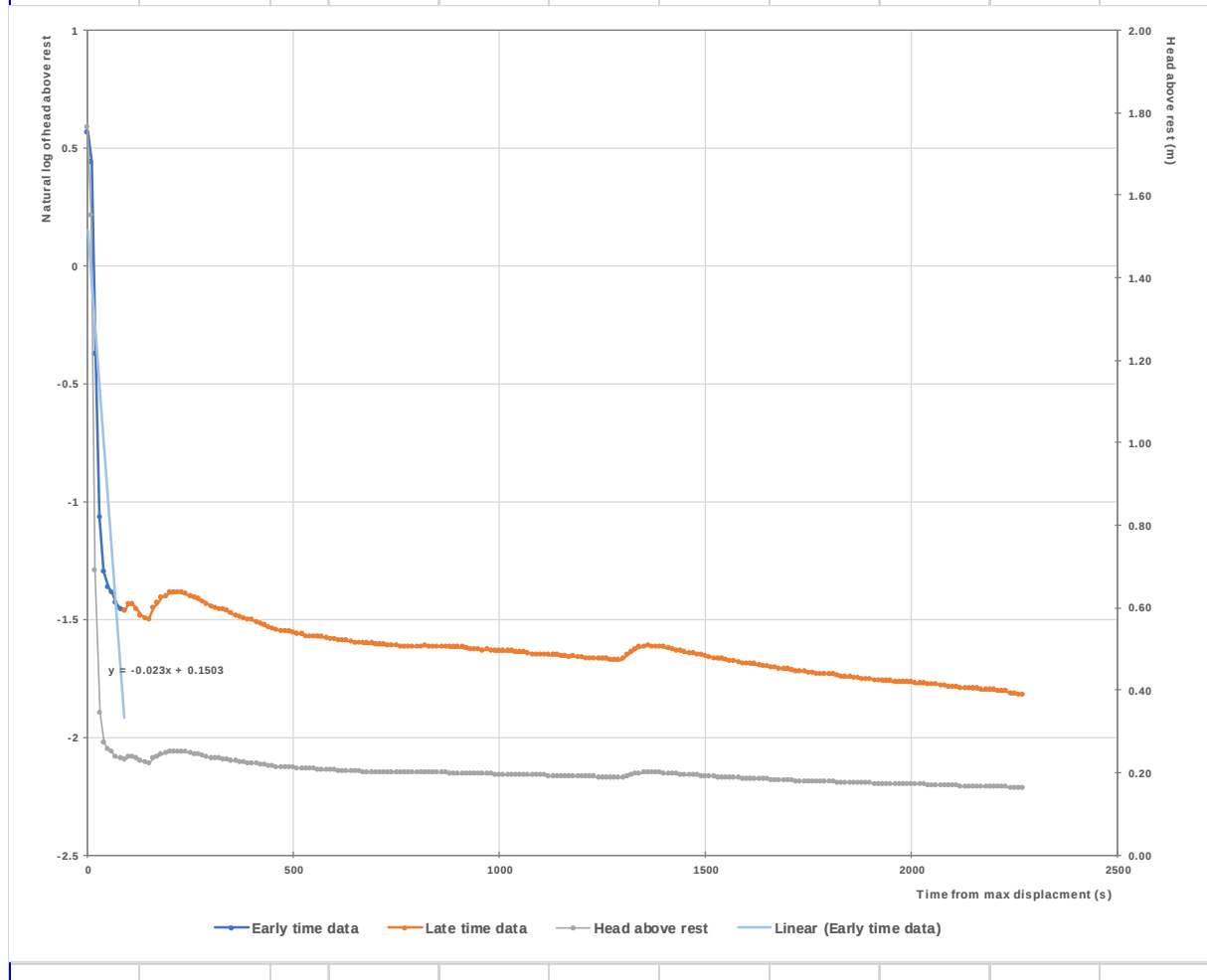
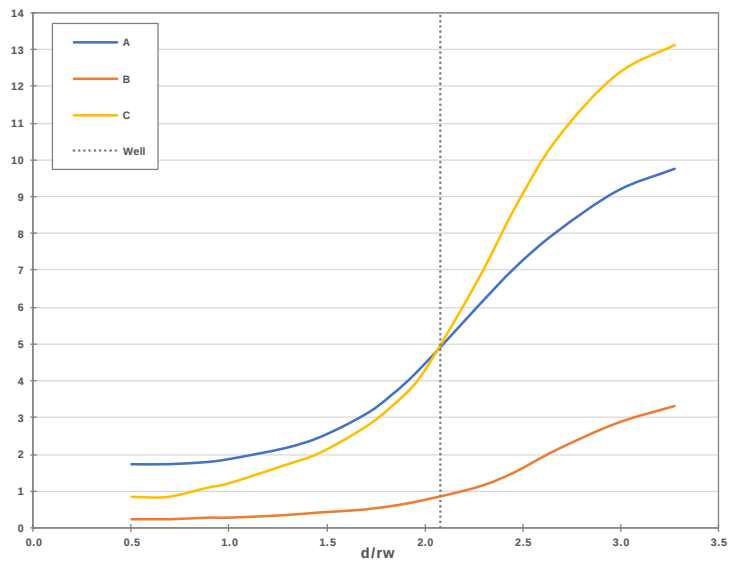


Assumes aquifer is unconfined, homogeneous etc.

K (md ⁻¹)	=	0.4013
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SWANWORTH QUARRY. QUARRY EXTENSION. PIEZOMETER PZ5/19.			
BOUWER-RICE ANALYSIS (PARTIALLY PENETRATING BOREHOLE)			
CALCULATION FOR HYDRAULIC CONDUCTIVITY (K) FROM SLUG TEST			
Assumes aquifer is unconfined, homogeneous etc.			
INPUTS			
Screen length (m); d	=	9.00	
Drilled radius (m); r_w	=	0.05	
Casing radius (m); r_c	=	0.03	
Base of deposit (mb collar)	=	41.55	
Base of piezometer (mb collar)	=	18.00	
Dip to water level (m)	=	7.27	
Graph gradient (s^{-1}); $(1/t)\ln(h_0/h_t)$ (linear approx. to early time data)	=	0.023	
A	=	4.924688329	
B	=	0.856526917	
(Published graph from d/r_w)			
Calculations			
D (m)	=	34.28	
b (m)	=	10.73	
d/r_w	=	180	
$\ln(Re/r_w)$	=	3.823571437	
K (ms^{-1})	=	3.05355E-06	
K (md^{-1})	=	0.2638	





Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 5 Swanworth Quarry – Water quality data

	Analyte:	Bicarbonate Alkalinity as CaCO3 w	Carbonate Alkalinity as CaCO3 w	Total Alkalinity as CaCO3 w	Total Acidity as CaCO3 w	Conductivity uS/cm @ 25C w	pH units w	Total Hardness as CaCO3	Total Organic Carbon w	Biochemical Oxygen Demand w	Chemical Oxygen Demand (Settle)	Meoprop	Ammonia (Free) as N calc a	GRO-HSA 0	Diesel Range Organics	TPH GC	TPHFD	Asenic as (Dissolved)	Cadmium as Cd (Dissolved)	Chromium as Cr (Dissolved)	Cobalt as Co (Dissolved)	Copper as Cu (Dissolved)	Lead as Pb (Dissolved)	Manganese as Mn (Dissolved)	Mercury as Hg (Dissolved)	Molybdenum as Mo (Dissolved)	Nickel as Ni (Dissolved)	Selenium as Se (Dissolved)	Vanadium as V (Dissolved)	Zinc as Zn (Dissolved)	Barium as Ba (Dissolved) a	Boron as B (Dissolved) a	Calcium as Ca (Dissolved) a	Iron as Fe (Dissolved) a	Magnesium as Mg (Dissolved) a	Phosphorus as P (Dissolved) a		
	Method Code:	WSLM12	WSLM12	WSLM12	WSLM17	WSLM2	WSLM3	Calc_HD	WSLM13	WSLM20	WSLM11	AHB	FNH3CALC	GROHSA	TPHFID	TPHFID	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	ICPMSW	
	Units:	mg/l	mg/l	mg/l	mg/l	uS/cm	pH units	mg/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Sample Desc	Date Sampled																																					
S1	15/02/2019	219		219	Nil	617	7.7	322	0.62	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.04	109	0.12	12	<0.1		
S2	15/02/2019	224		224	Nil	719	8.3	309	0.82	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	104	0.12	12	<0.1			
S3	15/02/2019	161		161	Nil	609	8.2	232	0.64	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.04	70	0.09	14	<0.1			
S4	15/02/2019	137		137	Nil	618	8	239	0.27	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	76	0.09	12	<0.1			
S5	15/02/2019	238		238	Nil	762	8	345	1.2	<1.0	7	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.002	0.03	0.06	105	0.12	20	<0.1				
S6	15/02/2019	212		212	Nil	697	8.2	293	1	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.04	91	0.11	16	<0.1			
S7	15/02/2019	209		209	Nil	721	8.2	310	3.6	<1.0	10	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.07	96	0.12	17	<0.1			
S8	15/02/2019	233		233	Nil	785	8.2	342	1.3	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.003	0.02	0.06	104	0.12	20	<0.1			
Pz2_19	15/02/2019	289		289	Nil	952	7.6	279	1.4	1.4	6	< 0.04	0.02	< 0.100	0.092	0.36	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.027	<0.0001	0.005	0.005	<0.001	<0.001	0.021	0.09	1	77	0.1	21	<0.1			
Pz3_19	15/02/2019	223		223	Nil	1600	8	638	4.7	4.8	20	< 0.02	0.07	< 0.100	0.104	0.213	<0.001	<0.0001	<0.001	0.004	<0.001	<0.001	0.114	<0.0001	0.064	0.022	<0.001	<0.001	0.019	0.16	2.97	112	0.11	87	<0.1			
Pz4_19	15/02/2019	222		222	Nil	607	7.8	257	1.3	1.1	12	< 0.02	0.02	< 0.100	0.024	0.063	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.05	<0.0001	0.008	0.005	0.002	<0.001	0.016	0.04	0.45	60	0.09	26	<0.1			
Pz5_19	15/02/2019	166		166	Nil	738	8	245	2.2	<2.0	10	< 0.02	0.04	< 0.100	0.071	0.095	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.02	<0.0001	0.019	0.004	0.002	<0.001	<0.002	0.05	0.64	47	0.07	31	<0.1			
PW1	15/02/2019	320		320	Nil	675	7.7	403	4.8	<1.0	16	< 0.02	<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	0.002	<0.001	0.003	<0.001	<0.002	<0.0001	<0.001	0.001	<0.001	<0.001	0.006	0.13	0.05	150	0.14	7	<0.1			
S1	01/03/2019	234		234	Nil	719	7.4	327					<0.01	< 0.100	1.95	2.73	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.0001	0.002	<0.001	<0.001	<0.001	<0.001	0.003	0.02	<0.01	111	0.17	12	<0.1	
S2	01/03/2019	234		234	Nil	707	7.8	319					<0.01	< 0.100	0.424	0.62	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	<0.01	108	0.15	12	<0.1	
S3	01/03/2019	165		165	Nil	551	7.8	202					<0.01	< 0.100	0.052	0.213	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.01	<0.01	61	0.12	12	<0.1	
S4	01/03/2019	144		144	Nil	598	7.5	228					<0.01	< 0.100	0.026	0.107	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.01	<0.01	73	0.12	11	<0.1	
S5	01/03/2019	248		248	Nil	878	7.6	386					<0.01	< 0.100	0.016	0.068	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.0001	<0.001	<0.001	<0.001	<0.001	0.003	0.02	<0.01	110	0.16	27	<0.1		
S6	01/03/2019														< 0.01	< 0.01																						
Pz1_19	01/03/2019	128		128	Nil	510	7.5	178					<0.01	< 0.100	1.67	7.57	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.053	<0.0001	0.015	0.002	<0.001	<0.001	<0.002	0.02	0.33	53	0.16	11	0.1		
Pz2_19	01/03/2019	281		281	Nil	834	7.4	316					<0.01	< 0.100	0.022	0.08	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	0.01	<0.0001	0.003	0.005	<0.001	<0.001	0.026	0.05	0.29	102	0.14	15	<0.1			
Pz3_19	01/03/2019	287		287	Nil	1560	7.6	737					0.03	< 0.100	0.066	0.162	<0.001	<0.0001	<0.001	0.004	0.003	<0.001	0.053	<0.0001	0.036	0.026	<0.001	<0.001	0.019	0.12	1.51	135	0.16	97	<0.1			
Pz4_19	01/03/2019	235		235	Nil	655	7.7	264					0.01	< 0.100	0.022	0.064	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	0.033	<0.0001	0.01	0.005	<0.001	<0.001	0.016	0.04	0.44	61	0.11	27	<0.1			
S1	18/03/2019	230		230	Nil	716	7.8	352					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.02	0.04	121	0.22	12	<0.1	
S2	18/03/2019	236		236	Nil	715	8	348					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.02	118	0.23	13	<0.1	
S3	18/03/2019	165		165	Nil	565	8	237					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	72	0.15	14	<0.1	
S4	18/03/2019	142		142	Nil	605	7.8	254					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01	0.03	82	0.18	12	<0.1	
S5	18/03/2019	241		241	Nil	859	7.8	392					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.02	0.06	114	0.24	26	<0.1	
S6	18/03/2019	224		224	Nil	694	7.9	319					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.082	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.02	0.03	103	0.21	15	0.1		
S7	18/03/2019	239		239	Nil	756	8.1	353					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.06	110	0.24	19	<0.1	
S8	18/03/2019	245		245	Nil	860	8	397					<0.01	< 0.100	< 0.010	< 0.010																						

Pz2 19	01/04/2019	265	0	265	Nil	799	7.4	375					<0.01	< 0.100	0.067	0.212	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.005	<0.0001	0.002	0.004	<0.001	<0.001	0.021	0.04	0.16	127	0.18	14	<0.1	
Pz3 19	01/04/2019	304	0	304	Nil	1230	7.3	610					<0.01	< 0.100	0.077	0.235	<0.001	<0.0001	<0.001	0.002	0.002	<0.001	0.03	<0.0001	0.013	0.018	<0.001	<0.001	0.015	0.06	0.72	129	0.18	70	<0.1	
Pz4 19	01/04/2019	263	0	263	Nil	749	7.5	332					<0.01	< 0.100	0.023	0.081	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.008	<0.0001	0.004	0.004	<0.001	<0.001	0.016	0.05	0.31	82	0.14	31	<0.1	
Pz5 19	01/04/2019	139	0	139	Nil	586	7.7	218					<0.01	< 0.100	0.024	0.067	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.002	<0.0001	0.01	0.003	<0.001	<0.001	0.01	0.05	0.32	51	0.1	22	<0.1	
S1	22/05/2019	250		250	Nil	733	7.8	366					<0.01	< 0.100	<0.01	0.012	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.02	0.02	125	0.16	13	<0.1
S2	22/05/2019	249		249	Nil	729	8	368					<0.01	< 0.100	<0.01	0.015	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.02	<0.01	126	0.16	13	<0.1
S3	22/05/2019	174		174	Nil	544	8	235					<0.01	< 0.100	<0.01	0.014	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	<0.01	71	0.12	14	<0.1
S4	22/05/2019	145		145	Nil	605	7.8	254					<0.01	< 0.100	<0.01	0.013	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.02	<0.01	82	0.14	12	<0.1
S5	22/05/2019	226		226	Nil	811	7.9	372					<0.01	< 0.100	<0.01	0.017	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	0.008	0.02	0.03	111	0.15	23	<0.1	
Pz1 19	22/05/2019	281		281	Nil	839	7.7	444					<0.01	< 0.100	0.09	0.498	0.002	<0.0001	<0.001	0.003	<0.001	<0.001	0.188	<0.0001	0.006	0.009	<0.001	<0.001	<0.002	0.07	0.19	143	0.19	21	<0.1	
Pz2 19	22/05/2019	281		281	Nil	759	7.6	414					<0.01	< 0.100	<0.01	0.021	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	0.001	<0.001	<0.001	0.008	0.02	0.02	146	0.18	12	<0.1	
Pz3 19	22/05/2019	301		301	Nil	1060	7.6	565					<0.01	< 0.100	0.03	0.056	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.018	<0.0001	0.006	0.012	<0.001	<0.001	0.016	0.08	0.35	129	0.17	59	<0.1	
Pz4 19	22/05/2019	275		275	Nil	747	7.9	343					0.01	< 0.100	0.02	0.043	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.031	<0.0001	0.004	0.004	<0.001	<0.001	0.016	0.05	0.33	83	0.12	33	<0.1	
Pz5 19	22/05/2019	142		142	Nil	577	7.9	225					<0.01	< 0.100	0.03	0.047	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.027	<0.0001	0.007	0.003	<0.001	<0.001	0.003	0.05	0.25	57	0.09	20	<0.1	
PW1	22/05/2019	333		333	Nil	817	7.6	467					<0.01	< 0.100	<0.01	< 0.010	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	<0.002	<0.0001	<0.001	0.001	<0.001	<0.001	0.018	0.15	<0.01	174	0.19	8	<0.1	
S1	24/06/2019	251		251	Nil	738	7.6	363	0.63	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.015	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.02	0.01	124	0.18	13	<0.1
S2	24/06/2019	255		255	Nil	731	8	366	0.95	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.023	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.02	125	0.18	13	<0.1
S3	24/06/2019	181		181	Nil	551	7.9	237	0.61	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.015	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	72	0.14	14	<0.1
S4	24/06/2019	146		146	Nil	614	7.6	249	0.45	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.02	0.01	80	0.16	12	<0.1
S5	24/06/2019	225		225	Nil	803	7.8	359	0.92	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.013	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.02	0.05	106	0.16	23	<0.1
S6	24/06/2019	221		221	Nil	694	7.7	314	0.68	<1.0	<5	< 0.02	<0.01	< 0.100	< 0.010	0.012	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.02	0.02	101	0.16	15	<0.1
S8	24/06/2019	233		233	Nil	831	7.8	367	0.96	<1.0	<5	< 0.02	<0.01	< 0.100	0.011	0.024	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.1	109	0.17	23	<0.1
Pz1 19	24/06/2019	288		288	Nil	861	7.5	447	2	<1.0	<5	< 0.02	<0.01	< 0.100	0.026	0.106	<0.001	<0.0001	<0.001	0.002	<0.001	<0.001	0.046	<0.0001	0.004	0.005	<0.001	<0.001	0.003	0.07	0.19	146	0.2	20	<0.1	
Pz2 19	24/06/2019	290		290	Nil	778	7.6	407	0.67	<1.0	<5	< 0.02	<0.01	< 0.100	0.016	0.052	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.03	0.02	145	0.21	11	<0.1
Pz3 19	24/06/2019	308		308	Nil	1110	7.6	571	1.5	<1.0	<5	< 0.02	<0.01	< 0.100	0.03	0.055	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.021	<0.0001	0.007	0.009	<0.001	<0.001	0.024	0.08	0.53	123	0.17	64	<0.1	
Pz4 19	24/06/2019	272		272	Nil	716	7.7	319	1.4	1.5	5	< 0.02	<0.01	< 0.100	0.012	0.028	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.017	<0.0001	0.004	0.004	<0.001	<0.001	0.022	0.08	0.35	75	0.14	32	<0.1	
Pz5 19	24/06/2019	102		102	Nil	403	7.8	171	1.3	<1.0	<5	< 0.02	<0.01	< 0.100	0.012	0.023	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	0.003	0.002	<0.001	<0.001	0.003	0.04	0.06	52	0.11	10	<0.1	
PW1	24/06/2019	333		333	Nil	818	7.4	435	3	<1.0	5	< 0.02	<0.01	< 0.100	< 0.010	0.019	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.15	0.03	161	0.22	8	<0.1
S2	30/07/2019	197		197	Nil	712	8.1	347					<0.01	< 0.100	< 0.010	0.021	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.02	0.03	119	0.76	12	<0.1
S3	30/07/2019	186		186	Nil	542	7.9	224					<0.01	< 0.100	< 0.010	< 0.010	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.04	70	0.63	12	<0.1
S4	30/07/2019	154		154	Nil	583	7.6	236					<0.01	< 0.100	< 0.010	0.014	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.02	0.02	78	0.65	10	<0.1
S5	30/07/2019	169		237	Nil	748	7.9	342					<0.01	< 0.100	0.12	0.16	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.02	0.05	109	0.73	17	<0.1
Pz1 19	30/07/2019	184		184	Nil	847	7.4	443					<0.01	< 0.100	0.047	0.251	0.001	<0.0001	<0.001	0.002	<0.001	<0.001	0.104	<0.0001	0.004	0.007	<0.001	<0.001	0.173	0.26	0.37	146	0.85	19	<0.1	
Pz2 19	30/07/2019	153		153	Nil	755	7.5	401					<0.01	< 0.100</																						

PW1	14/11/2019	357		357	Nil	789	7.3	438	6	<1.0	16	<0.02	<0.01	< 0.100	0.02	0.061	<0.001	<0.00002	<0.001	<0.001	0.002	<0.001	<0.002	<0.00003	<0.001	0.002	<0.001	<0.001	0.012	0.16	0.03	164	0.16	7	<0.1	
S2	07/06/2020	235	Nil	235	Nil	728	7.9	341					<0.01	<0.100		0.02	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	117	<0.01	12	<0.1	
S3	07/06/2020	154	Nil	154	Nil	536	7.9	216					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	67	<0.01	12	<0.1	
S4	07/06/2020	129	Nil	129	Nil	594	7.7	230					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	75	<0.01	11	<0.1	
S5	07/06/2020	207	Nil	207	Nil	808	7.9	344					<0.01	<0.100		0.02	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	0.001	<0.001	<0.001	0.012	0.02	0.05	106	<0.01	19	<0.1	
PZ1-19	07/06/2020	271	Nil	271	Nil	888	7.4	480					<0.01	<0.100		0.2	<0.001	<0.00002	<0.001	0.003	<0.001	<0.001	0.06	<0.00003	0.004	0.007	<0.001	<0.001	<0.002	0.07	0.11	159	<0.01	20	<0.1	
PZ2-19	07/06/2020	273	Nil	273	Nil	785	7.7	407					<0.01	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	0.001	<0.001	<0.001	0.013	0.03	0.03	145	<0.01	11	<0.1	
PZ3-19	07/06/2020	296	Nil	296	Nil	984	7.7	481					<0.01	<0.100		0.05	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	0.005	<0.001	<0.001	0.018	0.03	0.2	115	<0.01	47	<0.1	
PZ4-19	07/06/2020	291	Nil	291	Nil	949	7.8	308					0.02	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	<0.001	0.002	0.034	<0.00003	0.004	0.003	<0.001	<0.001	0.023	0.05	0.5	66	<0.01	35	<0.1	
S1	16/09/2020	261	Nil	261	Nil	745	7.7	350					<0.01	<0.100		<0.01	<0.001	0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	120	<0.01	12	<0.1	
S2	16/09/2020	253	5	263	Nil	736	8.1	357					<0.01	<0.100		0.01	<0.001	0.00007	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	123	<0.01	12	<0.1	
S3	16/09/2020	165	Nil	165	Nil	551	7.9	222					<0.01	<0.100		0.02	<0.001	0.00006	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.04	69	<0.01	12	<0.1	
PZ1-19	16/09/2020	308	Nil	308	Nil	993	7.4	<6.6					<0.01	<0.100		0.05	<0.001	0.00005	<0.001	0.002	<0.001	<0.001	0.035	<0.00003	0.004	0.009	<0.001	<0.001	0.219	<0.01	<0.01	<1	<0.01	<1	<0.1	
PZ2-19	16/09/2020	289	Nil	289	Nil	787	7.6	414					<0.01	<0.100		0.02	<0.001	0.00015	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	0.001	<0.001	<0.001	0.013	0.03	0.02	148	<0.01	11	<0.1	
PZ3-19	16/09/2020	300	Nil	300	Nil	960	7.6	444					<0.01	<0.100		0.04	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	0.002	<0.001	<0.001	0.011	0.04	0.36	94	<0.01	51	<0.1	
PZ4-19	16/09/2020	301	Nil	301	Nil	788	7.8	332					<0.01	<0.100		0.03	<0.001	0.0001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.003	0.004	<0.001	<0.001	0.019	0.06	0.38	75	<0.01	35	<0.1	
PZ5-19	16/09/2020	201	Nil	201	Nil	671	7.7	267					<0.01	<0.100		0.04	<0.001	0.00009	<0.001	<0.001	<0.001	<0.001	0.048	<0.00003	0.006	0.005	<0.001	<0.001	<0.002	0.05	0.49	55	<0.01	31	<0.1	
S1	03/11/2020	232	Nil	232	Nil	748	7.7	345	0.45	<1.0	7	<0.02	<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.02	118	<0.01	12	<0.1	
S2	03/11/2020	230	Nil	230	Nil	739	8	<6.6	1.5	1.2	6	<0.02	<0.01	<0.100		0.01	<0.001	0.00009	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<0.01	<0.01	<1	<0.01	<1	<0.1	
S3	03/11/2020	158	Nil	158	Nil	570	7.9	220	0.51	<1.0	<5	<0.02	<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	68	<0.01	12	<0.1	
Quarry Sump	03/11/2020	59.9	Nil	59.9	28	1500	7.5	913	1	<1.0	<5	<0.02	<0.01	<0.100		0.01	<0.001	0.00011	<0.001	<0.001	<0.001	<0.001	0.027	<0.00003	0.003	0.007	<0.001	<0.001	<0.002	0.05	0.02	284	<0.01	50	<0.1	
PZ1-19	03/11/2020	265	Nil	265	Nil	987	7.5	509	1.5	<1.0	6	<0.02	<0.01	<0.100		<0.01	<0.001	0.00006	<0.001	<0.001	<0.001	<0.001	0.007	<0.00003	0.003	0.005	<0.001	<0.001	<0.002	0.08	0.1	170	<0.01	20	<0.1	
PZ2-19	02/11/2020	272	Nil	272	Nil	772	7.6	384	0.4	2	<5	<0.02	<0.01	<0.100		0.02	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.009	0.03	0.02	137	<0.01	10	<0.1	
PZ3-19	02/11/2020	311	Nil	311	Nil	950	7.8	410	0.67	<1.3	<5	<0.02	<0.01	<0.100		<0.01	<0.001	0.00005	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.003	<0.001	<0.001	<0.001	0.005	0.06	0.54	81	<0.01	51	<0.1	
PZ4-29	02/11/2020	245	Nil	245	Nil	678	7.7	306	0.98	1	6	<0.02	<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	0.003	<0.001	<0.002	<0.00003	0.002	0.003	<0.001	<0.001	0.043	0.04	0.18	99	<0.01	14	<0.1	
PZ5-19	02/11/2020	149	Nil	149	Nil	538	7.8	189	0.94	<1.0	<5	<0.02	<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.002	<0.00003	0.005	0.003	<0.001	<0.001	<0.002	0.05	0.27	50	<0.01	16	<0.1	
PZ1-20	03/11/2020	234	Nil	234	Nil	999	7.7	415	2.6	1.1	17	<0.02	0.02	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.007	<0.00003	0.01	0.008	<0.001	<0.001	0.004	0.04	0.48	95	<0.01	43	<0.1	
PZ2-20	03/11/2020	203	Nil	203	Nil	792	7.9	216	1.1	<1.0	11	<0.02	0.03	<0.100		0.05	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.003	<0.00003	0.02	0.003	<0.001	<0.001	<0.002	0.03	0.98	42	<0.01	27	<0.1	
PZ3-20	03/11/2020	129	Nil	129	Nil	427	8.3	43.2	3.2	<1.3	14	<0.02	0.03	<0.100		0.06	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.003	<0.00003	0.008	0.001	<0.001	<0.001	0.008	0.08	0.65	10	<0.01	5	<0.1	
S1	24/11/2020	226	Nil	226	Nil	687	7.7	332					<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	114	<0.01	12	<0.1	
S2	24/11/2020	239	Nil	239	Nil	694	8.1	338					<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.003	0.02	0.03	116	<0.01	12	<0.1	
S3	24/11/2020	158	Nil	158	Nil	536	8	220					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	68	<0.01	12	<0.1	
Quarry Sump	24/11/2020	45.7	Nil	45.7	Nil	1400	7.4	878					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.006	<0.00003	0.004	0.005	<0.001	<0.001	<0.002	0.04	0.02	272	<0.01	49	<0.1	
PZ1-19	24/11/2020	260	Nil	260	Nil	962	7.5	511					<0.01	<0.100		0.01	<0.001	0.00002	<0.001	<0.001	<0.001	<0.001	0.009	<0.00003	0.004	0.004	<0.001	<								

PZ2-19	17/12/2020	262	Nil	262	Nil	748	7.5	418					<0.01	<0.100		0.02	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.004	<0.00003	<0.001	0.001	<0.001	<0.001	0.024	0.04	0.04	149	0.01	11	<0.1	
PZ3-19	17/12/2020	314	Nil	314	Nil	929	7.6	449					<0.01	<0.100		0.02	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.003	<0.00003	0.002	<0.001	<0.001	<0.001	0.007	0.06	0.63	87	<0.01	57	<0.1	
PZ4-19	17/12/2020	287	Nil	287	Nil	726	7.6	338					<0.01	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	0.001	<0.001	0.003	<0.00003	0.002	0.003	<0.001	<0.001	0.11	0.05	0.4	84	<0.01	31	<0.1	
PZ5-19	17/12/2020	94.7	Nil	94.7	Nil	364	7.6	149					<0.01	<0.100		0.06	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.004	0.001	<0.001	<0.001	0.003	0.05	0.11	44	<0.01	10	<0.1	
PZ1-20	17/12/2020	236	Nil	236	Nil	967	7.6	449					0.01	<0.100		0.06	<0.001	<0.00002	<0.001	<0.001	0.001	<0.001	0.004	<0.00003	0.008	0.008	<0.001	<0.001	0.016	0.04	0.49	106	<0.01	45	<0.1	
PZ2-20	17/12/2020	125	Nil	125	Nil	644	7.7	261					<0.01	<0.100		0.03	<0.001	<0.00002	0.002	<0.001	<0.001	<0.001	<0.002	<0.00003	0.005	0.004	<0.001	<0.001	0.007	0.04	0.24	77	<0.01	17	<0.1	
PZ3-20	17/12/2020	98.6	Nil	98.6	Nil	447	7.8	103					<0.01	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.006	0.002	<0.001	<0.001	0.008	0.02	0.45	28	<0.01	8	<0.1	
S1	18/01/2021	228	Nil	228	Nil	714	7.8	355					<0.01	<0.100		0.01	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.02	123	<0.01	11	<0.1	
S2	18/01/2021	225	Nil	225	Nil	705	8.2	351					<0.01	<0.100		0.01	<0.001	0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.02	121	<0.01	12	<0.1	
S3	18/01/2021	153	Nil	153	Nil	537	7.9	233					<0.01	<0.100		0.01	<0.001	0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	69	<0.01	13	<0.1	
Quarry Sump	18/01/2021	48.6	Nil	48.6	Nil	1290	7.3	825					<0.01	<0.100		0.02	<0.001	0.00006	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	0.003	<0.001	<0.001	0.002	0.03	0.01	251	<0.01	48	<0.1	
Pz1-19	18/01/2021	297	Nil	297	Nil	909	7.6	505					<0.01	<0.100		0.01	<0.001	0.00005	<0.001	<0.001	<0.001	<0.001	0.012	<0.00003	0.002	0.005	<0.001	<0.001	0.01	0.07	0.08	173	0.01	18	<0.1	
Pz2-19	18/01/2021	263	Nil	263	Nil	771	7.8	410					<0.01	<0.100		0.02	<0.001	0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.016	0.02	0.02	147	0.01	10	<0.1	
Pz3-19	18/01/2021	317	Nil	317	Nil	944	7.9	432					0.01	<0.100		0.03	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.012	<0.00003	0.002	0.001	<0.001	<0.001	0.013	0.05	0.56	86	<0.01	53	<0.1	
Pz4-19	18/01/2021	288	Nil	288	Nil	751	7.9	331					<0.01	<0.100		0.03	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	0.053	<0.00003	0.002	0.003	<0.001	<0.001	0.015	0.05	0.47	76	<0.01	34	<0.1	
Pz5-19	18/01/2021	88.9	Nil	88.9	Nil	339	7.5	124					<0.01	<0.100		0.02	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	<0.001	<0.001	<0.001	0.004	0.04	0.04	42	<0.01	5	<0.1	
Pz1-20	18/01/2021	194	Nil	194	Nil	727	7.8	347					<0.01	<0.100		0.04	<0.001	0.00002	<0.001	<0.001	0.004	<0.001	<0.002	<0.00003	0.002	0.006	<0.001	<0.001	0.014	0.03	0.1	111	<0.01	17	<0.1	
Pz2-20	18/01/2021	103	Nil	103	Nil	556	7.6	232					<0.01	<0.100		0.04	<0.001	0.00003	0.002	<0.001	0.001	<0.001	<0.002	<0.00003	0.001	0.002	<0.001	<0.001	0.011	0.04	0.06	77	<0.01	10	<0.1	
Pz3-20	18/01/2021	109	Nil	109	Nil	511	7.8	75.9					0.01	<0.100		0.03	0.001	0.00003	<0.001	<0.001	<0.001	<0.001	0.003	<0.00003	0.006	0.001	<0.001	<0.001	0.003	0.01	0.59	18	<0.01	7	<0.1	
S1	19/04/2021	208	10.8	230	Nil	717	7.8	346	0.47	<1.0	<5	<0.02	<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	120	<0.01	11	<0.1	
S2	19/04/2021	201	Nil	201	Nil	676	7.9	292					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.02	0.03	98	<0.01	12	<0.1	
S3	19/04/2021	145	5.1	155	Nil	519	7.8	210					<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	0.01	0.03	65	<0.01	12	<0.1	
PZ1-19	19/04/2021	529	Nil	529	Nil	874	7.6	455	0.95	<2.0	<5	<0.02	<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	0.008	<0.00003	0.003	0.005	<0.001	<0.001	<0.002	0.07	0.09	152	<0.01	19	<0.1	
PZ2-19	19/04/2021	296	Nil	296	Nil	771	7.8	405	0.53	1.3	<5	<0.02	<0.01	<0.100		0.04	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.016	0.02	0.02	146	<0.01	10	<0.1	
PZ3-19	19/04/2021	344	Nil	344	Nil	940	8	389	1.4	1.3	5	<0.02	0.03	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	<0.001	<0.001	<0.001	0.003	0.05	0.61	72	<0.01	51	<0.1	
PZ4-19	19/04/2021	296	Nil	296	Nil	753	8	304	1	1.3	6	<0.02	<0.01	<0.100		0.07	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.002	0.002	0.001	<0.001	0.01	0.05	0.45	69	<0.01	32	<0.1	
PZ5-19	19/04/2021	174	Nil	174	Nil	489	7.8	175	0.93	1	<5	<0.02	<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.003	0.001	<0.001	<0.001	0.012	0.05	0.27	45	<0.01	15	<0.1	
PZ1-20	19/04/2021	189	Nil	189	Nil	815	7.8	387					<0.01	<0.100		0.01	<0.001	<0.00002	<0.001	<0.001	0.003	<0.001	<0.002	<0.00003	0.002	0.005	<0.001	<0.001	0.04	0.04	0.08	126	<0.01	18	<0.1	
PZ2-20	19/04/2021	115	Nil	115	Nil	575	7.7	241					<0.01	<0.100		0.03	<0.001	<0.00002	0.002	<0.001	0.002	<0.001	<0.002	<0.00003	0.002	0.002	<0.001	<0.001	0.027	0.04	0.06	80	<0.01	10	<0.1	
PZ3-20	19/04/2021	122	Nil	122	Nil	556	7.8	76					<0.01	<0.100		0.01	0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	0.006	<0.001	<0.001	<0.001	0.006	0.01	0.6	17	<0.01	8	<0.1	
S1	19/07/2021	235	Nil	235	Nil	717	7.6	352	0.45	<1.0	<5	<0.02	<0.01	<0.100		<0.01	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.01	0.02	0.03	121	<0.01	12	<0.1	
S2	19/07/2021	215	8.7	232	Nil	715	8	311					<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.018	0.02	0.03	105	<0.01	12	<0.1	
S3	19/07/2021	158	2.7	164	Nil	537	7.8	214	0.5	1	<5	<0.02	<0.01	<0.100		<0.01	<0.001	0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.006	0.01	0.04	66	<0.01	12	<0.1	
S4	19/07/2021	128	Nil	128	Nil	588	7.6	226					<0.01	<0.100		<0.01	<0.001	<0.00002	<0.001	<0.001	<0.001	<0.001	<0.002	<0.00003	<0.001	<0.001	<0.001	<0.001	0.002	0.01	0.03	74	<0.01	10	<0.1	
S5	19/07/2021	213	Nil	213	Nil	802	7.6	336					<0.01	<0.100		<0.01	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.002	<												

	Analyte:	Potassium as K (Dissolved) a	Sodium as Na (Dissolved) a	Total Sulphur as SO4 (Dissolved) a	Fluoride as F a	Ammoniacal Nitrogen as N	Chloride as Cl w	Nitrate as N	Nitrite as N	Phosphate as P	PCB101	PCB118	PCB138	PCB153	PCB180	PCB208	PCB52	Phenol Index as C6H5OH	1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane	1,2-Dibromooethane	1,2-Dibromobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane			
	Method Code: Units:	ICPWATVA R	ICPWATVA R	ICPWATVA R	ISE F	KONEN S	KONEN S	KONEN S	KONEN S	KONEN S	PCBCONE C	PCBCONE C	PCBCONE C	PCBCONE C	PCBCONE C	PCBCONE C	PCBCONE C	SFA PI	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	
	Date Sampled	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
S1	15/02/2019	<1	26	28	0.1	0.03	50	9.9	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S2	15/02/2019	<1	27	29	0.1	0.04	52	8.3	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S3	15/02/2019	2	32	34	<0.1	0.03	57	3.9	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S4	15/02/2019	1	31	27	<0.1	0.02	56	13.5	<0.01	0.06	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S5	15/02/2019	2	35	50	0.2	0.04	67	7.6	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S6	15/02/2019	3	32	34	0.1	0.03	60	6.9	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S7	15/02/2019	1	34	58	0.2	0.04	64	1.7	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S8	15/02/2019	2	36	52	0.2	0.03	68	7.2	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pz2_19	15/02/2019	5	110	26	0.5	1	107	8.8	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pz3_19	15/02/2019	8	124	597	1.6	1.9	67	<0.2	2.59	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pz4_19	15/02/2019	6	34	44	0.6	0.7	34	3	0.57	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pz5_19	15/02/2019	4	63	168	1	0.9	30	<0.2	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PW1	15/02/2019	2	18	32	0.2	0.02	27	3.6	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
S1	01/03/2019	<1	24	27		<0.01	48	11.5	<0.01	<0.01																														
S2	01/03/2019	<1	25	27		0.02	49	10.7	<0.01	0.02																														
S3	01/03/2019	2	26	27		<0.01	51	4.3	<0.01	0.03																														
S4	01/03/2019	1	29	26		<0.01	55	13.8	<0.01	0.06																														
S5	01/03/2019	2	41	80		0.01	77	6.2	<0.01	0.02																														
S6	01/03/2019																			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0		
Pz1_19	01/03/2019	3	32	59		0.2	48	<0.2	<0.01	<0.01																														
Pz2_19	01/03/2019	2	42	25		0.3	63	11.3	<0.01	<0.01																														
Pz3_19	01/03/2019	7	82	524		1.7	44	1.4	1.03	<0.01																														
Pz4_19	01/03/2019	6	33	42		0.6	34	4.8	0.51	<0.01																														
S1	18/03/2019	1	27	29		0.02	51	10.6	<0.01	0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S2	18/03/2019	1	27	29		0.02	53	9.9	<0.01	0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S3	18/03/2019	3	31	30		0.01	55	4	<0.01	0.02									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S4	18/03/2019	2	31	28		<0.01	56	13.7	<0.01	0.05									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S5	18/03/2019	2	42	72		0.02	77	6.3	<0.01	0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S6	18/03/2019	3	32	32		0.05	59	5.9	<0.01	0.05									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
S7	18/03/2019																		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0		
S8	18/03/2019	1	36	63		0.03	66	1.6	<0.01	<0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
Pz1_19	18/03/2019	2	42	74		0.04	76	6.1	<0.01	0.02									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	
Pz2_19	18/03/2019	5	28	71		0.18	51	<0.2	<0.01	<0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2	<1.0	<5.0	5	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	1		
Pz3_19	18/03/2019	2	33	27		0.1	53	11	0.04	<0.01									<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0		
Pz4_19	18/03/2019	6	69	440		1.2	42	1.9	1	&																														

[illegible]

[illegible]

	Analyte :	1,4-Dichlorobenzene	2- Chlorotoluene	2,2-Dichloropropane	4-Chlorotoluene	Benzene	Bromobenzene	Bromochloromethane	Bromodichloromethane	Bromoform	Bromomethane	Carbon Tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	os 1,3-Dichloropropene	Cis-1,2-dichloroethene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane	Ethylbenzene	Hexachlorobutadiene	Isopropylbenzene	m and p-Xylene	Naphthalene	n-Butylbenzene	o-Xylene	pIsopropyltoluene	Propylbenzene	sec-Butylbenzene	Styrene	
	Method Code:	VOCHSA W	VOCHSA W	VOCHSAW	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSAW	VOCHSAW	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSAW	VOCHSA W	VOCHSAW	VOCHSAW	VOCHSAW	VOCHSA W	VOCHSAW	VOCHSAW	VOCHSAW	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSA W	VOCHSAW	VOCHSA W	VOCHSA W	VOCHSA W
	Units:	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Sampl e Desc	Date Sampled																																
S1	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S2	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S3	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S4	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S5	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S6	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S7	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S8	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz2_1 9	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz3_1 9	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz4_1 9	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz5_1 9	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
PW1	15/02/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S1	01/03/2019																																
S2	01/03/2019																																
S3	01/03/2019																																
S4	01/03/2019																																
S5	01/03/2019																																
S6	01/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0		
Pz1_1 9	01/03/2019																																
Pz2_1 9	01/03/2019																																
Pz3_1 9	01/03/2019																																
Pz4_1 9	01/03/2019																																
S1	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S2	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S3	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S4	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S5	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S6	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S7	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S8	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz1_1 9	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz2_1 9	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz3_1 9	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz4_1 9	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Pz5_1 9	18/03/2019	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
S1	01/04/2019																																
S2	01/04/2019																																
S3	01/04/2019																																
S4	01/04/2019																																
S5	01/04/2019																																
Pz1_1 9	01/04/2019																																

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S2	07/06/2020																														
S3	07/06/2020																														
S4	07/06/2020																														
S5	07/06/2020																														
P21-19	07/06/2020																														
P22-19	07/06/2020																														
P23-19	07/06/2020																														
P24-19	07/06/2020																														
S1	16/09/2020																														
S2	16/09/2020																														
S3	16/09/2020																														
P21-19	16/09/2020																														
P22-19	16/09/2020																														
P23-19	16/09/2020																														
P24-19	16/09/2020																														
P25-19	16/09/2020																														
S1	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
S2	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
S3	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
Quarry Sump	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P21-19	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P22-19	02/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P23-19	02/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P24-29	02/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P25-19	02/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	1	<5	<1	<1	<5	<5	<1	<5	<1	2	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P21-20	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P22-20	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
P23-20	03/11/2020	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<1	<1	<5	<5	<1	<5	<1	<1	<1	<1	<1	<5	<1	<1	<5	<1	<1	<1	<1	<1
S1	24/11/2020																														
S2	24/11/2020																														
S3	24/11/2020																														
Quarry Sump	24/11/2020																														
P21-19	24/11/2020																														
P22-19	24/11/2020																														
P23-19	24/11/2020																														
P24-29	24/11/2020																														
P25-19	24/11/2020																														
P21-20	24/11/2020																														
P22-20	24/11/2020																														
P23-20	24/11/2020																														
S1	17/12/2020																														
S2	17/12/2020																														
S3	17/12/2020																														
S6	17/12/2020																														
Quarry Sump	17/12/2020																														
P21-19	17/12/2020																														
P22-19	17/12/2020																														
P23-19	17/12/2020																														

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PZ2-19	17/12/2020										<0.01	<0.01	<0.01	<0.01	0.02	0.01	<0.01		
PZ3-19	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01		
PZ4-19	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01		
PZ5-19	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01		
PZ1-20	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.01	<0.01	
PZ2-20	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.02	<0.01	
PZ3-20	17/12/2020										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	
											<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	
S1	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	
S2	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	
S3	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	
Quarry Sump	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	
Pz1-19	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Pz2-19	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Pz3-19	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02	
Pz4-19	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	
Pz5-19	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	
Pz1-20	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	
Pz2-20	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	
Pz3-20	18/01/2021										<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.02	<0.01	
											<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.01	
S1	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<1
S2	19/04/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
S3	19/04/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	
PZ1-19	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1
PZ2-19	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.01	<1
PZ3-19	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.03	<1
PZ4-19	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	<0.01	<1
PZ5-19	19/04/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1
PZ1-20	19/04/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1
PZ2-20	19/04/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
PZ3-20	19/04/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	
										<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
S1	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<1
S2	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	
S3	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<1
S4	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	
S5	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
S6	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
SUMP	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	
PZ1-19	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<1
PZ2-19	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02	<1
PZ3-19	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.07	<1
PZ4-19	19/07/2021	<1	<5	<1	<1	<1	<5	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.17	<1
PZ5-19	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	
PZ1-20	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
PZ2-20	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	
PZ3-20	19/07/2021									<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.01	



Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 6 Source Protection Zone calculations

Manual for the production of Groundwater Source Protection Zones, Environment Agency. March 2019.

The Schedule 5 Notice issued in regard to the planning application for Swanworth requires that detail on the flow paths and velocity to the licensed spring valley outfalls in Hill Bottom (Quarry Combe) is provided. The licenced abstractions comprise the three locations L1a to L1c (*figure 12*), which feed to a collection chamber at L1c, for piped transfer to Westhill Combe.

The aforementioned velocity calculations are assessed using the methodology detailed in EA document: “Manual for the production of Groundwater Source Protection Zones, Environment Agency. March 2019”. The methodology for defining Source Protection Zones for a spring source is summarised at appendix C of the document, details of which are provided below.

Source Protection Zones are normally defined by travel time to the point of abstraction, SPZ1 being the 50-day travel time and SPZ2 being the 400-day travel time. For a spring catchment the travel time distances can be calculated using the velocity equation derived from Darcy's Law:

$$d = \frac{Kit}{ne}$$

where:

d = up-gradient distance from source for a particular time-of-travel

K = hydraulic conductivity

i = hydraulic gradient

t = time-of travel

ne = effective (kinematic) porosity

Using the highest permeability value derived from field testing (some 0.4m/d), the piezometric gradient recorded within the upstream aquifer (0.019 – section 2.7.5) and the minimum porosity for the Portland Sand aquifer (0.033 – table 9) the above calculations suggest the 50-day travel radius would extend some 12m from the spring, whilst the 400-day travel radius would extend 92m from the spring.

Taking into account the geological setting and configuration of spring emergence in the valley flank i.e., aquifer only present to the north/northwest of the spring, it is considered appropriate to focus the defined source protection zone in this direction i.e., apply the 50-day radius to 24m up gradient and the 400-day radius to 184m up gradient.

The closest spring to the infill area is L1a, which is located in the northeastern section of Quarry Combe. This is situated some 400m from the closest section of infill (the narrow neck connecting the existing Site to the Northern Extension) and more than 550m from the main area of infill to the north. On this basis it is clear that the infill area would reside outside any SPZ1/SPZ2 areas defined on the foregoing basis.



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**Appendix 7 Statistical analysis of background water quality
data**

Chloride

D'Agostino's Test for Normal / Log-Normal Distribution

From: "Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final Technical Report P1-471, 2002.

Chloride

PZ2-19

Concentrations <LOD excluded

Statistical test below suggests first four samples can be regarded as outlier data. Excluding data from first 4-no. sample rounds yields conformance with both Normal & Log-Normal Test

Baseline Data (mg/l)

Date	PZ1-19	PZ2-19	PZ3-19	PZ4-19	PZ5-19
15/02/2019		107	67	34	30
01/03/2019	48	63	44	34	33
18/03/2019	51	53	42	34	33
01/04/2019	54	51	42	33	32
22/05/2019	56	44	43	34	38
24/06/2019	58	43	44	34	28
30/07/2019	56	43	46	33	
14/11/2019	54	42	46	33	28
07/06/2020	60	42	47	78	
16/09/2020	59	42	46	37	36
02/11/2020	56	41	45	29	27
24/11/2020	57	41	44	30	29
17/12/2020	55	41	45	33	24
18/01/2021	61	43	48	35	38
19/04/2021	58	39	44	33	24
19/07/2021	59	40	43	39	22

Chloride Concentration (mg/l)

Natural Logs of Baseline Data

Date	PZ1-19	PZ2-19	PZ3-19	PZ4-19	PZ5-19
15/02/2019		4.673	4.205	3.526	3.401
01/03/2019	3.871	4.143	3.784	3.526	
18/03/2019	3.932	3.970	3.738	3.526	3.497
01/04/2019	3.989	3.932	3.738	3.497	3.466
22/05/2019	4.025	3.784	3.761	3.526	3.638
24/06/2019	4.060	3.761	3.784	3.526	3.332
30/07/2019	4.025	3.761	3.829	3.497	
14/11/2019	3.989	3.738	3.829	3.497	3.332
07/06/2020	4.094	3.738	3.850	4.357	
16/09/2020	4.078	3.738	3.829	3.611	3.584
02/11/2020	4.025	3.714	3.807	3.367	3.296
24/11/2020	4.043	3.714	3.784	3.401	3.367
17/12/2020	4.007	3.714	3.807	3.497	3.178
18/01/2021	4.111	3.761	3.871	3.555	3.638
19/04/2021	4.060	3.664	3.784	3.497	3.178
19/07/2021	4.078	3.689	3.761	3.664	3.091

D'Agostino's Test for Normal Distribution

Count [x]	Sorted Data [A]	x-(n+1)/2 [B]	Product of A & B
1	39	-5.5	-214.5
2	40	-4.5	-180
3	41	-3.5	-143.5
4	41	-2.5	-102.5
5	41	-1.5	-61.5
6	42	-0.5	-21
7	42	0.5	21
8	42	1.5	63
9	43	2.5	107.5
10	43	3.5	150.5
11	43	4.5	193.5
12	44	5.5	242

NORMALITY DISTRIBUTION TEST

n	12
Mean	41.75
Standard Deviation	1.42
T	54.50
D	0.266
Y	-1.847
Y 1% value	-4.04
Y 99% value	0.45
Y in range? (& therefore Data is Normally	Yes
Parameter level and percentile (assuming normal distribution)	
μ + 2σ	45 mg/l
Percentile	97.725%
μ + 3σ	46 mg/l
Percentile	99.865%

LOG-NORMALITY DISTRIBUTION TEST

n	12
Mean	3.73
Standard Deviation	0.03
T	1.31
D	0.265
Y	-1.919
Y 1% value	-4.04
Y 99% value	0.45
Y in range? (& therefore Data is Log Normally	Yes
Parameter level and percentile (assuming log-normal distribution)	
μ + 2σ	45 mg/l
Percentile	97.725%
μ + 3σ	46 mg/l
Percentile	99.865%

D'Agostino's Test for Log-Normal Distribution

Count [x]	Sorted Data [A]	x-(n+1)/2 [B]	Product of A & B
1	3.664	-6	-20.1
2	3.689	-5	-16.6
3	3.714	-4	-13.0
4	3.714	-3	-9.3
5	3.714	-2	-5.6
6	3.738	-1	-1.9
7	3.738	1	1.9
8	3.738	2	5.6
9	3.761	3	9.4
10	3.761	4	13.2
11	3.761	5	16.9
12	3.784	6	20.8

Outlier test (as detailed in Annex A of "Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final technical report P1-471, 2002.

Reduced dataset - removing first three values

Mean	42.4615385	Std Dev	2.9044616
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Standardised data

Standardised data	Number	Reordered data
2.940	1	-1.192
0.530	2	-0.848
0.185	3	-0.503
0.185	4	-0.503
-0.159	5	-0.503
-0.159	6	-0.159
-0.159	7	-0.159
-0.503	8	-0.159
-0.503	9	0.185
-0.503	10	0.185
0.185	11	0.185
-1.192	12	0.530
-0.848	13	2.940

This and three earlier data points identified as outliers (Normal and L-Normal datasets): >Critical Value for Normal distribution (probability less than 1 in 100)

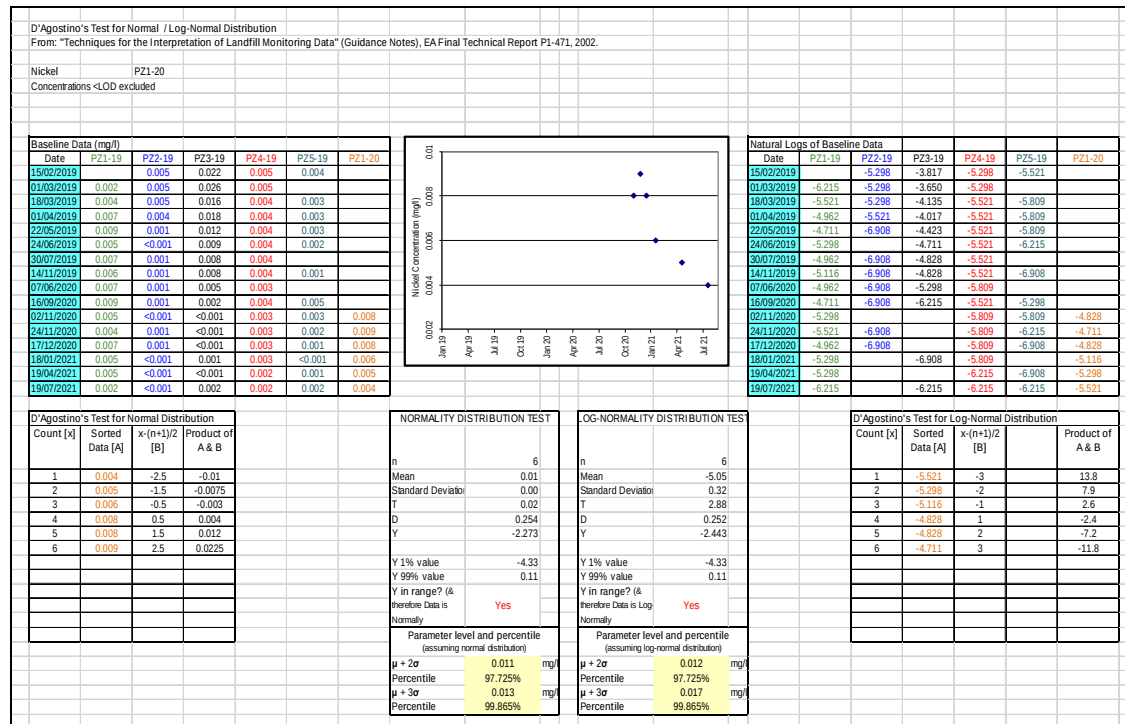
Reduced dataset - removing first three values

Mean	3.747	Std Dev	0.064614126
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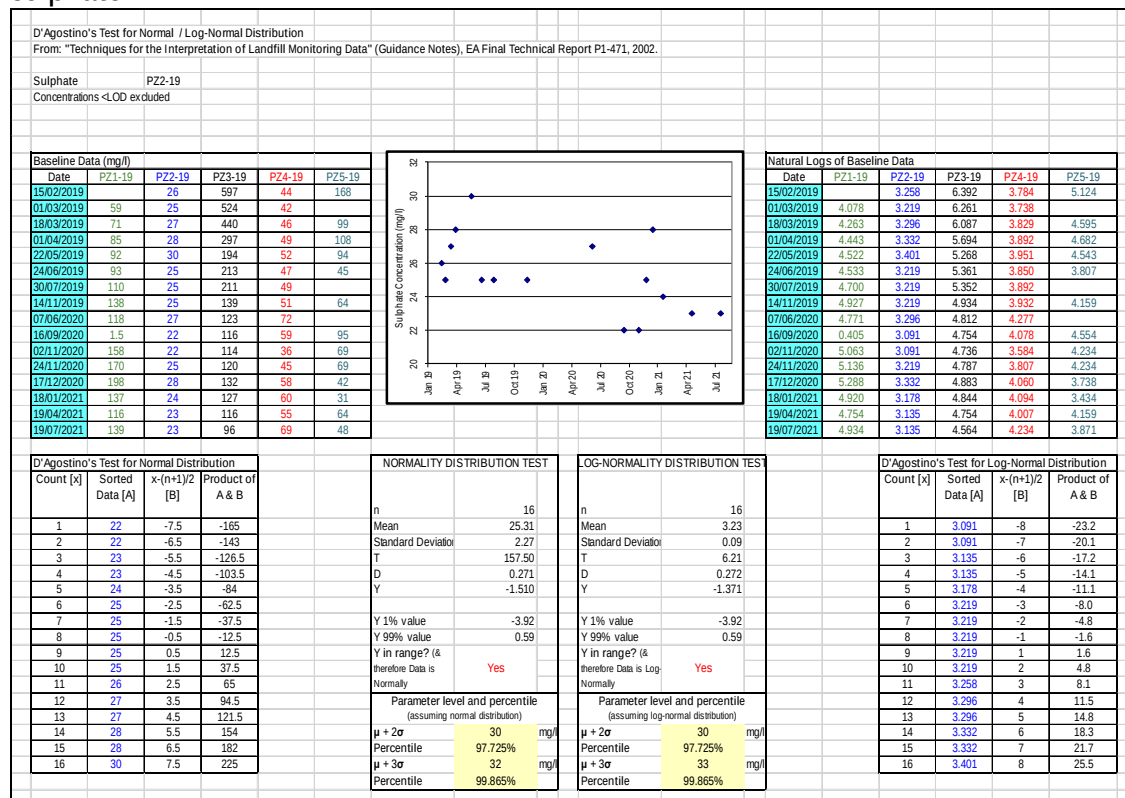
Standardised data

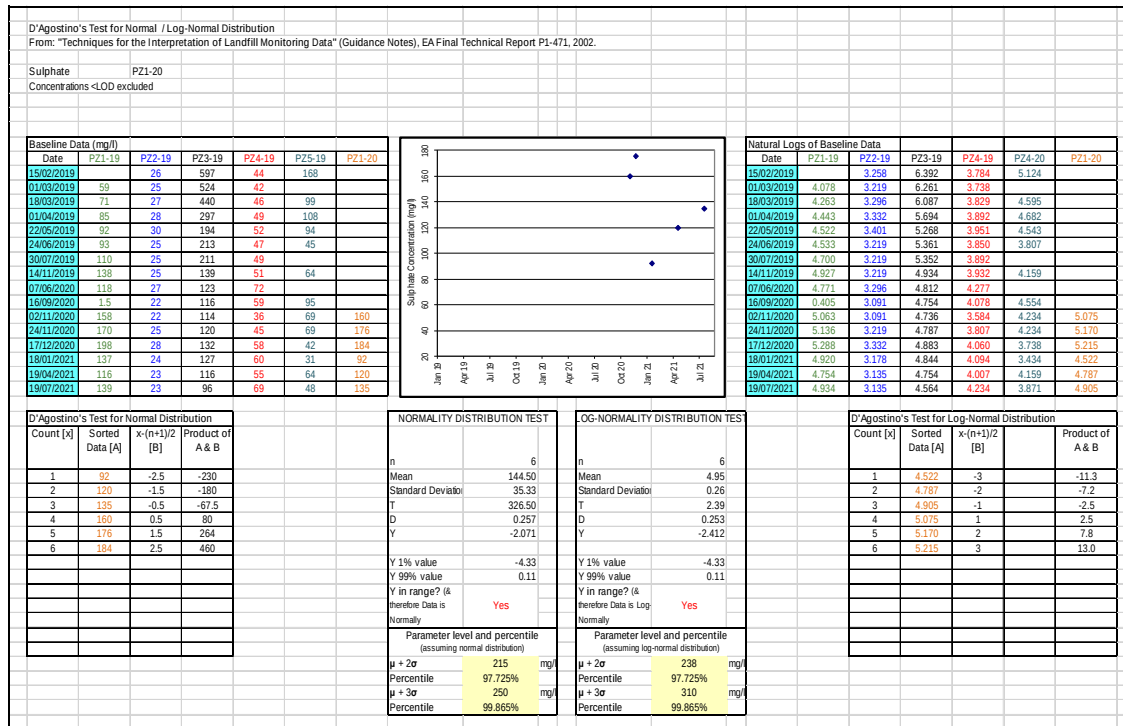
Standardised data	Number	Reordered data
2.867	1	-1.285
0.582	2	-0.893
0.226	3	-0.511
0.226	4	-0.511
-0.138	5	-0.511
-0.138	6	-0.138
-0.138	7	-0.138
-0.511	8	-0.138
-0.511	9	0.226
-0.511	10	0.226
0.226	11	0.226
-1.285	12	0.582
-0.893	13	2.867

Nickel

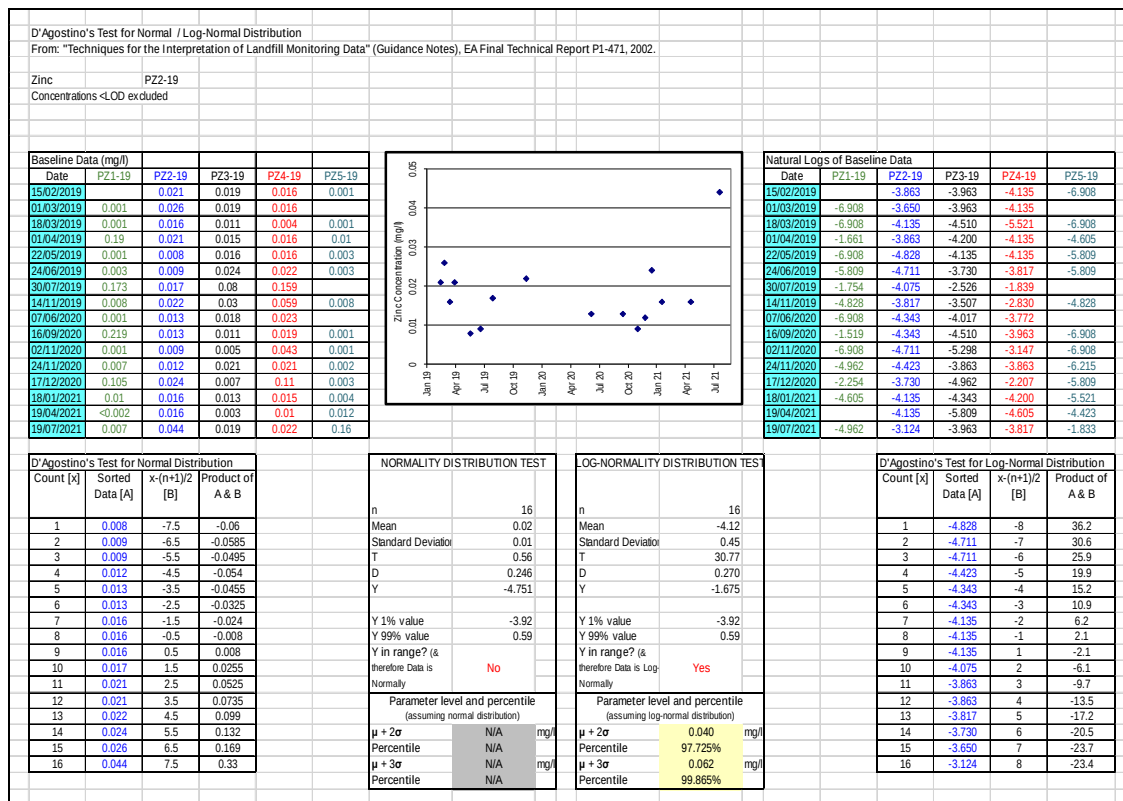


Sulphate





Zinc

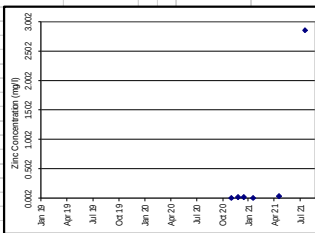


D'Agostino's Test for Normal / Log-Normal Distribution

From: "Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final Technical Report P1-471, 2002.

Zinc
Concentrations <LOD excluded

Baseline Data (mg/l)					
Date	P21-19	P22-19	P23-19	P24-19	P25-19
15/02/2019		0.021	0.019	0.016	0.001
01/03/2019	0.001	0.026	0.019	0.016	
18/03/2019	0.001	0.016	0.011	0.004	0.001
01/04/2019	0.19	0.021	0.015	0.016	0.01
22/05/2019	0.001	0.008	0.016	0.016	0.003
24/06/2019	0.003	0.009	0.024	0.022	0.003
30/07/2019	0.173	0.017	0.08	0.159	
14/11/2019	0.008	0.022	0.03	0.059	0.008
07/06/2020	0.001	0.013	0.018	0.023	
16/09/2020	0.219	0.013	0.011	0.019	0.001
02/11/2020	0.001	0.009	0.005	0.043	0.001
24/11/2020	0.007	0.012	0.021	0.021	0.002
17/12/2020	0.105	0.024	0.007	0.11	0.003
18/01/2021	0.01	0.016	0.013	0.015	0.004
19/04/2021	<0.002	0.016	0.003	0.01	0.012
19/07/2021	0.007	0.044	0.019	0.022	0.16



Natural Logs of Baseline Data					
Date	P21-19	P22-19	P23-19	P24-19	P25-19
15/02/2019		-3.863	-3.963	-4.136	-6.908
01/03/2019	-6.908	-3.860	-3.963	-4.136	
18/03/2019	-6.908	-4.136	-4.510	-5.521	-6.908
01/04/2019	-1.661	-3.863	-4.200	-4.136	-4.605
22/05/2019	-6.908	-4.828	-4.135	-4.135	-5.809
24/06/2019	-5.809	-4.711	-3.730	-3.617	-5.809
30/07/2019	-1.754	-4.075	-2.526	-1.839	
14/11/2019	-4.828	-3.817	-3.507	-2.830	-4.828
07/06/2020	-6.908	-4.343	-4.017	-3.772	
16/09/2020	-1.515	-4.343	-4.510	-3.963	-6.908
02/11/2020	-6.908	-4.711	-5.298	-3.147	-6.908
24/11/2020	-4.962	-4.423	-3.963	-3.963	-5.215
17/12/2020	-2.254	-3.730	-4.962	-2.207	-5.809
18/01/2021	-4.605	-4.136	-4.343	-4.200	-5.521
19/04/2021	-4.136	-5.809	-4.605	-4.423	-3.219
19/07/2021	-4.962	-3.124	-3.963	-3.617	-1.833

D'Agostino's Test for Normal Distribution			
Count [x]	Sorted Data [A]	x-(n+1)/2 [B]	Product of A & B
1	0.004	-2	-0.008
2	0.014	-1	-0.014
3	0.016	0	0
4	0.019	1	0.019
5	0.04	2	0.08

NORMALITY DISTRIBUTION TEST	
n	5
Mean	0.02
Standard Deviation	0.01
T	0.08
D	0.233
Y	-3.664
Y 1% value	-4.40
Y 99% value	0.02
Y in range? (if therefore Data is	Yes
Normally	
Parameter level and percentile (assuming normal distribution)	
$\mu + 2\sigma$	0.045 mg/l
Percentile	97.725%
$\mu + 3\sigma$	0.058 mg/l
Percentile	99.865%

LOG-NORMALITY DISTRIBUTION TEST	
n	5
Mean	-4.22
Standard Deviation	0.83
T	4.91
D	0.236
Y	-3.439
Y 1% value	-4.40
Y 99% value	0.02
Y in range? (if therefore Data is Log-	Yes
Normally	
Parameter level and percentile (assuming log-normal distribution)	
$\mu + 2\sigma$	0.078 mg/l
Percentile	97.725%
$\mu + 3\sigma$	0.178 mg/l
Percentile	99.865%

D'Agostino's Test for Log-Normal Distribution			
Count [x]	Sorted Data [A]	x-(n+1)/2 [B]	Product of A & B
1	-5.521	-2	11.0
2	-4.269	-1	4.3
3	-4.135	0	0.0
4	-3.963	1	-4.0
5	-3.219	2	-6.4

Outlier test (as detailed in Annex A of "Techniques for the Interpretation of Landfill Monitoring Data" (Guidance Notes), EA Final technical report P1-471, 2002.

Reduced dataset - removing first three values

Mean 0.4905 Std Dev 1.1559747

Standardised data	Number	Reordered data
-0.421	1	-0.421
-0.408	2	-0.412
-0.410	3	-0.410
-0.412	4	-0.408
-0.390	5	-0.390
2.041	6	2.041

Data point identified as an outlier (Normal and L-Normal datasets): >Critical Value for Normal distribution (probability less than 1 in 100)

Reduced dataset - removing first three values

Mean -1.343 Std Dev 2.2761914

Standardised data	Number	Reordered data
-0.957	1	-0.957
-0.272	2	-0.407
-0.348	3	-0.348
-0.407	4	-0.272
0.055	5	0.055
1.929	6	1.929



Suttles Stone Quarries

Swanworth Quarry

Worth Matravers, Dorset

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Appendix 8 RAM Model Summary Output

RAM MODEL – Secondary A Bedrock Aquifer (Northern Extension – Portland Sand) : Swanworth_RAM_HRA1_Lev3.xls

Source Type

☒ Soil Source ☐ Groundwater Source

Level Number

☐ Level One

☐ Level Two

☒ Level Three

☐ Level Four

☐ Advanced

Parameter Values

☒ Deterministic ☐ Probabilistic

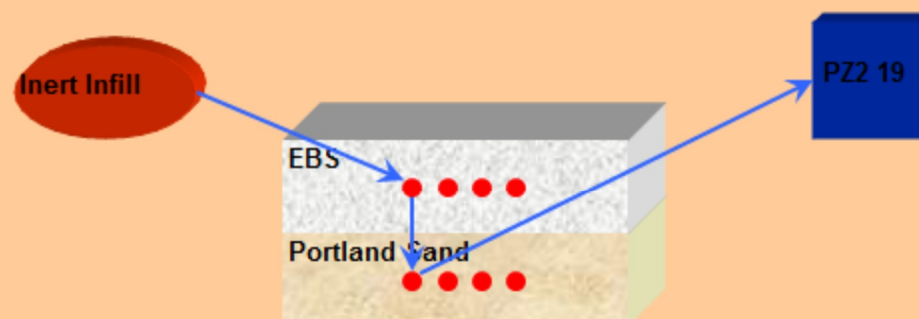
Created: 10/10/2021 20:33:18

by: Admin

Version: 3.00.00 Adv

Site: Swanworth Northern Extension

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited



SOURCE CONCENTRATIONS: Inert Infill

Source Data Options

- ☐ Pore water concentrations
- ☒ Leaching test
- ☐ Soil contaminant concentrations

SOIL SOURCE

Source Type

- ☐ Constant source
- ☒ Declining source

Source Geometry

Inert_Infill_Source_length	475	m
Inert_Infill_Source_width	208	m
Inert_Infill_Source_area	98800	m2
Inert_Infill_Source_thickness	8.96	m
Inert_Infill_Source_volume	885248	m3

General Source Properties

Inert_Infill_Source_field_capacity	[-]	0.2
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Source Contaminant Information

Source determinand names		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
Inert_Infill_Leaching_test_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4
Inert_Infill_Initial_inventory	kg	8.85248	14163.97	8.85248	0.17705	7.081984	17704.96	70.81984
Inert_Infill_Input_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4

HYDROGEOLOGICAL UNITS

Hydrogeological Units		EBS	Portland Sand
Hydrogeology_Unit_Thickness	m	1	39.1
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	-7	-5.33
Hydrogeology_Hydraulic_Conductivity	m/s	1E-07	4.68E-06
Hydrogeology_Hydraulic_Gradient	[-]	1.2	0.019
Hydrogeology_Porosity	[-]	0.2	0.132
Hydrogeology_Velocity	m/s	6E-07	6.73E-07
Hydrogeology_Tortuosity	[-]	10	10

WATER BALANCE

Infiltration through the soil zone source
Source Name: Inert Infill

Effective_Rainfall	315 mm/year
Infiltration_Factor	1 [-]
Infiltration_Rate	315 mm/year
Infiltration_Area	98800 m2
Q_Infiltration	0.000986 m3/s

PATHWAY SUMMARY

Path 1	Section 1		Section 2	Section 3		Section 4	
Path 1 Type	Source		Unit	Unit		Receptor	
Path 1 Name	Inert Infill		EBS: Node 1	Portland Sand: Node 1		PZ2 19	
Path 1 Process	Declining source		ADRD (1D)	ADRD (1D) + Dilution		Monitoring Borehole	
Path 1 Standards						Target Standard	EQS
Path 1 Parameter1	Q_managed [m3/s]	0.000E+00	Velocity [m/s]	6.000E-07	Velocity [m/s]	6.733E-07	
Path 1 Parameter2	Managed time [years]	0.000E+00	Dispersivity [m]	0.1	Dispersivity [m]	0.1	
Path 1 Parameter3	Q_path [m3/s]	9.862E-04	Travel Distance [m]	1.0	Travel Distance [m]	0.1	
Path 1 Parameter4	Q_decline [m3/s]	9.862E-04			Mixing Depth [m]	23.0	
Path 1 Parameter5					Mixing Width [m]	585.0	
Path 1 Parameter6			Q Dilute [m3/s]	0	Q Dilute [m3/s]	1.196E-03	Q dilute [m3/s] 0.000E+00

ATTENUATION PARAMETERS

Hydrogeological Units	EBS	Portland Sand
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General properties

Attenuation_Dry_bulk_density	kg/m3	2000	2000
Attenuation_Fraction_organic_carbon	[-]	0.5	

Contaminant specific parameters

Arsenic

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.38E+02	1.38E+02
Attenuation_Retardation_Species_1	[-]	1376	2084.33
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0

Chloride

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_2	[-]	1	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

Lead

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2.70E+05	2.70E+05
Attenuation_Retardation_Species_3	[-]	2700001	4030310
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0

Mercury

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2532.5	2532.5
Attenuation_Retardation_Species_4	[-]	25326	33261.3
Attenuation_Half_Life_Species_4	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	0	0

Nickel

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	430	430
Attenuation_Retardation_Species_5	[-]	4301	6516.15
Attenuation_Half_Life_Species_5	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	0	0

Sulphate

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_6	[-]	1	1
Attenuation_Half_Life_Species_6	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	0	0

Zinc

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	3015	3015
Attenuation_Retardation_Species_7	[-]	3016	4563.18
Attenuation_Half_Life_Species_7	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	0	0

BREAKTHROUGH RESULTS

Site Name: "Swanworth Northern Extension"

Level 3

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Concentrations in mg/L in PZ2 19

Compared with EQS target concentration in mg/L

1.000E-02	2.500E+02	1.000E-02	1.000E-03	2.000E-02	2.500E+02	1.000E-02
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Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	0.000E+00	3.064E+01	0.000E+00	0.000E+00	0.000E+00	3.830E+01	0.000E+00
5	1.426E-19	1.517E+01	0.000E+00	0.000E+00	1.293E-30	1.896E+01	0.000E+00
10	6.426E-11	6.298E+00	0.000E+00	0.000E+00	0.000E+00	7.872E+00	9.007E-20
25	3.772E-05	4.509E-01	0.000E+00	1.516E-35	1.591E-13	5.636E-01	7.598E-09
100	1.132E-03	7.483E-07	0.000E+00	0.000E+00	8.477E-05	9.353E-07	4.230E-03
1000	3.764E-13	0.000E+00	0.000E+00	1.735E-06	1.651E-07	0.000E+00	2.497E-08
10000	0.000E+00	9.320E-10	0.000E+00	6.240E-13	0.000E+00	1.165E-09	0.000E+00

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Remedial Target Concentrations in mg/L in Inert Infill

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	6.528E+02	1.000E+40	1.000E+40	1.000E+40	6.528E+02	1.000E+40
5	3.507E+15	1.319E+03	1.000E+40	1.000E+40	6.188E+26	1.319E+03	1.000E+40
10	7.780E+06	3.176E+03	1.000E+40	1.000E+40	1.000E+40	3.176E+03	4.441E+16
25	1.325E+01	4.436E+04	1.000E+40	6.595E+28	5.027E+09	4.436E+04	5.265E+05
100	4.419E-01	2.673E+10	1.000E+40	1.000E+40	9.438E+00	2.673E+10	9.456E-01
1000	1.328E+09	1.000E+40	1.000E+40	5.764E-01	4.844E+03	1.000E+40	1.602E+05
10000	1.000E+40	2.146E+13	1.000E+40	1.603E+06	1.000E+40	2.146E+13	1.000E+40

Compared with source concentrations in mg/L

5.000E-02	8.000E+01	5.000E-02	1.000E-03	4.000E-02	1.000E+02	4.000E-01
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Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Dilution Factor

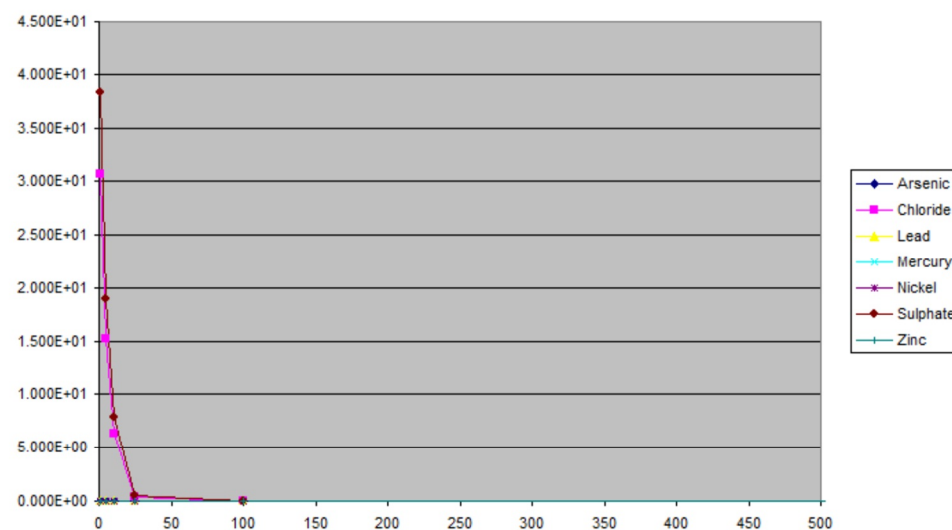
2.212E+00 for all species and timeslices

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Attenuation Factor

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	1.180E+00	1.000E+40	1.000E+40	1.000E+40	1.180E+00	1.000E+40
5	1.585E+17	2.384E+00	1.000E+40	1.000E+40	1.398E+28	2.384E+00	1.000E+40
10	3.517E+08	5.741E+00	1.000E+40	1.000E+40	1.000E+40	5.741E+00	2.007E+18
25	5.991E+02	8.019E+01	1.000E+40	2.981E+31	1.136E+11	8.019E+01	2.380E+07
100	1.997E+01	4.832E+07	1.000E+40	1.000E+40	2.133E+02	4.832E+07	4.274E+01
1000	6.004E+10	1.000E+40	1.000E+40	2.605E+02	1.095E+05	1.000E+40	7.239E+06
10000	1.000E+40	3.880E+10	1.000E+40	7.244E+08	1.000E+40	3.880E+10	1.000E+40

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19



RAM MODEL – Sensitivity analysis 1. Secondary A Bedrock Aquifer (Northern Extension – Portland Sand) : Swanworth_RAM_SENS1_Lev3.xls

Source Type

☒ Soil Source ☐ Groundwater Source

Level Number

☐ Level One
☐ Level Two
☒ Level Three
☐ Level Four
☐ Advanced

Parameter Values

☒ Deterministic ☐ Probabilistic

Created: 10/10/2021 20:33:18
by: Admin
Version: 3.00.00 Adv
Site: Swanworth Northern Extension

Numerical value

Suggested formula

Probabilistic parameters

Data specified elsewhere

Suggested formula edited

Inert Infill

EBS

Portland Sand

PZ2 19

SOURCE CONCENTRATIONS: Inert Infill

Source Data Options

- ☐ Pore water concentrations
- ☒ Leaching test
- ☐ Soil contaminant concentrations

SOIL SOURCE

Source Type

- ☐ Constant source
- ☒ Declining source

Source Geometry

Inert_Infill_Source_length	475	m
Inert_Infill_Source_width	208	m
Inert_Infill_Source_area	98800	m2
Inert_Infill_Source_thickness	8.96	m
Inert_Infill_Source_volume	885248	m3

General Source Properties

Inert_Infill_Source_field_capacity	[-]	0.2
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Source Contaminant Information

Source determinand names		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
Inert_Infill_Leaching_test_concentration	mg/L	0.1	160	0.1	0.002	0.08	200	0.8
Inert_Infill_Initial_inventory	kg	17.70496	28327.94	17.70496	0.354099	14.16397	35409.92	141.6397
Inert_Infill_Input_concentration	mg/L	0.1	160	0.1	0.002	0.08	200	0.8

HYDROGEOLOGICAL UNITS

Hydrogeological Units		EBS	Portland Sand
Hydrogeology_Unit_Thickness	m	1	39.1
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	-7	-5.33
Hydrogeology_Hydraulic_Conductivity	m/s	1E-07	4.68E-06
Hydrogeology_Hydraulic_Gradient	[-]	1.2	0.019
Hydrogeology_Porosity	[-]	0.2	0.132
Hydrogeology_Velocity	m/s	6E-07	6.73E-07
Hydrogeology_Tortuosity	[-]	10	10

WATER BALANCE

Infiltration through the soil zone source
Source Name: Inert Infill

Effective_Rainfall	315	mm/year
Infiltration_Factor	1	[-]
Infiltration_Rate	315	mm/year
Infiltration_Area	98800	m2
Q_Infiltration	0.000986	m3/s

PATHWAY SUMMARY

Path 1

- Path 1 Type
- Path 1 Name
- Path 1 Process
- Path 1 Standards
- Path 1 Parameter1
- Path 1 Parameter2
- Path 1 Parameter3
- Path 1 Parameter4
- Path 1 Parameter5
- Path 1 Parameter6

Section 1		Section 2		Section 3		Section 4	
Source		Unit		Unit		Receptor	
Inert Infill		EBS: Node 1		Portland Sand: Node 1		PZ2 19	
Declining source		ADRD (1D)		ADRD (1D) + Dilution		Monitoring Borehole	
						Target Standard	
Q_managed [m3/s]		Velocity [m/s]		Velocity [m/s]		EQS	
Managed time [years]		Dispersivity [m]		Dispersivity [m]			
Q_path [m3/s]		Travel Distance [m]		Travel Distance [m]			
Q_decline [m3/s]				Mixing Depth [m]			
				Mixing Width [m]			
		Q_Dilute [m3/s]		Q_Dilute [m3/s]		Q_dilute [m3/s]	

ATTENUATION PARAMETERS

Hydrogeological Units	EBS	Portland Sand
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General properties

Attenuation_Dry_bulk_density	kg/m3	2000	2000
Attenuation_Fraction_organic_carbon	[-]	0.5	

Contaminant specific parameters

Arsenic

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.38E+02	1.38E+02
Attenuation_Retardation_Species_1	[-]	1376	2084.33
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0

Chloride

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_2	[-]	1	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

Lead

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2.70E+05	2.70E+05
Attenuation_Retardation_Species_3	[-]	2700001	4030310
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0

Mercury

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2532.5	2532.5
Attenuation_Retardation_Species_4	[-]	25326	33261.3
Attenuation_Half_Life_Species_4	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	0	0

Nickel

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	430	430
Attenuation_Retardation_Species_5	[-]	4301	6516.15
Attenuation_Half_Life_Species_5	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	0	0

Sulphate

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_6	[-]	1	1
Attenuation_Half_Life_Species_6	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	0	0

Zinc

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	3015	3015
Attenuation_Retardation_Species_7	[-]	3016	4563.18
Attenuation_Half_Life_Species_7	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	0	0

BREAKTHROUGH RESULTS

Site Name: "Swanworth Northern Extension"

Level 3

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Concentrations in mg/L in PZ2 19

Compared with EQS target concentration in mg/L

1.000E-02	2.500E+02	1.000E-02	1.000E-03	2.000E-02	2.500E+02	1.000E-02
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Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	0.000E+00	6.128E+01	0.000E+00	0.000E+00	0.000E+00	7.660E+01	0.000E+00
5	2.852E-19	3.033E+01	0.000E+00	0.000E+00	2.586E-30	3.792E+01	0.000E+00
10	1.285E-10	1.260E+01	0.000E+00	0.000E+00	0.000E+00	1.574E+01	1.801E-19
25	7.544E-05	9.018E-01	0.000E+00	3.033E-35	3.183E-13	1.127E+00	1.520E-08
100	2.263E-03	1.497E-06	0.000E+00	0.000E+00	1.695E-04	1.871E-06	8.460E-03
1000	7.527E-13	0.000E+00	0.000E+00	3.470E-06	3.303E-07	0.000E+00	4.995E-08
10000	0.000E+00	1.864E-09	0.000E+00	1.248E-12	0.000E+00	2.330E-09	0.000E+00

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Remedial Target Concentrations in mg/L in Inert Infill

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	6.528E+02	1.000E+40	1.000E+40	1.000E+40	6.528E+02	1.000E+40
5	3.507E+15	1.319E+03	1.000E+40	1.000E+40	6.188E+26	1.319E+03	1.000E+40
10	7.780E+06	3.176E+03	1.000E+40	1.000E+40	1.000E+40	3.176E+03	4.441E+16
25	1.325E+01	4.436E+04	1.000E+40	6.595E+28	5.027E+09	4.436E+04	5.265E+05
100	4.419E-01	2.673E+10	1.000E+40	1.000E+40	9.438E+00	2.673E+10	9.456E-01
1000	1.328E+09	1.000E+40	1.000E+40	5.764E-01	4.844E+03	1.000E+40	1.602E+05
10000	1.000E+40	2.146E+13	1.000E+40	1.603E+06	1.000E+40	2.146E+13	1.000E+40

Compared with source concentrations in mg/L

1.000E-01	1.600E+02	1.000E-01	2.000E-03	8.000E-02	2.000E+02	8.000E-01
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Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

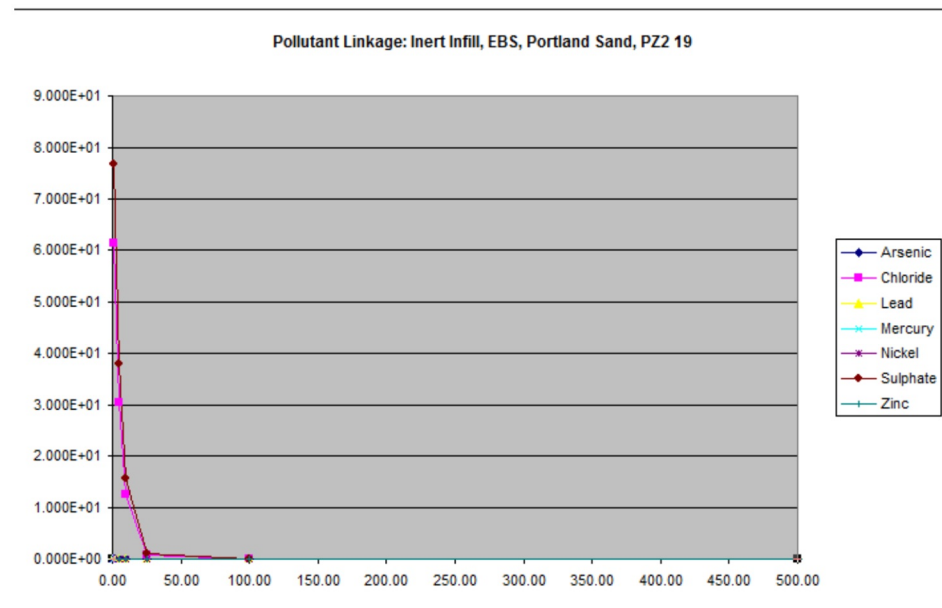
Dilution Factor

2.212E+00 for all species and timeslices

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Attenuation Factor

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	1.180E+00	1.000E+40	1.000E+40	1.000E+40	1.180E+00	1.000E+40
5	1.585E+17	2.384E+00	1.000E+40	1.000E+40	1.398E+28	2.384E+00	1.000E+40
10	3.517E+08	5.741E+00	1.000E+40	1.000E+40	1.000E+40	5.741E+00	2.007E+18
25	5.991E+02	8.019E+01	1.000E+40	2.981E+31	1.136E+11	8.019E+01	2.380E+07
100	1.997E+01	4.832E+07	1.000E+40	1.000E+40	2.133E+02	4.832E+07	4.274E+01
1000	6.004E+10	1.000E+40	1.000E+40	2.605E+02	1.095E+05	1.000E+40	7.239E+06
10000	1.000E+40	3.880E+10	1.000E+40	7.244E+08	1.000E+40	3.880E+10	1.000E+40



RAM MODEL – Sensitivity analysis 2. Secondary A Bedrock Aquifer (Northern Extension – Portland Sand) : Swanworth_RAM_SENS2_Lev3.xls

Source Type

☒ Soil Source ☐ Groundwater Source

Level Number

☐ Level One
☐ Level Two
☒ Level Three
☐ Level Four
☐ Advanced

Parameter Values

☒ Deterministic ☐ Probabilistic

Created: 10/10/2021 20:33:18
by: Admin
Version: 3.00.00 Adv
Site: Swanworth Northern Extension

Numerical value

Suggested formula

Probabilistic parameters

Data specified elsewhere

Suggested formula edited

Inert Infill

EBS

Portland Sand

PZ2 19

SOURCE CONCENTRATIONS: Inert Infill

Source Data Options

- ☐ Pore water concentrations
- ☒ Leaching test
- ☐ Soil contaminant concentrations

SOIL SOURCE

Source Type

- ☐ Constant source
- ☒ Declining source

Source Geometry

Inert_Infill_Source_length	475	m
Inert_Infill_Source_width	208	m
Inert_Infill_Source_area	98800	m2
Inert_Infill_Source_thickness	8.96	m
Inert_Infill_Source_volume	885248	m3

General Source Properties

Inert_Infill_Source_field_capacity	[-]	0.2
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Source Contaminant Information

Source determinand names		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
Inert_Infill_Leaching_test_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4
Inert_Infill_Initial_inventory	kg	8.85248	14163.97	8.85248	0.17705	7.081984	17704.96	70.81984
Inert_Infill_Input_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4

HYDROGEOLOGICAL UNITS

Hydrogeological Units		EBS	Portland Sand
Hydrogeology_Unit_Thickness	m	1	39.1
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	-7	-6.635
Hydrogeology_Hydraulic_Conductivity	m/s	1E-07	2.32E-07
Hydrogeology_Hydraulic_Gradient	[-]	1.2	0.019
Hydrogeology_Porosity	[-]	0.2	0.132
Hydrogeology_Velocity	m/s	6E-07	3.34E-08
Hydrogeology_Tortuosity	[-]	10	10

WATER BALANCE

Infiltration through the soil zone source
Source Name: Inert Infill

Effective_Rainfall	315	mm/year
Infiltration_Factor	1	[-]
Infiltration_Rate	315	mm/year
Infiltration_Area	98800	m2
Q_Infiltration	0.000986	m3/s

PATHWAY SUMMARY

Path 1

Path 1 Type
Path 1 Name
Path 1 Process
Path 1 Standards
Path 1 Parameter1
Path 1 Parameter2
Path 1 Parameter3
Path 1 Parameter4
Path 1 Parameter5
Path 1 Parameter6

Section 1		Section 2		Section 3		Section 4	
Source		Unit		Unit		Receptor	
Inert Infill		EBS: Node 1		Portland Sand: Node 1		PZ2 19	
Declining source		ADRD (1D)		ADRD (1D) + Dilution		Monitoring Borehole	
						Target Standard	
						EQS	
Q_managed [m3/s]	0.000E+00	Velocity [m/s]	6.000E-07	Velocity [m/s]	3.336E-08		
Managed time [years]	0.000E+00	Dispersivity [m]	0.1	Dispersivity [m]	0.1		
Q_path [m3/s]	9.862E-04	Travel Distance [m]	1.0	Travel Distance [m]	0.1		
Q_decline [m3/s]	9.862E-04			Mixing Depth [m]	23.0		
				Mixing Width [m]	585.0		
		Q_Dilute [m3/s]	0	Q_Dilute [m3/s]	5.924E-05	Q_dilute [m3/s]	0.000E+00

ATTENUATION PARAMETERS

Hydrogeological Units	EBS	Portland Sand
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General properties

Attenuation_Dry_bulk_density	kg/m3	2000	2000
Attenuation_Fraction_organic_carbon	[-]	0.5	

Contaminant specific parameters

Arsenic

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.38E+02	1.38E+02
Attenuation_Retardation_Species_1	[-]	1376	2084.33
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0

Chloride

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_2	[-]	1	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

Lead

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2.70E+05	2.70E+05
Attenuation_Retardation_Species_3	[-]	2700001	4030310
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0

Mercury

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2592.5	2592.5
Attenuation_Retardation_Species_4	[-]	25926	39281.3
Attenuation_Half_Life_Species_4	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	0	0

Nickel

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	430	430
Attenuation_Retardation_Species_5	[-]	4301	6516.15
Attenuation_Half_Life_Species_5	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	0	0

Sulphate

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_6	[-]	1	1
Attenuation_Half_Life_Species_6	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	0	0

Zinc

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	3015	3015
Attenuation_Retardation_Species_7	[-]	3016	4563.18
Attenuation_Half_Life_Species_7	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	0	0

BREAKTHROUGH RESULTS

Site Name: "Swanworth Northern Extension"

Level 3

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Concentrations in mg/L in PZ2 19

Compared with EQS target concentration in mg/L

1.000E-02	2.500E+02	1.000E-02	1.000E-03	2.000E-02	2.500E+02	1.000E-02
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Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	0.000E+00	6.473E+01	0.000E+00	0.000E+00	0.000E+00	8.091E+01	0.000E+00
5	9.702E-24	3.217E+01	0.000E+00	0.000E+00	0.000E+00	4.021E+01	2.815E-34
10	0.000E+00	1.336E+01	0.000E+00	0.000E+00	0.000E+00	1.670E+01	0.000E+00
25	3.535E-08	9.564E-01	0.000E+00	0.000E+00	0.000E+00	1.196E+00	5.654E-16
100	1.194E-03	1.585E-06	0.000E+00	3.143E-26	5.974E-07	1.982E-06	2.205E-04
1000	1.868E-05	0.000E+00	0.000E+00	2.187E-07	7.310E-05	0.000E+00	4.776E-04
10000	3.939E-12	1.939E-09	5.198E-26	9.730E-08	4.912E-08	2.425E-09	7.321E-08

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Remedial Target Concentrations in mg/L in Inert Infill

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	3.090E+02	1.000E+40	1.000E+40	1.000E+40	3.090E+02	1.000E+40
5	5.153E+19	6.217E+02	1.000E+40	1.000E+40	1.000E+40	6.217E+02	1.421E+31
10	1.000E+40	1.497E+03	1.000E+40	1.000E+40	1.000E+40	1.497E+03	1.000E+40
25	1.414E+04	2.091E+04	1.000E+40	1.000E+40	1.000E+40	2.091E+04	7.075E+12
100	4.188E-01	1.262E+10	1.000E+40	3.181E+19	1.339E+03	1.262E+10	1.814E+01
1000	2.676E+01	1.000E+40	1.000E+40	4.573E+00	1.094E+01	1.000E+40	8.375E+00
10000	1.269E+08	1.031E+13	9.618E+21	1.028E+01	1.629E+04	1.031E+13	5.464E+04

Compared with source concentrations in mg/L

5.000E-02	8.000E+01	5.000E-02	1.000E-03	4.000E-02	1.000E+02	4.000E-01
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Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

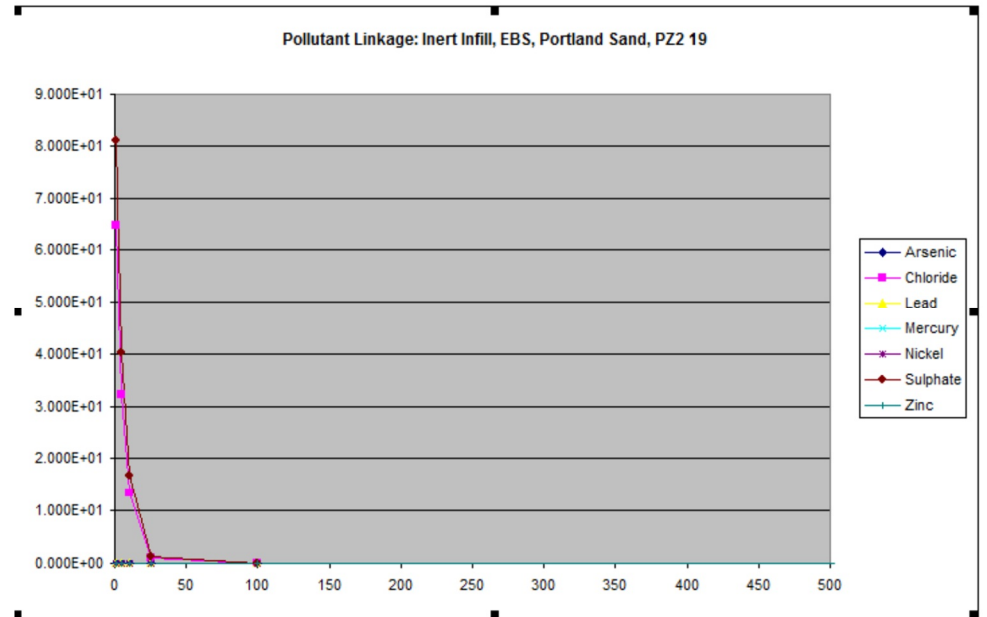
Dilution Factor

1.060E+00 for all species and timeslices

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Attenuation Factor

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	1.166E+00	1.000E+40	1.000E+40	1.000E+40	1.166E+00	1.000E+40
5	4.861E+21	2.346E+00	1.000E+40	1.000E+40	1.000E+40	2.346E+00	1.340E+33
10	1.000E+40	5.649E+00	1.000E+40	1.000E+40	1.000E+40	5.649E+00	1.000E+40
25	1.334E+06	7.891E+01	1.000E+40	1.000E+40	1.000E+40	7.891E+01	6.674E+14
100	3.950E+01	4.760E+07	1.000E+40	3.001E+22	6.316E+04	4.760E+07	1.711E+03
1000	2.525E+03	1.000E+40	1.000E+40	4.314E+03	5.162E+02	1.000E+40	7.901E+02
10000	1.197E+10	3.891E+10	9.073E+23	9.695E+03	7.682E+05	3.891E+10	5.154E+06



RAM MODEL – Sensitivity analysis 3. Secondary A Bedrock Aquifer (Northern Extension – Portland Sand) : Swanworth_RAM_SENS3_Lev3.xls

Source Type

☒ Soil Source ☐ Groundwater Source

Level Number

☐ Level One
☐ Level Two
☒ Level Three
☐ Level Four
☐ Advanced

Parameter Values

☒ Deterministic ☐ Probabilistic

Created: 10/10/2021 20:33:18
by: Admin
Version: 3.00.00 Adv
Site: Swanworth Northern Extension

Numerical value
Suggested formula
Probabilistic parameters
Data specified elsewhere
Suggested formula edited

Inert Infill

EBS

Portland Sand

PZ2 19

SOURCE CONCENTRATIONS: Inert Infill

Source Data Options

- ☐ Pore water concentrations
- ☒ Leaching test
- ☐ Soil contaminant concentrations

SOIL SOURCE

Source Type

- ☐ Constant source
- ☒ Declining source

Source Geometry

Inert_Infill_Source_length	475	m
Inert_Infill_Source_width	208	m
Inert_Infill_Source_area	98800	m2
Inert_Infill_Source_thickness	8.96	m
Inert_Infill_Source_volume	885248	m3

General Source Properties

Inert_Infill_Source_field_capacity	[-]	0.2
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Source Contaminant Information

Source determinand names		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
Inert_Infill_Leaching_test_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4
Inert_Infill_Initial_inventory	kg	8.85248	14163.97	8.85248	0.17705	7.081984	17704.96	70.81984
Inert_Infill_Input_concentration	mg/L	0.05	80	0.05	0.001	0.04	100	0.4

HYDROGEOLOGICAL UNITS

Hydrogeological Units				EBS	Portland Sand
Hydrogeology_Unit_Thickness	m	1	39.1		
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	-7	-5.33		
Hydrogeology_Hydraulic_Conductivity	m/s	1E-07	4.68E-06		
Hydrogeology_Hydraulic_Gradient	[-]	1.2	0.019		
Hydrogeology_Porosity	[-]	0.2	0.132		
Hydrogeology_Velocity	m/s	6E-07	6.73E-07		
Hydrogeology_Tortuosity	[-]	10	10		

WATER BALANCE

Infiltration through the soil zone source
Source Name: Inert Infill

Effective_Rainfall	315	mm/year
Infiltration_Factor	1	[-]
Infiltration_Rate	315	mm/year
Infiltration_Area	98800	m2
Q_Infiltration	0.000986	m3/s

PATHWAY SUMMARY

Path 1

- Path 1 Type
- Path 1 Name
- Path 1 Process
- Path 1 Standards
- Path 1 Parameter1
- Path 1 Parameter2
- Path 1 Parameter3
- Path 1 Parameter4
- Path 1 Parameter5
- Path 1 Parameter6

Section 1		Section 2		Section 3		Section 4	
Source		Unit		Unit		Receptor	
Inert Infill		EBS: Node 1		Portland Sand: Node 1		PZ2 19	
Declining source		ADRD (1D)		ADRD (1D) + Dilution		Monitoring Borehole	
						Target Standard	
Q_managed [m3/s]		0.000E+00		Velocity [m/s]		6.733E-07	
Managed time [years]		0.000E+00		Dispersivity [m]		0.1	
Q_path [m3/s]		9.862E-04		Travel Distance [m]		0.1	
Q_decline [m3/s]		9.862E-04		Mixing Depth [m]		23.0	
				Mixing Width [m]		1.0	
		Q_Dilute [m3/s]		0		Q_dilute [m3/s]	
				Q_Dilute [m3/s]		2.044E-06	
						0.000E+00	

ATTENUATION PARAMETERS

Hydrogeological Units	EBS	Portland Sand
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General properties

Attenuation_Dry_bulk_density	kg/m3	2000	2000
Attenuation_Fraction_organic_carbon	[-]	0.5	

Contaminant specific parameters

Arsenic

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.38E+02	1.38E+02
Attenuation_Retardation_Species_1	[-]	1376	2084.33
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0

Chloride

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_2	[-]	1	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

Lead

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2.70E+05	2.70E+05
Attenuation_Retardation_Species_3	[-]	2700001	4030310
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0

Mercury

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2532.5	2532.5
Attenuation_Retardation_Species_4	[-]	25326	33261.3
Attenuation_Half_Life_Species_4	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	0	0

Nickel

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	430	430
Attenuation_Retardation_Species_5	[-]	4301	6516.15
Attenuation_Half_Life_Species_5	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	0	0

Sulphate

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_6	[-]	1	1
Attenuation_Half_Life_Species_6	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	0	0

Zinc

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	3015	3015
Attenuation_Retardation_Species_7	[-]	3016	4563.18
Attenuation_Half_Life_Species_7	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	0	0

BREAKTHROUGH RESULTS

Site Name: "Swanworth Northern Extension"

Level 3

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Concentrations in mg/L in PZ2 19

Compared with EQS target concentration in mg/L

1.000E-02	2.500E+02	1.000E-02	1.000E-03	2.000E-02	2.500E+02	1.000E-02
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Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	0.000E+00	6.765E+01	0.000E+00	0.000E+00	0.000E+00	8.456E+01	0.000E+00
5	3.148E-19	3.349E+01	0.000E+00	0.000E+00	2.855E-30	4.186E+01	0.000E+00
10	1.419E-10	1.391E+01	0.000E+00	0.000E+00	0.000E+00	1.738E+01	1.989E-19
25	8.329E-05	9.956E-01	0.000E+00	3.348E-35	3.513E-13	1.244E+00	1.677E-08
100	2.498E-03	1.652E-06	0.000E+00	0.000E+00	1.872E-04	2.065E-06	9.340E-03
1000	8.316E-13	0.000E+00	0.000E+00	3.831E-06	3.646E-07	0.000E+00	5.514E-08
10000	0.000E+00	2.058E-09	0.000E+00	1.378E-12	0.000E+00	2.572E-09	0.000E+00

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Remedial Target Concentrations in mg/L in Inert Infill

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	2.957E+02	1.000E+40	1.000E+40	1.000E+40	2.957E+02	1.000E+40
5	1.588E+15	5.972E+02	1.000E+40	1.000E+40	2.802E+26	5.972E+02	1.000E+40
10	3.524E+06	1.438E+03	1.000E+40	1.000E+40	1.000E+40	1.438E+03	2.011E+16
25	6.003E+00	2.009E+04	1.000E+40	2.987E+28	2.277E+09	2.009E+04	2.385E+05
100	2.001E-01	1.211E+10	1.000E+40	1.000E+40	4.274E+00	1.211E+10	4.283E-01
1000	6.012E+08	1.000E+40	1.000E+40	2.611E-01	2.194E+03	1.000E+40	7.254E+04
10000	1.000E+40	9.719E+12	1.000E+40	7.259E+05	1.000E+40	9.719E+12	1.000E+40

Compared with source concentrations in mg/L

5.000E-02	8.000E+01	5.000E-02	1.000E-03	4.000E-02	1.000E+02	4.000E-01
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Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Dilution Factor

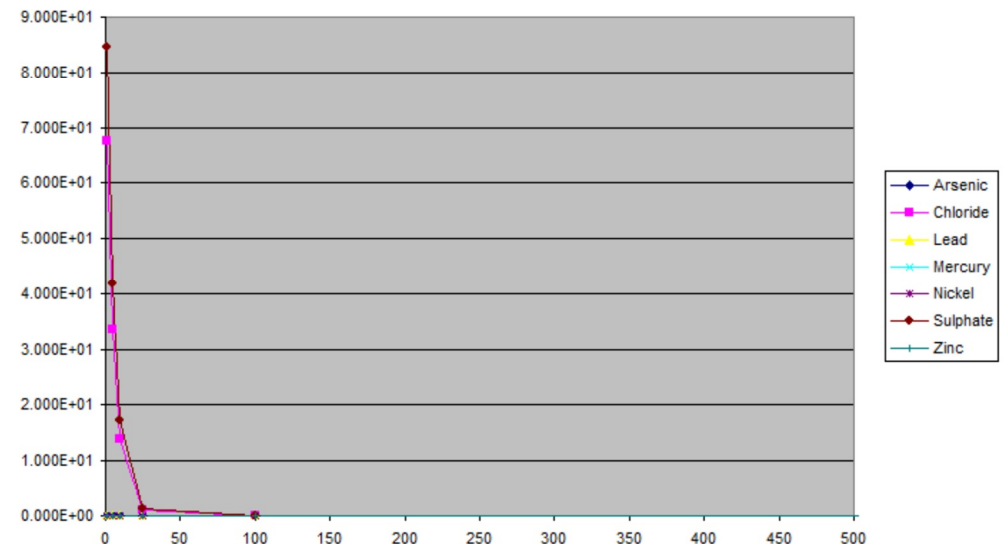
1.002E+00 for all species and timeslices

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Attenuation Factor

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	1.180E+00	1.000E+40	1.000E+40	1.000E+40	1.180E+00	1.000E+40
5	1.585E+17	2.384E+00	1.000E+40	1.000E+40	1.398E+28	2.384E+00	1.000E+40
10	3.517E+08	5.741E+00	1.000E+40	1.000E+40	1.000E+40	5.741E+00	2.007E+18
25	5.991E+02	8.019E+01	1.000E+40	2.981E+31	1.136E+11	8.019E+01	2.380E+07
100	1.997E+01	4.832E+07	1.000E+40	1.000E+40	2.133E+02	4.832E+07	4.274E+01
1000	6.000E+10	1.000E+40	1.000E+40	2.605E+02	1.095E+05	1.000E+40	7.239E+06
10000	1.000E+40	3.879E+10	1.000E+40	7.244E+08	1.000E+40	3.879E+10	1.000E+40

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19



RAM MODEL – Rogue Load analysis. Secondary A Bedrock Aquifer (Northern Extension – Portland Sand) : Swanworth_RAM_RL1_Lev3.xls

Source Type

☒ Soil Source ☐ Groundwater Source

Level Number

☐ Level One
☐ Level Two
☒ Level Three
☐ Level Four
☐ Advanced

Parameter Values

☒ Deterministic ☐ Probabilistic

Created: 10/10/2021 20:33:18
by: Admin
Version: 3.00.00 Adv
Site: Swanworth Northern Extension

Numerical value

Suggested formula

Probabilistic parameters

Data specified elsewhere

Suggested formula edited

Inert Infill

EBS

Portland Sand

PZ2 19

SOURCE CONCENTRATIONS: Inert Infill

Source Data Options

- ☐ Pore water concentrations
- ☒ Leaching test
- ☐ Soil contaminant concentrations

SOIL SOURCE

Source Type

- ☐ Constant source
- ☒ Declining source

Source Geometry

Inert_Infill_Source_length	475	m
Inert_Infill_Source_width	208	m
Inert_Infill_Source_area	98800	m2
Inert_Infill_Source_thickness	8.96	m
Inert_Infill_Source_volume	885248	m3

General Source Properties

Inert_Infill_Source_field_capacity	[.]	0.2
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Source Contaminant Information

Source determinand names		Arsenic	Chloride	Lead	Mercury	Nickel	Sulphate	Zinc
Inert_Infill_Leaching_test_concentration	mg/L	0.06	460	0.15	0.002	0.12	1500	1.2
Inert_Infill_Initial_inventory	kg	10.62298	81442.82	26.55744	0.354099	21.24595	265574.4	212.4595
Inert_Infill_Input_concentration	mg/L	0.06	460	0.15	0.002	0.12	1500	1.2

HYDROGEOLOGICAL UNITS

Hydrogeological Units		EBS	Portland Sand
Hydrogeology_Unit_Thickness	m	1	39.1
Hydrogeology_Log_Hydraulic_Conductivity	log(m/s)	-7	-5.33
Hydrogeology_Hydraulic_Conductivity	m/s	1E-07	4.68E-06
Hydrogeology_Hydraulic_Gradient	[-]	1.2	0.019
Hydrogeology_Porosity	[-]	0.2	0.132
Hydrogeology_Velocity	m/s	6E-07	6.73E-07
Hydrogeology_Tortuosity	[-]	10	10

WATER BALANCE

Infiltration through the soil zone source

Source Name: Inert Infill

Effective_Rainfall	315	mm/year
Infiltration_Factor	1	[-]
Infiltration_Rate	315	mm/year
Infiltration_Area	98800	m ²
Q Infiltration	0.000986	m ³ /s

PATHWAY SUMMARY

Path 1

Path 1 Type	Source		Unit	Unit	Receptor
Path 1 Name	Inert Infill		EBS: Node 1	Portland Sand: Node 1	PZ2 19
Path 1 Process	Declining source		ADRD (1D)	ADRD (1D) + Dilution	Monitoring Borehole
Path 1 Standards					Target Standard EQS
Path 1 Parameter1	Q_managed [m3/s]	0.000E+00	Velocity [m/s]	6.733E-07	
Path 1 Parameter2	Managed time [years]	0.000E+00	Dispersivity [m]	0.1	
Path 1 Parameter3	Q_path [m3/s]	9.862E-04	Travel Distance [m]	0.1	
Path 1 Parameter4	Q_decline [m3/s]	9.862E-04		Mixing Depth [m]	23.0
Path 1 Parameter5				Mixing Width [m]	585.0
Path 1 Parameter6			Q Dilute [m3/s]	0	Q dilute [m3/s] 0.000E+00

ATTENUATION PARAMETERS

Hydrogeological Units	EBS	Portland Sand
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General properties

Attenuation_Dry_bulk_density	kg/m3	2000	2000
Attenuation_Fraction_organic_carbon	[-]	0.5	

Contaminant specific parameters

Arsenic

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.38E+02	1.38E+02
Attenuation_Retardation_Species_1	[-]	1376	2084.33
Attenuation_Half_Life_Species_1	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_1	1/s	0	0

Chloride

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_2	[-]	1	1
Attenuation_Half_Life_Species_2	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_2	1/s	0	0

Lead

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2.70E+05	2.70E+05
Attenuation_Retardation_Species_3	[-]	2700001	4030310
Attenuation_Half_Life_Species_3	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_3	1/s	0	0

Mercury

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	2532.5	2532.5
Attenuation_Retardation_Species_4	[-]	25326	33261.3
Attenuation_Half_Life_Species_4	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_4	1/s	0	0

Nickel

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	430	430
Attenuation_Retardation_Species_5	[-]	4301	6516.15
Attenuation_Half_Life_Species_5	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_5	1/s	0	0

Sulphate

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	1.00E-03	1.00E-03
Attenuation_Retardation_Species_6	[-]	1	1
Attenuation_Half_Life_Species_6	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_6	1/s	0	0

Zinc

Attenuation_Partition_Coefficient_Kd_Speci	L/kg	3015	3015
Attenuation_Retardation_Species_7	[-]	3016	4563.18
Attenuation_Half_Life_Species_7	days	No Decay	No Decay
Attenuation_Decay_Coefficient_Species_7	1/s	0	0

BREAKTHROUGH RESULTS

Site Name: "Swanworth Northern Extension"

Level 3

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Concentrations in mg/L in PZ2 19

Compared with EQS target concentration in mg/L

1.000E-02	2.500E+02	1.000E-02	1.000E-03	2.000E-02	2.500E+02	1.000E-02
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Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	0.000E+00	1.762E+02	0.000E+00	0.000E+00	0.000E+00	5.745E+02	0.000E+00
5	1.711E-19	8.721E+01	0.000E+00	0.000E+00	3.879E-30	2.844E+02	0.000E+00
10	7.712E-11	3.621E+01	0.000E+00	0.000E+00	0.000E+00	1.181E+02	2.702E-19
25	4.527E-05	2.593E+00	0.000E+00	3.033E-35	4.774E-13	8.454E+00	2.279E-08
100	1.358E-03	4.302E-06	0.000E+00	0.000E+00	2.543E-04	1.403E-05	1.269E-02
1000	4.517E-13	0.000E+00	0.000E+00	3.470E-06	4.954E-07	0.000E+00	7.492E-08
10000	0.000E+00	5.360E-09	0.000E+00	1.248E-12	0.000E+00	1.747E-08	0.000E+00

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Remedial Target Concentrations in mg/L in Inert Infill

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	6.528E+02	1.000E+40	1.000E+40	1.000E+40	6.528E+02	1.000E+40
5	3.507E+15	1.319E+03	1.000E+40	1.000E+40	6.188E+26	1.319E+03	1.000E+40
10	7.780E+06	3.176E+03	1.000E+40	1.000E+40	1.000E+40	3.176E+03	4.441E+16
25	1.325E+01	4.436E+04	1.000E+40	6.595E+28	5.027E+09	4.436E+04	5.265E+05
100	4.419E-01	2.673E+10	1.000E+40	1.000E+40	9.438E+00	2.673E+10	9.456E-01
1000	1.328E+09	1.000E+40	1.000E+40	5.764E-01	4.844E+03	1.000E+40	1.602E+05
10000	1.000E+40	2.145E+13	1.000E+40	1.603E+06	1.000E+40	2.146E+13	1.000E+40

Compared with source concentrations in mg/L

6.000E-02	4.600E+02	1.500E-01	2.000E-03	1.200E-01	1.500E+03	1.200E+00
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Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Dilution Factor

2.212E+00 for all species and timeslices

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

Attenuation Factor

Time(years)	Species1 Arsenic	Species2 Chloride	Species3 Lead	Species4 Mercury	Species5 Nickel	Species6 Sulphate	Species7 Zinc
1	1.000E+40	1.180E+00	1.000E+40	1.000E+40	1.000E+40	1.180E+00	1.000E+40
5	1.585E+17	2.384E+00	1.000E+40	1.000E+40	1.398E+28	2.384E+00	1.000E+40
10	3.517E+08	5.741E+00	1.000E+40	1.000E+40	1.000E+40	5.741E+00	2.007E+18
25	5.991E+02	8.019E+01	1.000E+40	2.981E+31	1.136E+11	8.019E+01	2.380E+07
100	1.997E+01	4.832E+07	1.000E+40	1.000E+40	2.133E+02	4.832E+07	4.274E+01
1000	6.003E+10	1.000E+40	1.000E+40	2.605E+02	1.095E+05	1.000E+40	7.239E+06
10000	1.000E+40	3.879E+10	1.000E+40	7.244E+08	1.000E+40	3.880E+10	1.000E+40

Pollutant Linkage: Inert Infill, EBS, Portland Sand, PZ2 19

