Coombefield Quarry

Environmental Permit Application

Hydrogeological Risk Assessment

Portland Stone Ltd

September 2022

Prepared on Behalf of Tetra Tech Environment Planning Transport Limited.

Registered in England number: 03050297

Document Control

Document:	Hydrogeological Risk Assessment
Project:	Coombefield Quarry Permit Application
Client:	Portland Stone Ltd
Job Number:	784-B034779
File Origin:	X:\Projects\784-B034779 (Coombefield Quarry Permit Application)\60 Project Output\61 Work in Progress

Version:	1	**Status:**	Final
Date:	September 2022		
Prepared by: Alice Shaw	**Checked by:** Michael Jones	**Approved by:** Michael Jones	
Description of revision:			

Revision:		**Status:**	
Date:			
Prepared by:	**Checked by:**	**Approved By:**	
Description of revision:			

Revision:		**Status:**	
Date:			
Prepared by:	**Checked by:**	**Approved By:**	
Description of revision:			

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1.0 INTRODUCTION

1.1 REPORT CONTEXT

1.1.1 This report has been prepared by Tetra Tech on behalf of Portland Stone Limited (PSL) to support an environmental permit application for Coombefield Quarry (the site) at Southwell Road, Isle of Portland, Dorset, DT5 2EG.

1.1.2 PSL are seeking to gain a bespoke environmental permit to allow the operation of an inert landfill and a waste management facility that will include the following:-

- Inert waste recycling facility (including crushing and screening); and
- Household, Commercial and Industrial (HCI) Waste Transfer Station (including waste electrical and electronic equipment (WEEE)) with treatment via manual sorting and separation (via a picking station), screening (with a vibrating screen separator), the shredding of specific non-hazardous waste streams to produce RDF and the baling of specific waste streams such as cardboard, plastics and RDF.

1.1.3 This document corresponds to Question 3, Appendix 4 of Part B4 of the Environmental Permit application forms, which requires the provision of a Hydrogeological Risk Assessment (HRA). As noted in the Part B4 application form and the Environment Agency's (EA) 'Landfill operators: environmental permits' guidance, a HRA is only required for an application that comprises a landfill for inert waste or a deposit for recovery operation. As such, this document solely relates to the inert landfill.

1.1.4 The objectives of this document are to assess whether the proposed waste disposal operations and end-use as an inert landfill, its engineered containment design and construction, monitoring network and management controls fulfil the requirements of the Groundwater Regulations 2009 and Landfill Directive 1999 and ensure that the site is in compliance with the requirements of the Environmental Permitting Regulations, 2010.

1.1.5 Details regarding other aspects of the proposed waste operation are provided in other supporting documents that have been prepared to support the Environmental Permit Application. This includes the Environmental Setting & Site Design (ESSD) report, Operating Techniques and Environmental Risk Assessment (ERA).

1.1.6 Due acknowledgement is made for specific background information used in this document which was obtained from Hydrological and Hydrogeological Assessment that was completed by BCL Consultant Hydrogeologists Limited (Version 2, October 2021) to support the planning application (P/DCC/2021/04835). Parts of this document are repeated here for completeness.

1.2 SITE LOCATION

1.2.1 The site is situated within the wider Coombefield Quarry site, which is located approximately 500m north east of Southwell, on the Isle of Portland in Dorset. The wider quarry site comprises two areas; the southern section is known as Coombefield South and the Northern Section (i.e. the site) is known as Coombefield North. The site is centred at approximate National Grid Reference (NGR) SY 69107 70631. The site location and environmental permit boundary is shown on Drawing Number PSL/B034779/PER/01.

1.2.2 The Isle of Portland is connected to the mainland by Chesil Beach. The island comprises a generally elevated landform, with the central and northern coastline sections defined by rugged and steep cliffs.

1.2.3 In proximity to the site, the natural (pre-extraction) land elevation generally declines towards the southeast, reducing from sixty metres above Ordnance Datum (mAOD) above the northwest of the Site, to 46 mAOD to the southeast at Southwell Road. Further to the east/southeast the landform drops steeply, forming the aforementioned cliffs down to sea level.

1.2.4 Within the extraction area, ground elevations at the site range from 27 mAOD at the current base of workings to 65 mAOD towards the northern flank of Coombefield Quarry North (the site). The base of working is currently 28m below predevelopment landform.

1.3 BRIEF SITE HISTORY

1.3.1 The wider Coombefield Quarry has been quarried intermittently since 1951 under Planning Permission reference 200411 granted by Dorset Council.

1.3.2 Permission 200411 is subject to a ‘Review of Old Mineral Permission’ (ROMP) application that was submitted around 2006. This process seeks to agree modern planning conditions and included proposals for the restoration details with an end date of 2042. The ROMP Application has not been determined and therefore there is not a fixed restoration end date or approved restoration details for Coombefield Quarry.

1.3.3 In June 2017, Dorset Council granted planning Permission WP/16/00818/NOTS to allow the operation of a mine in the southern section of the wider quarry site known as Coombefield South. The operation comprises the extraction of approximately 25,000m^3 of Portland dimension stone and would be worked by the 'Room and Pillar' method which is the same methodology that's used at other mines that are present on the Isle of Portland. Following extraction, the permission WP/16/00818/NOTS allows the void to be filled with waste rock that's generated from the mining process.

1.3.4 In May 2022, a Planning Permission was granted by Dorset Council (reference P/DCC/2021/04835) to allow the operation of an Inert Landfill and a Waste Management Facility in the northern section of the quarry site known as Coombefield North which is the application site.

1.4 PROPOSED DEVELOPMENT

1.4.1 The inert landfilling activities will comprise the importation of inert waste for infilling the quarry void that has been created from mineral extraction activities at the site.

1.4.2 The works would be undertaken in phases (as shown on Drawing Numbers 801-06 to 801-12) and the site would be restored in accordance with the restoration scheme (Drawing Numbers 801-13 and 801-14) that was approved by Dorset Council as part of the planning permission (reference P/DCC/2021/04835).

1.4.3 The operations will comprise six phases (Phase 1a, 1b, 2a, 2b, 3a and 3b), where progressive infilling and restoration will commence in Phase 1a located to the northeast of the site and will progress towards Phase 1b which is located to the north west of Phase 1a. There is an area of land to the north of Phase 1b that will be left as unrestored quarry face for geological and ecological interest.

1.4.4 Following the completion of Phases 1a and 1b, works will progress in a south-westerly direction.

1.5 LANDFILL DESIGN PHILOSOPHY

Basal Layer

1.5.1 Prior to the commencement of landfilling activities, a geological basal barrier will be constructed in compliance with the 'Landfill Operators: Environmental Permits' guidance (updated 17th February 2022), which specifies a minimum geological barrier of 1m thickness and shall have a hydraulic conductivity with less than or equal to 1×10^{-7} m/s (See cross section on Drawing Number PSL/B034779/HYD/01 showing engineering details).

Side Sloping Lining

1.5.2 An engineered side wall liner is to be constructed along the sidewall of the quarry and is to have a thickness of 1m and a permeability of no greater than $1x10^{-7}$ m/s.

1.5.3 The proposed construction of the basal and side liner would be to the specification detailed in the Construction Quality Assurance (CQA) Plan that will be produced for the site. The method and testing of the material will be pre-agreed with the Environment Agency (EA) and subsequently demonstrated to ensure that the quality of installation is to the required permeability standards (i.e. no greater than $1x10^{-7}$ m/s).

Capping

1.5.4 In accordance with the current requirements of the Landfill Directive, an engineered cap (clay or plastic) is not required. However, on completion of filling to final levels it is proposed the site will be capped with 1m of restoration soils.

Restoration

1.5.5 Works would initially involve levelling operations within the eastern part of Coombefield North, in order to broadly infill holes and depressions and smooth out mounds and old stockpiles, prior to commencement of the main infilling operations. This is illustrated on Drawing Number 801-04. Cross sections are also provided on Drawing Number 801-15.

1.5.6 The main infilling works comprise of inert material tipped, graded out and compacted in layers to form the restoration landform. This would be approximately 2m below the original ground levels. The existing northern slot area would not be infilled, with infilled material sloping down towards this part of the site, which would remain as existing.

1.5.7 Following creation of the final restoration landform, the land would be left to naturally regenerate, developing into calcareous grassland over a period of time. Stone walls would be built in the local vernacular style in accordance with the layout shown on Drawing Number 801-14. This layout has been influenced by the historical pattern of small fields divided by stone walls that was evident prior to mineral extraction. In addition, some areas of scrubby vegetation would be incorporated around the edge of the site, to help integrate the restored land with the existing scrubby vegetation around the site boundary.

1.5.8 Groups of boulders would be randomly placed across the landscape to evoke the craggy character of the wider landscape, most notably older quarries that have not been previously restored but have been effectively abandoned many decades ago, and which have naturally regenerated.

Aftercare

1.5.9 In accordance with Condition 6 of planning permission P/DCC/2021/04835, aftercare will be carried for a period of 10 years commencing on completion of the approved restoration scheme for phases 1a, 1b, 2a and 2b. For phases 3a, 3b and 4, aftercare will be carried out for a period of 5 years following the completion of the approved restoration scheme for these phases.

1.5.10 Details regarding the site's aftercare are provided in the Closure and Aftercare Plan (Appendix I of the Environmental Permit Application).

1.6 REGULATORY CONTEXT, GROUNDWATER AND SURFACE WATER PROTECTION

Aquifer designation

1.6.1 According to the Multi-Agency Geographic Information for the Countryside's (MAGIC) website, the Portland Stone Formation limestone is classified as a Principal Aquifer which reflects the unit's potential ability to store and transmit groundwater, where present in sufficient areal extent and suitable geological/hydrogeological setting.

1.6.2 The limestone unit features negligible primary (intergranular) permeability, with groundwater storage and movement being dependant on the development of secondary permeability (weathering/fracturing) features within the aquifer. On the Isle of Portland, the Portland Stone Formation aquifer is overlain by the Lulworth Formation, which comprise a series of sandy limestones and mudstones, with generally lower permeability than the underlying Portland Stone Formation aquifer.

1.6.3 The Portland Stone Formation is underlain by the Portland Sand Formation. The Portland Sand Formation comprises silty dolomitic sandstone, with thin shelly limestones. 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.

1.6.4 According to the MAGIC website and BCL Consultant Hydrogeologists Limited, both the Lulworth Formation and Portland Sand Formation are classified as "Secondary A Bedrock Aquifer" – being capable of supporting local water supplies and/or baseflow supplies to springs etc. This again being the case only if the units are present in suitable geological setting etc.

1.6.5 Due to the elevated and largely isolated location of the island landform, recharge to the Portland Stone Formation aquifer on the Isle of Portland can only occur from rainfall (as opposed to any lateral flow from other aquifers). Recharge is therefore expected to occur as diffuse and autogenic input, either through direct recharge to areas of Portland Stone Formation outcrop, or as leakage through the overlying Lulworth Formation, where present.

1.6.6 According to the MAGIC website, the site is not situated in a groundwater source protection zone.

Licensed and Unlicensed Abstractions

1.6.7 According to BCL Consultant Hydrogeologists Limited (2021) a radial search of the EA licensed abstraction database was undertaken and confirmed there are no licensed water abstractions on the Isle of Portland.

1.6.8 In addition, BCL Consultant Hydrogeologists Limited (2021) contacted The Environmental Health team of Dorset Council have confirmed there are no active or inactive abstractions on the Isle of Portland.

Water Table

1.6.9 It has been established that the site shall be worked dry as the void's level will be significantly above the water table i.e. leaving a saturated zone of approx. 24m. Hence, the installation is not described as being sub-water table.

Hydrology

1.6.10 According to BCL Consultant Hydrogeologists Limited (October 2021), a water features survey was undertaken in June 2021 which identified two areas of surface water within a 2km radius of the site. Details of these features are summarised in Table 1 below.

Table 1: Surface Water Features within 2km of the Site

Name	Type	Easting*	Northing*	Distance	Notes
Red Door Tunnel	Spring	369172	70211	0.2	Water emerges from the base of the cliff beneath Cheyne House.
Culvers Well	Spring	368405	69261	1.3	Dry at time of visit. Spring from Mesolithic site travels 300m through a gully and terminates as a waterfall on the cliff edge.

** - Indicates Approximate Location*

1.6.11 The outfall observed at Red Door Tunnel has been proposed as a monitoring point in the Hydrometric Monitoring Scheme (the HMS), however data is unsubstantial due to unsafe access.

1.6.12 A spring is located at the Culverwell Mesolithic Site approximately 1.3 km southwest of the site which is situated at 28 mAOD. As the highest groundwater elevation recorded within the site was 11.4 mAOD

(P2/21), this is not considered to be in hydraulic conductivity to the site.

1.6.13 The EA hold no data of surface water level or flow sites on the island.

1.6.14 In terms of flooding, the ‘Flood Maps for Planning’ Services indicates that the Site is not situated within a flood risk zone.

Ecology

1.6.15 A ‘Nature and Heritage Conservation Screen’ (EPR/LB3202GS/A001) was requested from the EA. The screen determines the presence of any site of nature and heritage conservation, or protected species or habitats that may be impacted by the proposal. A copy of the results is in the Environmental Risk Assessment (Appendix C of the Environmental Permit Application).

1.6.16 The results of the screen identified the following potential receptors:-

- Isle of Portland to Studland Cliffs (Special Area of Conservation) located approximately 45m east of the site;
- Studland to Portland (Special Area of Conservation) located approximately 215m east of the site;
- Isle of Portland (Site of Special Scientific Interest) located approximately 45m east of the site;
- Pennsylvania Quarry (Local Wildlife Site) located approximately 60m north east of the site;
- Deciduous Woodland located approximately 100m west of the site; and
- Maritime Cliffs and Slopes located approximately 45m east of the site.

2.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

2.0.1 The conceptual hydrogeological model for the site is based on the source-pathway-receptor linkages and relies on the geological and hydrogeological information gathered during site investigations.

2.0.2 A preliminary schematic conceptual hydrogeological model for the site is presented as cross sections in Drawing number PSL/B034779/HYD/01. This model will be updated as the site develops and more geological/hydrogeological information becomes available.

Source: potentially-contaminating leachate that could be generated by rainfall infiltration through the emplaced inert material and any moisture inherent to the inert material itself.

Pathways: to include the landfill liner system (base and sides), an unsaturated zone within the *in situ* geology, and a saturated zone below the groundwater table in which dilution and degradation processes may occur.

Receptors: the groundwater system beneath the site is considered to be the primary receptor. To our knowledge there are no secondary receptors in the form of licensed surface water abstractions.

2.0.3 A detailed discussion of the three components of the conceptual model is given in the sections below.

3.0 CONCEPTUAL MODEL: SOURCE TERM

3.0.1 The requirements of the Landfill Directive for the disposal of inert waste material do not necessitate the installation of a leachate management or monitoring system. However, given the sensitive nature of the underlying aquifer (Limestone) that will remain following removal of the superficial deposits a leachate source term component will be incorporated into this risk assessment process.

3.0.2 Permitted wastes accepted at the site will be strictly inert as classified under the Landfill Directive (1999/31/EC) and Council Decision (2003/33/EC) of 19 December 2002 'Establishing criteria and procedures for the acceptance of waste landfills'.

3.0.3 Details regarding the proposed waste types including restrictions are provided in the Operating Techniques (Appendix B of the Environmental Permit Application).

3.0.4 A volume of 660,200m^3 of imported material (or 990,300 tonnes using a conversion factor of 1.5m^3/tonne) is required in order to restore the site following mineral extraction.

3.0.5 The proposed types of waste to be deposited into the landfill void are detailed in the Operating Techniques report (Appendix B of the environmental permit application).

3.0.6 However, a consideration is made for the potential of accepting waste that is not inert (e.g. potentially contaminated soil) or non-inert waste concealed within a load of waste that appears to be inert. Due to the inert nature of the material to be used to restore the quarry, it is considered highly unlikely that water coming into contact with the material at the site will generate high concentrations of pollutants. It is proposed to screen incoming waste under Council Decision (2003/33/EC) Inert waste acceptance criteria.

3.0.7 It is recognised that hazardous substances and non-hazardous pollutants are present in these criteria and could occur from rogue loads of non-inert waste. However, to mitigate this, the operator would restrict the source of waste materials allowed on to the site and all waste would be subject to stringent Waste Acceptance Procedures (as detailed in the Operating Techniques, Appendix B of the Environmental Permit Application). It is therefore considered that hazardous substances are not expected to be present and non-hazardous substances are expected to be low.

3.0.8 The likelihood of any (or both) of these types of actions is predicted to be very low as strict source characterisation procedures will be applied to the loads being imported and visual inspection of each load will be undertaken prior to and during disposal.

3.0.9 Any fuel tanks and oil drums used on the site and by sub-contractors will be stored in a containment bund capable of containing 110% of the total quantity of fuel present at any one time.

3.0.10 All fuel spillages from moving plant or machinery will be remediated immediately in a safe and controlled manner by ensuring spills kits are kept on site and checked daily.

4.0 CONCEPTUAL MODEL: PATHWAYS

4.1 GEOLOGY

4.1.1 To characterise the geological setting for the site, BCL Consultant Hydrogeologists Limited used British Geological Survey (BGS) mapping and drilling data in combination with details obtained during a site-specific drilling exercise, to define the geological sequence in proximity to the site.

4.1.2 A summary of the stratigraphic sequence for the area encompassing the site, is provided below (order shown from youngest units to oldest):-

- Lulworth Formation – Limestones interbedded with marl and clay (>3m thick);
- Portland Stone Formation – White-grey oolitic limestone separated by chert beds (35m thick);
- Portland Sand Formation – Marls, clays and sandstones with dolomitic seams (42m thick); and
- Kimmeridge Clay – Clays, mudstones, shales and marls with some dolomitic seams (>100m thick).

4.1.3 The Lulworth Formation covers much of the southern and central sections of the island in outcrop, including the area encompassing the site. Within the site itself the Lulworth Formation has been removed to facilitate quarrying of the underlying Portland Stone Formation.

4.1.4 The Portland Stone Formation (PSTF) constitutes the economic mineral and records a pre-quarry thickness of around 35m.

4.1.5 Drilling logs for groundwater monitoring points installed are included at **Appendix A** with a piezometer location plan at PSL/B0134779/GW/01. The aforementioned logs record the presence of a laterally continuous 1.5m to 5m thick band of Portland Clay (uppermost unit within the Portland Sand Formation) underlying the base of the Portland Stone Formation.

4.1.6 Elevations of the Portland Clay horizon range from 22 mAOD at the northern slot (P4/21) reducing to 13 mAOD towards the south-west of the Site (P1/21).

4.1.7 No water strikes were recorded during drilling; however a delayed response of up to 24 hours was observed at each drilling location before water was recorded within the boreholes.

4.1.8 The groundwater monitoring points extend between 8.5m – 22m into the underlying Portland Sand Formation. The BGS describe the remaining units of the Portland Sand Formation as approximately 30m thick medium grey dolomitic sandstone with thin shelly limestones.

4.1.9 According to the results from the BGS' "Geology of Britain Viewer" there is no evidence of any mine activities (subsurface pathways) beneath the site.

4.2 HYDROGEOLOGY: AQUIFER DESIGNATION AND GROUNDWATER VULNERABILITY

4.2.1 The MAGIC website shows that the groundwater vulnerability for the site is High.

4.2.2 As noted in Section 1.6, the aquifer designation for the solid geology comprises a combination of Principal Aquifer for the Portland Stone Formation and Secondary A for the Portland Sand Formation and Lulworth Formation. There are no recorded aquifers within the superficial deposits.

4.3 GROUNDWATER MONITORING BOREHOLES

Groundwater levels

4.3.1 The available groundwater data submitted by PSL were plotted on the hydrograph of Appendix B (raw level data also in this appendix). The following comments apply to the plotted data:-

- The highest average water table levels are recorded in P2/21 and P3/21, whereas the lowest average levels were measured in borehole P1/21. Borehole P4/21 has reported dry conditions throughout the monitoring period.
- From these data the plotted groundwater contours indicate an inferred flow direction to be from north west to south east, mirroring the reported flow direction in the BCL report and topographic setting.
- A groundwater contour map has been prepared and is presented as Drawing Number PSL/B0134779/GW/01.

4.3.2 The current inferred groundwater flow direction has therefore allowed for the identification of the up- and down-gradient boreholes, namely:-

Up-gradient: P2/21 and P4/21;

Down-gradient:P1/21 and P3/21.

Baseline Groundwater Quality

4.3.3 Groundwater quality data were obtained from the boreholes forming the current monitoring network

(Drawing Number PSL/B0134779/GW/01) between August 2021 and May 2022.

4.3.4 The groundwater quality results for the indicator substances ammoniacal nitrogen (Amm. N) and chloride are chosen to identify are potential contamination arising from the landfill due to their high mobility. Sulphate is also included as an additional substance since it is identified as being a primary potential leachable component of inert materials along with chloride.

4.3.5 Various metals have also been included in the interpretation of the chemical characteristic of the groundwater and these have been discussed in the sections that follow.

4.3.6 The raw and plotted data to derive the time series chemographs are shown in Appendix C. Plotting of “less than” reported values has been possible by the application of the substitution rule of 0.5 x L, where L is the “less than” value, as per guidance “Final Technical Report P1-471_Techniques for the interpretation of monitoring data”.

4.3.7 It should be noted that potential outliers have not been removed at this stage due to the currently limited amount of monitoring information, but statistical analysis has been performed on the data set for the calculation of the Environmental Assessment Limits (EALs) in Section 6.2. A review of these monitoring data will be carried out once a reasonably robust set is available.

Up-gradient boreholes

- The Amm. N chemograph displays a peak in values on one occasion within P2/21 during October 2021 visit. The remaining data points are in a relatively linear pattern, with no discernible trends. Average concentrations of the plotted data are around 0.03mg/l.
- Chloride average concentrations are all below 100mg/l for up-gradient borehole P2/21. The trend displayed by the plotted values is generally stable and linear around an average of 60mg/l.
- Average sulphate values are around 300mg/l for this up-gradient borehole. The plot of these concentrations displays a relatively stable but slightly increasing trend as displayed by the data since April 2022. This trend will be monitored for any future changes.
- Common metal values up-gradient, most importantly with cadmium, lead and mercury have concentrations below the detection limits of the laboratory in most of the visits and iron being consistently found in the dissolved state. The remaining metals have varying concentrations between being below the limits of detection or a narrow range of values. The few organic compounds sampled also all show values below the limit of detection of the laboratory.

Down gradient boreholes

- The Amm. N plot is affected by spurious behaviour in the values found in P1/21 until October 2021, after which concentrations rapidly declined to around 1.5mg/l displaying a trend mostly linear and stable. Average concentrations and plotting trend for P3/21 is very similar to that of up-gradient P2/21 with an average value of 0.047mg/l.

- Average chloride concentrations in down-gradient boreholes P1/21 and P3/21 are also all below 100mg/l and fall within a very narrow average range of 50mg/l and 75mg/l respectively. The linear trends displayed in the chemograph by both monitoring points are a reflection of the narrow plotting range of these boreholes.

- Average sulphate values for P1/21 are around 700mg/l whereas for P3/21 these are below 100mg/l. The trend for P1/21 is initially more haphazard that that displayed by P3/21, which in turn is linear and stable. Interesting to note the harmonised low and high towards the end of the monitoring period between P1/21 and up-gradient P2/21.

- Metal values down-gradient display similar patterns to those up-gradient. Again, cadmium, lead and mercury have not been detected above the limit of detection of the laboratory in all visits and iron is being consistently found in the dissolved state. The remaining metals have varying concentrations between being below the limits of detection or a narrow range of values. The organic suite tested during the monitoring period in question has returned concentration for all substances below the laboratory's limit of detection.

4.3.8 As an overall comment, the groundwater quality between the up-gradient and down-gradient monitoring points is nearly identical, with P2/21 in all cases plotting between the graphs of the two down-gradient boreholes – a situation somewhat varied as expected to be found within a hydrogeological environment that has been anthropogenically influenced over many years of development.

4.3.9 Due to the limited amount of statistical data currently available, the development of groundwater quality patterns will become clearer as more information is gathered.

Long Term Hydrogeological Changes

4.3.10 Hydrogeological changes are not expected to occur within the Limestone formation due to the proposed extraction activities as the area has already been extensively anthropogenically affected. Therefore, long term influences cannot be predicted as a result of the anthropogenic affects experienced around the site.

4.3.11 Any impacts in terms of both magnitude and duration that future climatic changes could bring about on the groundwater regime are too difficult to predict given the localised nature of the development.

4.4 SURFACE WATER MONITORING

4.4.1 On site surface water quality data was obtained between September 2021 and May 2022.

4.4.2 The location of the monitoring point is shown on Drawing Number PSL/B0134779/MON/01.

4.4.3 The same three substances chosen to evaluate the quality of groundwater are discussed in this section.

4.4.4 Plots of Amm N, chloride and sulphate are found in Appendix C. The following comments apply:

1. Values of Amm N are mostly below the limit of detection of the laboratory and only one value is seen to create a relative spike is around 0.087mg/l.

2. Chloride's concentrations are linearly plotted around the 50mg/l value, which is very similar to that found in the groundwater quality discussions. No other discernible trend is seen.

3. A relative spurious low is seen in the sulphate plot from the sample collected during Dec. 2021. This low value of 0.04mg/l is anomalously not in range of the average values recorded 200mgl/ and 150mg/l.

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5.0 CONCEPTUAL MODEL: RECEPTORS

5.1 CURRENT LICENSED/EXEMPT GROUNDWATER OR SURFACE WATER ABSTRACTIONS

5.1.1 As noted in Sections 1.6.7 and 1.6.8, there are no licensed water abstractions on the Isle of Portland.

5.1.2 As noted in Section 1.6.6, the site does not lie within the source protection zone (SPZ). In addition, the MAGIC website indicates that the site does not coincide with a drinking water safeguard zone.

5.1.3 Therefore, the remaining geological unit(s) outside of the development i.e. the Portland Stone Formation (Limestone), is considered to be the principal receptor for this assessment.

5.2 EXISTING NATURAL/INDUCED DISCHARGES (E.G. SPRINGS/WETLANDS)

5.2.1 Groundwater flow direction appears to be down the topographic dip of the strata towards the south eastern boundary. There is a suspected spring emanating down-gradient of the area, however this feature can be risked out given the widespread anthropogenic impacts the area has undergone in the past.

Surface Water

5.2.2 As noted in Section 1.6, there are two surface water features within 2km of the site. The nearest feature is the Red Door Tunnel which is a spring that's located approximately 0.2km of the site (down gradient of the site). The second feature is the Culvers Well which is also a stream and is located approximately 1.3km from the site (down gradient of the site). This latter feature is significantly distant from the proposed development to be affected by any adverse impacts.

5.2.3 The restoration proposals will involve the placement of lower permeability infill material across much of the north-eastern section of the Site. This is likely to reduce the infiltration capacity of this area and as such, infiltration areas have been included within the restoration landform to receive runoff from the infill area.

5.2.4 The northern section of the site is to be graded towards the 'Slot,' which will include exposed limestone across the base and surrounding quarry faces. Similarly, the majority of the restoration landform is to be graded towards a bowl feature located in the southern section of the infill area. The southern flank of the bowl is to be left in continuity with the exposed quarry faces, with any water accumulation being allowed to dissipate back to ground.

5.3 SITES OF ECOLOGICAL OR NATURE CONSERVATION SIGNIFICANCE

5.3.1 As noted in Section 1.6, there are two SPAs, one SSSI and one local wildlife site within the vicinity of the site. In addition, there are areas within the vicinity of the site that comprise protected habitats. This includes deciduous woodland, Maritime Cliffs and Slopes.

6.0 QUANTITATIVE HYDROGEOLOGICAL RISK ASSESSMENT

6.1 THE NATURE OF THE ASSESSMENT

6.1.1 The proposed environmental permit application will be submitted for the site in order to receive inert materials. Given the definition of the inert wastes to be imported, the total leachability, pollutant content and ecotoxicity of any leachate generated are considered to be insignificant and unlikely to endanger the quality of any receiving environment.

6.1.2 In line with current legislation, inert landfills could be subject to a quantitative risk assessment process if a reduction in the specification of the Landfill Directive, Annex 1 “geological barrier”, would be considered and the receiving environment has been identified as being particularly sensitive.

6.1.3 In the case of the proposed geological barrier its specification, as set out in the Operating Techniques, will not be reduced therefore the receiving environment i.e. the limited areal extent of the Portland Stone Formation (Limestone), is not affected. However, a quantitative risk assessment will be undertaken in order to consider the risk due to an accidental acceptance of a rouge load of materials.

6.1.4 The inert nature of the materials imported into the site will ensure that any leachate generated (both in terms of quality and quantity) is expected to pose a negligible risk to the receiving environment therefore has considerably lowered the sensitivity of the first component of the Source-Pathway-Receptor linkage.

6.1.5 The likelihood of accidents that could result in a potential impact would be during the operational phase of the excavation and infilling activities, when plant and machinery are used in those tasks. Any fuel tanks and oil drums used on the site will be stored in a containment bund capable of containing 110% of the total quantity of fuel present at any one time.

6.1.6 All fuel spillages from moving plant or machinery will be remediated immediately in a safe and controlled manner by ensuring spills kits are kept on site and checked daily. However, the risk is considered low and closely related to efficient site management and conscientious equipment and plant operators who will ensure lowering/minimising risk through a robust implementation of site procedures which are detailed in the Operating Techniques document accompanying this application.

6.1.7 A risk screening exercise has also been carried out in order to identify key contaminants potentially generated within the leachate and associated with the Waste Acceptance Criteria (WAC) to be adopted, in accordance with EU Council Decision 2003/33/EC.

6.1.8 However, a quantitative assessment will be undertaken based on the principal nature of the aquifer around and beneath the site and the possibility of a rogue load(s) being accepted on site, on the assumption that some materials would not be subjected to testing, even though it has been stated that specific waste codes will be tested for (see paragraph 6.1.13).

6.1.9 A risk screening exercise has also been carried out in order to identify key contaminants potentially generated within the leachate and associated with the Waste Acceptance Criteria (WAC) to be adopted, in accordance with EU Council Decision 2003/33/EC.

6.1.10 The WAC parameters for inert waste used as key indicators substances are listed in Table 2 below. Equivalent leachability values for the inert WAC concentrations have been calculated using the methodology of C=A/10, where C is the contaminant concentration within the eluate (mg/l) and A is the leachate contaminant concentration within the soil sample (mg/kg).

Table 2: Inert WAC and Equivalent Leachate Quality

Substance	Leaching Limit (mg/kg) L/S=10l/kg	Leachate Concentration (mg/l)
Hazardous Substances		
Arsenic	0.5	0.05
Chromium VI*	0.5	0.05
Lead	0.5	0.05
Mercury	0.01	0.001
Non-hazardous Pollutants		
Antimony	0.06	0.006
Barium	20	2
Cadmium	0.04	0.004
Chloride	800	80
Copper	2	0.2
Fluoride	10	1
Molybdenum	0.5	0.05
Nickel	0.4	0.04
Selenium	0.1	0.01
Sulphate	1000	100
Zinc	0.4	0.04
Phenol Index**	1	0.1

* *Note: Chromium VI is a hazardous substance. However, the source term concentration taken from European Union Council Decision 2003/33/EC is for total chromium. It is conservatively assumed that all chromium is present as chromium VI and is therefore considered as hazardous.*

** *Note: Phenol Index is not a substance, so instead the chemical Phenol has been chosen.*

6.1.11 The equivalent leachate concentrations will be screened against the Environmental Assessment Levels (EALs) as discussed and developed in the next section.

6.2 ENVIRONMENTAL ASSESSMENT LIMITS (EALS)

6.2.1 Although the site will accept inert materials, a set of EALs will be proposed since these represent a pollutant concentration at which no significant risks to human health are expected and in order to protect the identified potential principal receptor i.e. groundwater, down gradient of the site.

6.2.2 It is proposed to set the EALs at the UKDWS (or EQS for freshwater in the absence of a UKDWS value, except where background quality exceeds the specified standard) for non-hazardous pollutants for the inert WAC indicator substances listed in Table 3.

6.2.3 For hazardous substances, the EALs will be set at the corresponding minimum reporting value (MRV) as defined in EA guidance – "Hazardous substances to groundwater: minimum reporting values" and UK Technical Advisory Group (UKTAG) – "Technical report on groundwater hazardous substances" or where background water quality exceeds the specified standard.

6.2.4 In the event that background quality exceeds the specified standards, the EAL will be set at the maximum recorded concentration, following removal of outliers where necessary. Where background concentration is less than the corresponding environmental standard, the EAL will be derived as the midpoint between the maximum concentration and the environmental standard. Appendix C shows the statistical derivation of the chosen EALs.

Table 3: Inert WAC and EALs

Substance	EQS (µg/l)	UKDWS (µg/l)	MRV (µg/l)	Selected EAL (µg/l)	Max. conc. (µg/l)
Hazardous Substances					
Arsenic	20	10	5	5	5.97
Chromium VI	5	1	5	5	NM
Lead	20	10	0.2	0.2	0.2
Mercury	1	1	0.02	0.02	0.1
Non-hazardous Pollutants					
Antimony		5		4.2	1.7
Barium		1,300		724.1	148.2
Cadmium	5	5		3	1
Chloride	250,000	250,000		168,800	87,600
Chromium	20	50		29	8
Copper	1	2,000		1005.50	11

Fluoride		1,500		923.50	347
Molybdenum		70		45	20
Nickel	4	20		16.40	12.8
Selenium		10		6.25	2.5
Sulphate		250,000		250,000	825,000
Zinc	12.3			8.65	5
Amm N		500		500	2,500
Phenol	7.7			4.35	1

**NM denotes parameter not included in the monitoring of groundwater quality.*
***Cells coloured grey indicate no water quality screening or MRV available*

6.2.5 It is noted that the limit of detection (LOD) for mercury is greater than the UKTAG limit of quantification of the MRVs. The concentration thus obtained is not above the LOD therefore the baseline LOD has been used as the EAL.

6.2.6 It is recommended these EALs be reviewed during the annual monitoring reporting procedure but also informally following each monitoring visit due to the specific environmental circumstances associated with the site once operational.

6.3 THE HYDROGEOLOGICAL RISK ASSESSMENT

6.3.1 Quantitative assessments are not typically requested for inert restoration sites as they fall outside the scope of the Groundwater Directive unless the proposed site is located within a setting which presents a risk to a sensitive receptor (i.e. Principal Aquifer or Secondary A Aquifer), in which case further consideration of risk due to the accidental acceptance of contaminated material is required.

6.3.2 However, since the proposed development is located on a Limestone (principal) aquifer, it is a consideration to safeguard this sensitive receptor by undertaking a quantitative risk assessment to identify potential contamination.

6.4 PROPOSED ASSESSMENT SCENARIOS AND PRIORITY CONTAMINANTS MODELLED

6.4.1 The restoration of the site will be achieved by using inert waste materials which will be subject to a robust Waste Acceptance procedure during the entire operation.

6.4.2 An engineered geological barrier will be formed at the base of the void with sidewall liners. Both the geological barrier and sidewall liners will be will 1m in thickness with a minimum hydraulic conductivity of $1x10^{-7}$m/s or 0.5m thick layer with a minimum hydraulic conductivity of $5x10^{-8}$m/s.

6.4.3 There will be no difference in the water balance or contaminant transport mechanisms and processed between the operational and post close phases. Therefore, a single lifecycle has been considered in the quantitative assessments. The models conservatively assume that the site is filled within a relatively short time (17 years) and therefore the operational phase is not simulated. The model considers the post-completion phase.

6.4.4 As there is no cap or artificial sealing liner considered, there is no consideration of deterioration of these components by the risk model.

6.4.5 In addition to the above, a 'Rogue Load' Assessment has also been carried out, which simulates higher leachate concentrations resulting from a 'rouge' non-inert waste types being present in the waste mass.

6.4.6 WAC (waste acceptance criteria) parameters for inert waste have been used as the key indicator substances to be modelled. Equivalent leachability concentrations for the Inert WAC values have been calculated in Table 2 (Section 6.1). The equivalent 'leachate' concentrations have been screened against the EALs which are outlined in Section 6.2. The concentrations which exceed the EALS (highlighted in orange) are detailed in Table 4 below.

Table 4: Inert WAC, Leachate Quality and EALs

Substance	Leaching Limit (mg/kg) L/S=10l/kg	Leachate Concentration (mg/l)	EALs (mg/l)
Hazardous Substances			
Arsenic	0.5	0.05	0.005
Chromium VI*	0.5	0.05	NM
Lead	0.5	0.05	0.0002
Mercury	0.01	0.001	0.00002
Non-hazardous Pollutants			
Antimony	0.06	0.006	0.0042
Barium	20	2	0.724
Cadmium	0.04	0.004	0.003
Chloride	800	80	169
Copper	2	0.2	1.0
Fluoride	10	1	0.923
Molybdenum	0.5	0.05	0.045
Nickel	0.4	0.04	0.0164
Selenium	0.1	0.01	0.00625
Sulphate	1000	100	250
Zinc	0.4	0.04	0.00864
Phenol Index**	1	0.1	0.00435
Amm N		0.5	0.5

6.4.7 In addition to Inert WAC limits, the Landfill Directive recommends using parameters for early indication of a change in quality. Ammoniacal Nitrogen (Amm N) will also be used within the model to determine the potential nature of the 'leachate' generated. The source term for Amm N has been assumed in the absence of a WAC limit. A value of 0.5mg/l has been applied in the model as the 'leachate' source which is the UKDWS for ammonium and therefore is considered to be a highly conservative assessment of 'leachate' quality for inert waste.

6.5 QUANTITATIVE RISK ASSESSMENT MODEL

6.5.1 The Environment Agency approved computer software LandSim (Version 2.5.16) is used to model the risks arising from the entire site on the groundwater system. This simulation package is considered valid for the quantification of the risks associated with the development as it uses a probabilistic approach to quantitatively assess potential hazards to receptors.

6.5.2 Analysis was undertaken on the basis of the following assumptions/criteria which are also applicable to this review process:-

1. The underlying groundwater table was assumed to be the primary receptor;
2. A declining source term was used to reflect flushing of contaminants from the waste by infiltrating precipitation;
3. Retardation or degradation of contaminants in the clay liner was modelled;
4. An aftercare period of 100 years is chosen to represent a reasonable timespan for the site to stabilise and ensure that it poses no environmental threat. During this period of long-term management, it is assumed that active control and management of the monitoring network will be carried as part of the permit;
5. The receptors for the purposes of the model are:-
   - Base of the unsaturated zone for hazardous substances; and
   - A monitoring borehole located hydraulically down gradient at the site boundary for non-hazardous pollutants.

6.5.3 Model defaults have only been used where site-specific data are unavailable and applied with a range of values wherever possible, rather than a single input. It is considered the approach to model the entire site as one single cell to be more conservative than using smaller individual cells as this would have a far larger impact on the environment.

6.5.4 Table D in Appendix D presents the model's input parameters, values and justifications for their applicability to the simulation.

6.6 LANDSIM MODEL RESULTS

6.6.1 The LandSim results in graphical format are presented in Appendix E.

6.6.2 The concentrations of the modelled Hazardous substances at the base of the unsaturated zone, as predicted by LandSim, are presented in Table 5, along with concentrations of the modelled Non-hazardous pollutants at the off-site down hydraulic gradient receptor (Table 6).

6.6.3 All results are reproduced at the worst case or 95th percentile, since this level of confidence provides a robust factor of safety in the reporting of the simulated results.

Hazardous Substances

6.6.4 Table 5 and the LandSim plot confirm that the chosen indicator substances were not detected within the stipulated management period of 100 years.

Table 5: Predicted concentrations of hazardous substances at base of unsaturated zone within 100 years (95th percentile)

Parameter	Concentration at 100 years	MRVs (mg/l)
Arsenic	0.0mg/l	0.005
Lead	1e^{-20}mg/l	0.0002
Mercury	0.0mg/l	1e-5

Non-hazardous pollutants

6.6.5 The model predicts that the concentrations of the modelled Non-hazardous pollutants (Table 6) would not exceed their relevant EALs at the receptor point, with 95% probability and within the chosen management period of 100 years, except for Amm N.

Table 6: Predicted concentrations of non-hazardous pollutants at off-site receptor within 100 years (95th percentile)

Parameter	Concentration at 100 years (mg/l)	EALs (mg/l)
Ammoniacal N	1.85	1.2
Antimony	3.7e-^{19}	0.005
Barium	0.0	1.3
Cadmium	1e^{-19}	0.00254
Nickel	1e^{-19}	0.12
Selenium	2.71e^{-20}	0.007
Zinc	0.005	0.015
Phenol	4e^{-19}	0.0077

6.6.6 From the above results of the LandSim simulations it is concluded that the predicted discharges will remain in compliance with the requirements of the Groundwater Regulations, 2016, throughout the lifecycle of the installation.

6.7 SENSITIVITY ANALYSIS

6.7.1 The nature of the material proposed for the restoration of Coombefield Quarry is inert. The material is therefore unlikely to exceed the inert test criteria (Inert WAC Assessment) limits. It is expected that 'leachate' concentrations generated will be lower that the upper limits of the WAC threshold.

6.7.2 However, to assess the risk of 'rogue loads' being accepted at the site and as part of the sensitivity analysis model, simulations based on the maximum concentration of WAC source term inputs multiplied by a factor of 1.5 have been run. These upper limits have been used to define the source term inputs into the model 'leachate' inventory and are intended to provide a worst-case scenario as the model assumes that all waste deposited at the site is greater than the inert WAC.

6.7.3 The maximum simulated contaminant concentration of hazardous substances and non-hazardous pollutants are reported in Table 7 and Table 8 respectively, at the 'Phase Monitor Well' when the initial concentration of contaminants is increased to account for the acceptance of a rogue load at the site.

Table 7: Simulation of predicted concentrations of hazardous substances at base of unsaturated zone within 100 years after rouge load (95th percentile)

Parameter	Concentration at 100 years	MRVs (mg/l)
Arsenic	0.0mg/l	0.005

Lead	0.0mg/l	0.0002
Mercury	$3.2e^{-24}$mg/l	1e-5

Table 8: Predicted concentrations of non-hazardous pollutants at off-site receptor within 100 years after rouge load (95th percentile)

Parameter	Concentration at 100 years (mg/l)	EALs (mg/l)
Ammoniacal N	1.86	1.2
Antimony	0.0	0.005
Barium	0.0	1.3
Cadmium	0.0	0.00254
Nickel	0.0	0.12
Selenium	0.0	0.007
Zinc	0.02	0.015
Phenol	0.0	0.0077

6.7.4 All of the simulated maximum concentrations, using rogue load 'leachate' concentration estimates as the source term, fall below their respective EALs again with the exception of Amm N and a marginal breach by Zinc.

6.7.5 Maximum (at 95th%) concentrations increase when rogue load leachate concentration estimates were used as the source term, as expected, however it appears that the model is only marginally sensitive to contaminant concentrations changes at the source, when compared to the original values.

6.8 COMPLIANCE LIMITS

6.8.1 Although the site will accept inert materials, a set of Compliance Limits (CL) will still be required to form part of the Environmental Permit, since this is defined as a value set at the down gradient compliance points P1/21 and P3/21, calculated to be a maximum concentration allowable at that point in order to protect the identified potential principal receptor i.e. groundwater.

6.8.2 However, compliance limits will not be derived and presented at this stage in the application process since the baseline groundwater quality is impaired by potential anthropogenic inputs and the monitoring data set is not considered to be developed enough to obtain reach realistic values. Therefore, it is proposed that compliance limits will be submitted at a later date and after consultation with the Agency.

7.0 REVIEW OF TECHNICAL PRECAUTIONS

7.1 REVIEW OF TECHNICAL PRECAUTIONS

7.1.1 A series of necessary technical precautions have been identified as part of this risk assessment, which will be reviewed during the life of the permit.

Capping

7.1.2 On completion of infilling to final waste levels, the installation will not require a capping system but the final landform will be restored with soil materials recovered during the preparation phase of the site.

Lining Design

7.1.3 The base and side slopes will have an engineered containment system, which has been risk assessed on the basis of the proposed design and according to the waste stream to be imported.

7.1.4 Additional confidence in the robustness of these designs will be provided by the CQA supervision programme that will be implemented during the construction phases of each individual cell.

Leachate Head Control, Drainage and Extraction Systems

7.1.5 These operational controls will not be required as the installation is an inert landfill.

Groundwater Management

7.1.6 Given the difference in proposed basal level of the development and current average groundwater elevations it is not expected to encounter groundwater inflows into the working. Therefore a dewatering system will not be implemented in order to work the void safely.

7.1.7 The operator will also ensure that any rainfall collected within the open void is managed as necessary. Site CQA supervision will also ensure that any potential heave encountered during construction works will be managed and that safe working conditions will be maintained.

Surface Water Management

7.1.8 As noted in Section 5.2, the restoration proposals will involve the placement of lower permeability infill material across much of the north-eastern section of the Site. This is likely to reduce the infiltration capacity of this area and as such, infiltration areas have been included within the restoration landform to receive runoff from the infill area.

7.1.9 The northern section of the Site is to be graded towards the ‘Slot,’ which will include exposed limestone across the base and surrounding quarry faces. Similarly, the majority of the restoration landform is to be graded towards a bowl feature located in the southern section of the infill area. The southern flank of the bowl is to be left in continuity with the exposed quarry faces, with any water accumulation being allowed to dissipate back to ground.

8.0 REQUISITE SURVEILLANCE

8.1 THE RISK BASED MONITORING SCHEME

Groundwater Monitoring

8.1.1 Groundwater level and chemical data are to be collected from the groundwater monitoring points shown in Drawing PSL/B0134779/MON/01.

8.1.2 The minimum number of parameters to be sampled and monitoring frequency to be included in the Environmental Permit are presented in Table 9 below. These requirements are considered adequate in providing an ongoing characterisation of the groundwater conditions.

Table 9: Groundwater Determinants and Sampling Frequency

Monthly	Quarterly	Annually
Levels	pH, Chloride, Alkalinity, Amm N, Sulphate, Sodium, Potassium, Iron, Manganese, Cadmium, Chromium, Copper, Calcium, Nickel, Lead, Zinc, Electrical conductivity, Magnesium, Selenium, Mercury	*To include quarterly suites plus:*

Surface Water

8.1.3 Surface water is sampled from surface water monitoring point SW1 as shown on Drawing Number PSL/B0134779/MON/01.

8.1.4 The frequency and sampling suite to be implemented for the characterisation of surface water quality is presented in Table 10.

Table 10: Surface Water Determinants and Sampling Frequency

Quarterly
pH, Chloride, Amm N, Phosphorus, Suspended Solids, Sulphate, COD, Electrical conductivity, suspended solids, visual oils and grease

8.2 CONTINGENCY ACTION PLAN

8.2.1 An annual review of the proposed compliance limits will be carried out and any alterations in the compliance levels discussed and agreed with the EA.

8.2.2 Where the site monitoring programme identifies an increase in groundwater determinants that could lead to a breach, then a series of contingency actions will be required. Suggested contingency actions, which will need to be agreed with the EA, are presented in Table 11.

Table 11: Suggested Contingency Actions

Appropriate Contingency Action	Timescale
Advise Site Management	Immediately
Advise Operator's Environmental Manager	Within 1 day
Advise EA	Within 1 day
Confirm by repeat sampling and analysis	Within 1 Month
Review existing monitoring information	1 Month
Review site management/operations, implement actions to prevent future failure of a compliance level	3 Months
Review assumptions in conceptual site model	3 Months
Review existing HRA Compliance Levels	6 Months
Consult EA about need for corrective action	6 Months

9.0 CONCLUSIONS

9.0.1 The proposed engineered containment for the inert landfill at the site (Coombefield Quarry) complies with the requirements of the Landfill Directive.

9.0.2 The proposed installation will comply with current engineering design, materials, specifications and CQA protocols applicable to current landfill containment best practices.

9.0.3 An independent CQA procedure will be carried out for all aspects of the basal and sidewall lining construction. This ensures that the liner meets the required engineering standards and thus complies with the Landfill Directive and will not have an impact on the groundwater system.

9.0.4 The quantitative modelling has demonstrated that the proposed geological barrier will provide adequate containment of landfill 'leachate' to meet the requirements of Landfill Directive (1999/31/EC) and will provide sufficient attenuation to prevent a risk to the underlying strata and groundwater environment.

9.0.5 Compliance limits for groundwater have not yet been derived due to the impact of anthropogenic inputs and limited set of monitoring data. It is suggested that in the latter part of the application process compliance limits will be submitted and included in the permit after consultation with the Agency. An informal annual review of the compliance limits is recommended and discussed with Agency once these are agreed.

9.0.6 The requirements of the Groundwater Regulations, 2016, have been satisfied by the inclusion of requisite surveillance of the groundwater quality to be carried out regularly as discussed in Section 6.

DRAWINGS

PSL/B034779/PER/01- Environmental Permit Boundary

PSL/B034779/GW/01 – Average Groundwater contours

PSL/B034779/HYD/01 – Geological Cross Sections

801-06 to 801-12 – Phasing Plans (7 Drawings)

801-13 – Restoration Landform

801-14 – Restoration Proposals

801-04 – Pre-Development Landform

801-15 – As Existing and Proposed Cross Sections A-A’ & B-B’

PSL/B0134779/MON/01 – Borehole Location Plan

APPENDICES

APPENDIX A – BOREHOLE LOGS

APPENDIX B – GROUNDWATER LEVEL DATA AND PLOT

APPENDIX C – GROUNDWATER QUALITY DATA AND PLOTS

APPENDIX D – LANDSIM PARAMETERS

APPENDIX E – LANDSIM GRAPHICAL OUTPUTS

BORE HOLE LOG

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel / Fax. 01694 751251
Email: office@hughesdrilling.co.uk

Client: BCL HYDRO

Site/Location: Portland, Coombefield

B.H. No.(s): P1 Sheet No: 1

B.H. Co-ordinates:

Date Started: 02/06/21 Completed: 04/06/21 Drillers: Ollie Abbott/Dan Barrett

Rig Type: Sonic Rotary

Flush/Additives: Air

Drill Method: DTH

Casing Detail/Depth: N/A

In-hole Equip: 5" Hammer

Others: N/A

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS	
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: Piezo SIZE: 60mm PVC HEADWORKS: Security Cover From:	To:
	0.00	25	25	Good	Portland Stone until 25m	0m	42m [illegible]
	25	29	4	N/A	Clay for 4m. Extremely slow drilling. Lost flush at 27m → EOH No water strike		
	29	42	13	N/A	Drilling speed increased. Possibly in Sandstone, but no flush. Pulled Rods to clear blockage. Afterwards, drilled to 42m, still no flush. (EOH)		
					Pulled rods and installed Piezo at 42m (No collapse)		
					Piezo: 15m Slotted Pipe 27m Plain Pipe After 72 hours: 11m of water in hole		

BORE HOLE LOG

Client: BCL Hydro

Site/Location: Portland, Coombefield quarry

B.H. No.(s): P2 Sheet No: 1

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel / Fax. 01694 751251
Email: office@hughesdrilling.co.uk

B.H. Co-ordinates:

Date Started: 07/06/21 Completed: 08/06/21 Drillers: D.Barrett / J. Hughes

Rig Type: Sonic Rotary

Drill Method: DTH

In-hole Equip: 5" Hammer

Flush/Additives: ~~[illegible]~~ Air

Casing Detail/Depth: N/A

Others: N/A

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS	
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: Piezo SIZE: 60mm PVC HEADWORKS: Security Cover From:	To:
	0.00	32.5	32.5		Limestone Until 32.5m	0m	42.5m
	32.5	34m	1.5		Clay for 1.5m Drilling Significantly Slower, No Water Strike.		
	34	43.5	9.5		Drilling Speed back up, lost flush at Surface. Suspected Sandstone, Sticking to Clay above.		
	(EOH)				Pulled rods and installed Piezo to 42.5m (1m of Collapse)		
					~~15m~~ Piezo - 15m Slotted pipe 27.5m Plain pipe 9m of Water in hole when dipped after 24 hours		

BORE HOLE LOG

Client: BCL Hydro

Site/Location: Coombefield Quarry, Portland

B.H. No.(s): P3 Sheet No: 1

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel / Fax. 01694 751251
Email: office@hughesdrilling.co.uk

B.H. Co-ordinates:

Date Started: 14/06/21 Completed: 16/06/21 Drillers: D.Barrett / J.Hughes

Rig Type: Sonic
Drill Method: DTH
In-hole Equip: 5" DTH

Flush/Additives: Air
Casing Detail/Depth: N/A
Others: N/A

SAMPLE INTERVAL					DESCRIPTION OF STRATA/SAMPLE	INSTALLATION DETAILS	
RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	TYPE: Piezo SIZE: 60mm PVC HEADWORKS: Security Cover From:	To:
	0	38.5	38.5m		Portland Limestone	0	52m
	38.5	43.5	5m		Clay for 5m, lost flush around 40m.		
	43.5m	52m	8.5m		No flush Suspected Sand Stone.		
	(EOH)				Pulled rods and installed Piezo at 52m.		
					8.5m of water in hole after 24 hours.		
					Piezo - 15m Slotted 37m Plain		

BORE HOLE LOG

HUGHES DRILLING

Church Stretton, Shropshire, SY6 6LU.
Tel / Fax. 01694 751251
Email: office@hughesdrilling.co.uk

Client: BCL Hydro

Site/Location: Coombefield quarry, Portland

B.H. No.(s): P4 Sheet No: 1

B.H. Co-ordinates:

Date Started: 08/06/21 Completed: 14/06/21 Drillers: D.Barrett / J. Hughes

Rig Type: Sonic
Drill Method: DTH
In-hole Equip: 5" Hammer

Flush/Additives: Air
Casing Detail/Depth: N/A
Others: N/A

INSTALLATION DETAILS
TYPE: Piezo
SIZE: 60mm PVC
HEADWORKS: Security Cover

RUN / SAMPLE No.	FROM: O mts	TO:	Mts Drilled	Recovery Mts. Good / Poor etc.	DESCRIPTION OF STRATA/SAMPLE — DRILLERS OBSERVATIONS Re: Rock Type, B.H. Conditions, Water Strikes etc.	INSTALLATION From:		To:
	0	1m	1m		Capstone on Surface to 1m Very hard. Slow drilling			
	1	15m	14m		Limestone.			
	15	20	5m		Lost flush + Hammer, Suspected "Gully" or Cavity. Cavity wall grabbing rods at 20m.			
	(EOH)				(HOLE ABANDONED at 20m)			
					MOVED LOCATION 12m to EAST OF FIRST HOLE.	0	15m Slotter 36m plain	51m
	0	15m	15m		Portland LimeStone			
	15	20m	5m		Lost flush, Very fractured ground Suspect still on edge of Cavity.			
	20	31	11m		Regained flush - Portland Lime Stone.			
	31	33	2m		Hard Clay band (Dry cuttings) Lost flush again at 32m			
	33	34	1m		Sandstone, fine brown Sand Cuttings			
	34	38.5m	4.5m		Soft Clay black in Colour, No flush Pulled Rods to Clear blockage.			
	38.5	41m	2.5m		Black angular rock cuttings. Lost flush at 41m			
	41m	51m	10m		No Flush, Suspected Soft black Clay.			
	(EOH)				(2m water in hole at 24 hours) Very fractured Ground. Piezo installed to 51mtr.			

P1/21		**15/6/21**	**1/7/21**	**4/8/21**	**9/9/21**	**7/10/21**	**4/11/21**	**16/12/21**	**27/1/22**	**17/2/22**	**31/3/22**	**14/4/22**	**29/4/22**	**13/5/22**	**27/5/22**	Average	Minimum	Maximum
Borehole Top	**mAOD**	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8	37.8			
Water Level	**mbgl**	34.45	32.64	31.71	32.71	31.84	32.60	32.65	32.21	32.45	32.6	32.42	32.53	32.68	32.83			
Groundwater Level	**mAOD**	3.35	5.16	6.09	5.09	5.96	5.2	5.15	5.59	5.35	5.2	5.38	5.27	5.12	4.97	**5.2**	**3.35**	**6.09**

P2/21

Borehole Top	**mAOD**	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33	51.33			
Water Level	**mbgl**	39.9	39.21	40.06	38.65	40.04	40.24	40.37	39.56	40.77	40.6	40.59	40.74	40.88	40.92			
Groundwater Level	**mAOD**	11.43	12.12	11.27	12.68	11.29	11.09	10.96	11.77	10.56	10.73	10.74	10.59	10.45	10.41	**11.1**	**10.41**	**12.68**

P3/21

Borehole Top	**mAOD**	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3	56.3			
Water Level	**mbgl**	49.63	45.69	45.17	46.21	45.90	45.91	46.20	45.86	43.21	45.89	46.08	46.40	46.10	46.15			
Groundwater Level	**mAOD**	6.67	10.61	11.13	10.09	10.4	10.39	10.1	10.44	13.09	10.41	10.22	9.9	10.2	10.15	**10.3**	**6.67**	**13.09**

P4/21

Borehole Top	**mAOD**	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46	53.46			
Water Level	**mbgl**	46.18	50.14	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry			
Groundwater Level	**mAOD**	7.28	3.32													**5.3**	**3.32**	**7.28**

Coombefield Quarry - Groundwater Levels
P1/21
P2/21
P3/21
P4/21
Level (mAOD)
0
2
4
6
8
10
12
14
15/6/21
15/7/21
15/8/21
15/9/21
15/10/21
15/11/21
15/12/21
15/1/22
15/2/22
15/3/22
15/4/22
15/5/22
Date

Chloride

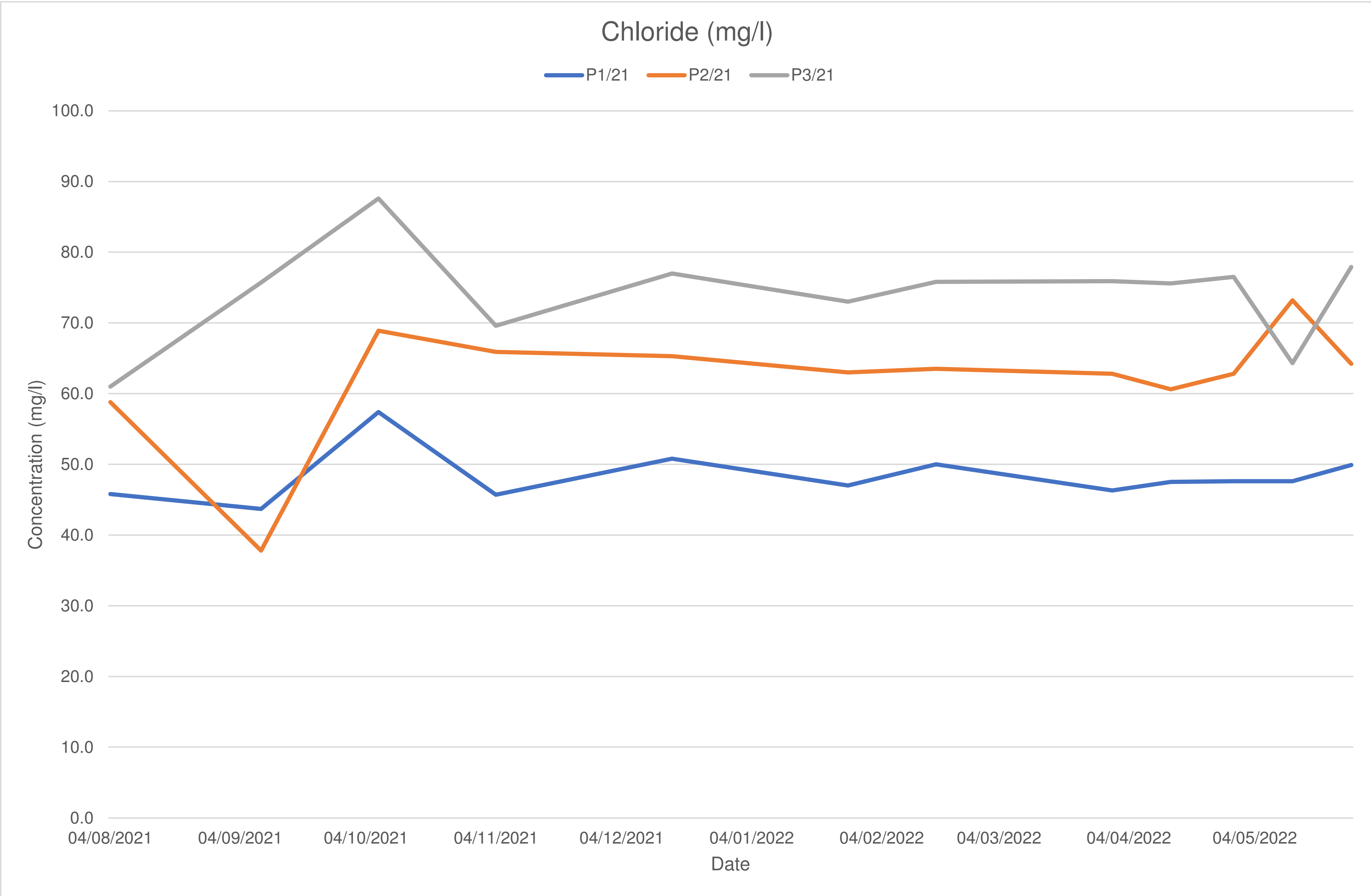
	04/08/2021	09/09/2021	07/10/2021	04/11/2021	16/12/2021	27/01/2022	17/02/2022	31/03/2022	14/04/2022	29/04/2022	13/05/2022	27/05/2022
P1/21	45.8	43.7	57.4	45.7	50.8	47.0	50.0	46.3	47.5	47.6	47.6	49.9
P2/21	58.8	37.8	68.9	65.9	65.3	63.0	63.5	62.8	60.6	62.8	73.2	64.2
P3/21	61.0	75.7	87.6	69.6	77.0	73.0	75.8	75.9	75.6	76.5	64.3	77.9

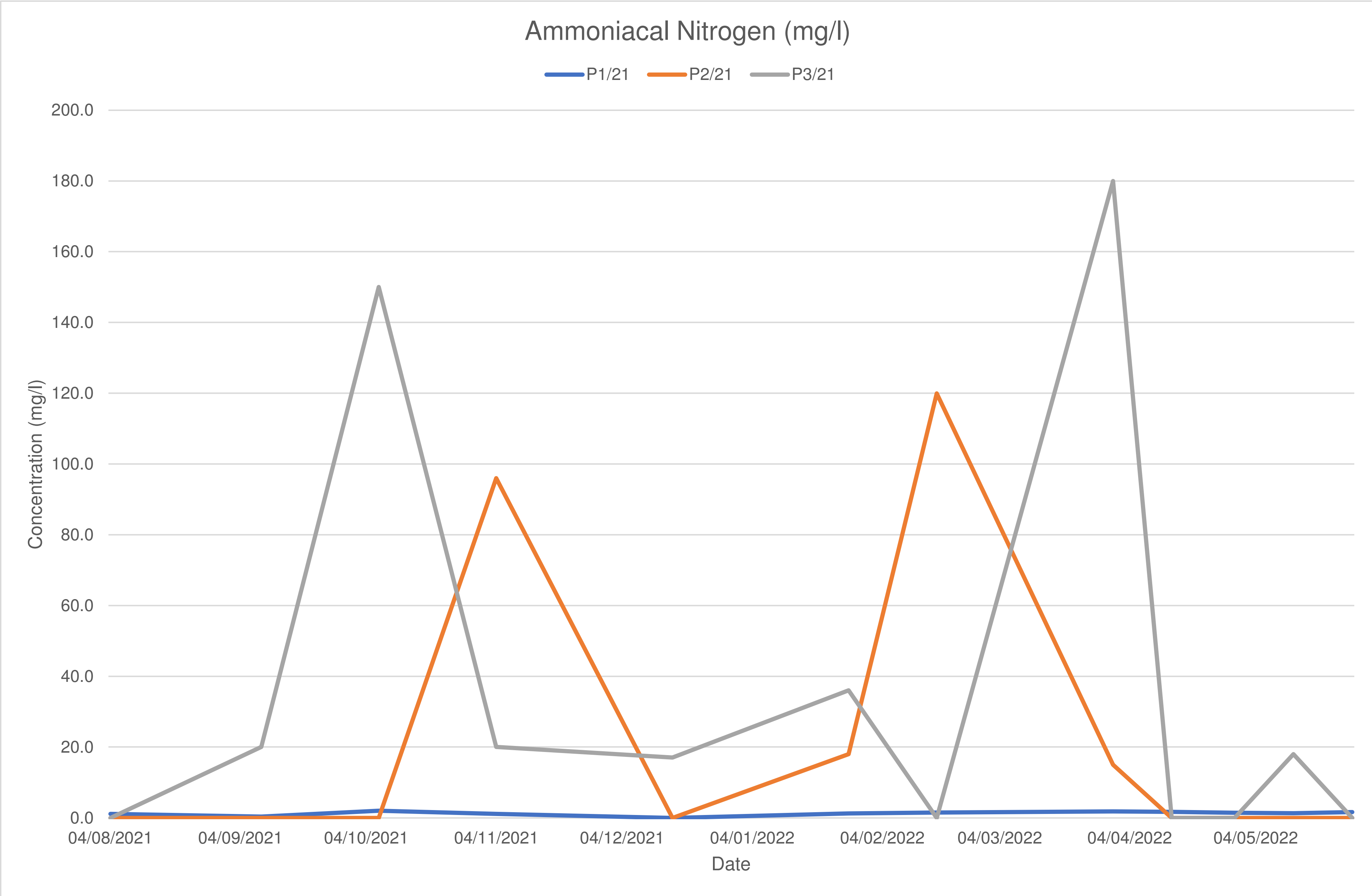
Ammonical Nitrogen

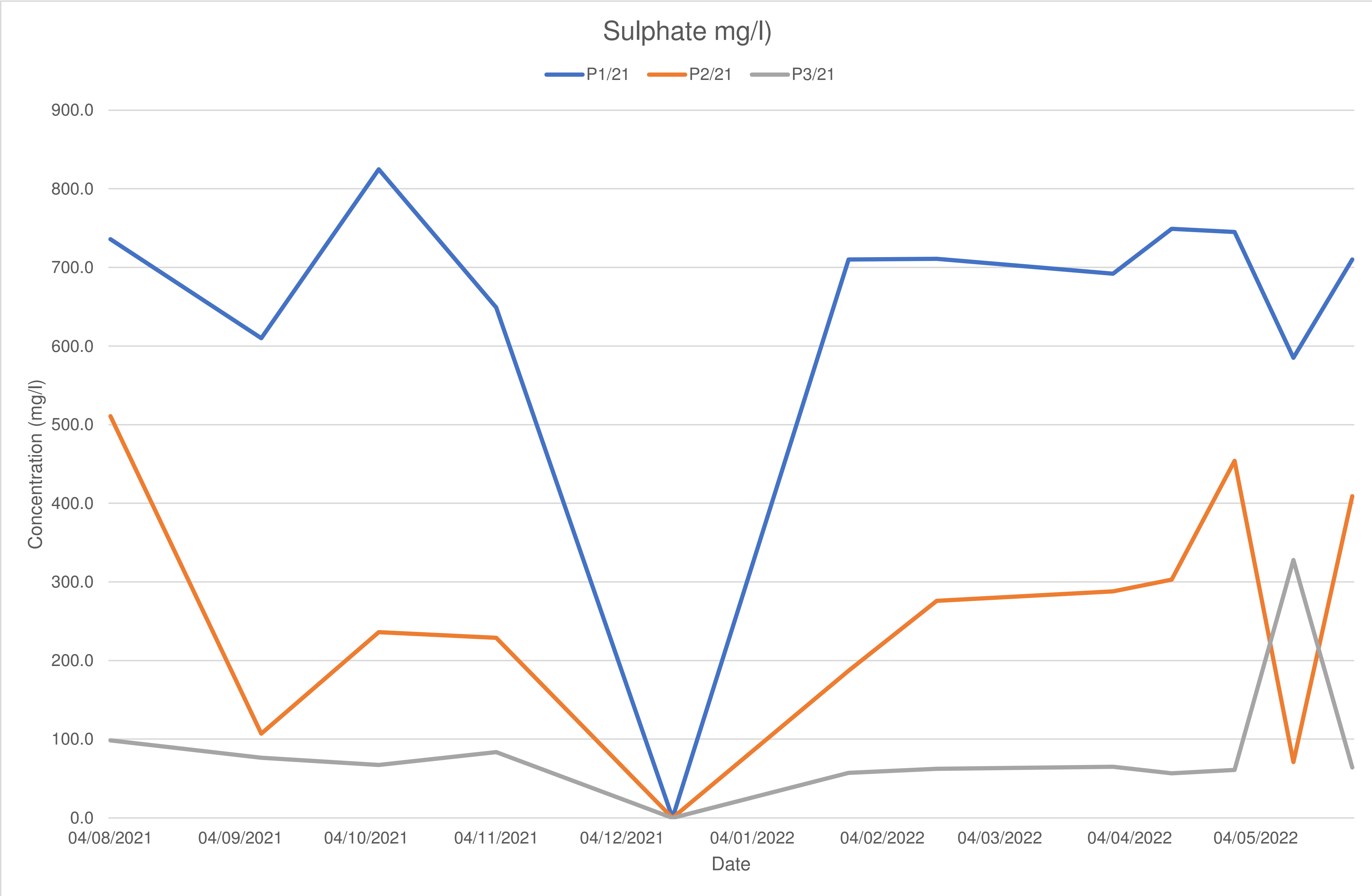
	04/08/2021	09/09/2021	07/10/2021	04/11/2021	16/12/2021	27/01/2022	17/02/2022	31/03/2022	14/04/2022	29/04/2022	13/05/2022	27/05/2022
P1/21	1.1	0.32	2.0	1.1	<0.0015	1.2	1.5	1.8	1.7	1.4	1.3	1.6
P2/21	< 15	< 15	< 15	96.0	< 15	18.0	120.0	15.0	< 15	< 15	< 15	< 15
P3/21	< 15	20.0	150.0	20.0	17.0	36.0	< 15	180.0	< 15	< 15	18.0	< 15

Sulphate

	04/08/2021	09/09/2021	07/10/2021	04/11/2021	16/12/2021	27/01/2022	17/02/2022	31/03/2022	14/04/2022	29/04/2022	13/05/2022	27/05/2022
P1/21	736.0	610.0	825.0	649.0	< 0.04	710.0	711.0	692.0	749.0	745.0	585.0	710.0
P2/21	511.0	107.0	236.0	229.0	< 0.04	187.0	276.0	288.0	303.0	454.0	70.8	409.0
P3/21	98.4	76.2	67.3	83.5	< 0.04	57.0	62.2	65.0	56.5	60.8	328.0	64.0


Chloride (mg/l)
P1/21
P2/21
P3/21
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Concentration (mg/l)
04/08/2021
04/09/2021
04/10/2021
04/11/2021
04/12/2021
04/01/2022
04/02/2022
04/03/2022
04/04/2022
04/05/2022
Date


Ammoniacal Nitrogen (mg/l)
P1/21
P2/21
P3/21
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Concentration (mg/l)
04/08/2021
04/09/2021
04/10/2021
04/11/2021
04/12/2021
04/01/2022
04/02/2022
04/03/2022
04/04/2022
04/05/2022
Date


Sulphate mg/l)
P1/21
P2/21
P3/21
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Concentration (mg/l)
04/08/2021
04/09/2021
04/10/2021
04/11/2021
04/12/2021
04/01/2022
04/02/2022
04/03/2022
04/04/2022
04/05/2022
Date

													Ave	Std Dev	**Complianc**
Chloride															
P2/21	58.8	37.8	68.9	65.9	65.3	63.0	63.5	62.8	60.6	62.8	73.2	64.2	62	9	**88**
Amm N															
P2/21	0.0015	0.0180	0.0015	0.1200	0.0190	0.0240	0.1500	0.0200	0.0015	0.0015	0.0015	0.0015	0.03	0.05	**0.18**
Sulphate															
P2/21	511.0	107.0	236.0	229.0	201.0	187.0	276.0	288.0	303.0	454.0	328.0	409.0	294	117	**645**

																										Max
Chloride	mg/l	45.8	43.7	57.4	45.7	50.8	61	75.7	87.6	69.6	77	47	50	46.3	47.5	47.6	47.60	49.90	73	75.8	75.9	75.6	76.5	64.30	77.90	87.6
Fluoride	mg/l	0.285	0.25	0.25	0.346	0.2	0.259	0.347	0.284	0.255	0.199	0.271	0.309	0.274	0.31	0.277	0.221	0.265	0.283	0.305	0.344	0.281	0.312	0.3	0.28	0.347
Sulphate	mg/l	736	610	825	649	680	98.4	76.2	67.3	83.5	69	710	711	692	749	745	585	710	57	62.2	65	56.5	60.8	328	64	825
Barium	mg/l	0.0147	0.0206	0.0122	0.0111	174	0.1482	0.0905	0.0784	0.0674	59.6	0.0112	0.0049	0.0132	0.0134	0.0114	0.0112	0.0121	0.0807	0.0744	0.0809	0.0928	0.079	0.0826	0.0829	174
Cadmium	mg/l	0.0008	0.0008	0.0008	0.0008	0.001	0.0008	0.0008	0.0008	0.0008	0.001	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.001
Chromium	mg/l	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.005	0.001	0.008	0.001	0.001	0.001	0.008	0.008	0.001	0.007	0.001	0.001	0.001	0.004	0.002	0.008
Mercury	mg/l	0.0001	0.0001	0.0001	0.0001	10.4	0.0001	0.0001	0.0001	0.0001	2.11	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	10.4
Molybdenum	mg/l	0.005	0.01	0.008	0.002	277	0.017	0.02	0.011	0.01	45.4	0.001	0.011	0.001	0.008	0.008	0.002	0.001	0.004	0.011	0.009	0.006	0.011	0.013	0.008	277
Nickel	mg/l	0.0008	0.0031	0.0008	0.0008	254	0.0111	0.0128	0.0066	0.0057	25.3	0.0008	0.0037	0.0008	0.0008	0.0008	0.0015	0.0022	0.0008	0.006	0.0015	0.0008	0.0019	0.0053	0.0039	254
Zinc	mg/l	0.002	0.005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.005
Antimony (dissolved)	µg/l	1.6	0.8	0.9	0.6	0.4	1.3	0.9	0.9	0.6	0.4	1	1.7	0.80	0.5	0.7	0.4	0.5	0.7	0.4	0.5	0.6	0.6	0.5	1.1	1.7
Arsenic (dissolved)	µg/l	5.97	1.07	0.74	0.56	0.85	0.46	0.7	0.52	0.15	0.57	2.33	4.48	2.01	0.69	0.62	0.38	0.55	0.6	1.44	0.6	0.25	0.31	0.17	0.25	5.97
Copper (dissolved)	µg/l	3.7	2.4	2.8	1.8	11	2.4	1.4	1.2	0.8	2.7	4.6	7.8	1.80	1.2	2.3	6.4	3.8	1.2	6	2.2	2.9	2.3	1.7	1.1	11
Lead (dissolved)	µg/l	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.20
Selenium (dissolved)	µg/l	1.5	1.3	2.1	1.6	1.2	1.6	1.4	2.5	2.1	2	1.2	1.8	1.20	0.7	2.1	2	1.2	1.8	2.3	1.5	0.8	2.4	2.3	2	2.5
Phenol	ug/l	1	1	1	1	33	1	1	1	1	34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	34

Data with outliers removed

																										Max
Chloride	mg/l	45.8	43.7	57.4	45.7	50.8	61	75.7	87.6	69.6	77	47	50	46.3	47.5	47.6	47.60	49.90	73	75.8	75.9	75.6	76.5	64.30	77.90	87.6
Fluoride	mg/l	0.285	0.25	0.25	0.346	0.2	0.259	0.347	0.284	0.255	0.199	0.271	0.309	0.274	0.31	0.277	0.221	0.265	0.283	0.305	0.344	0.281	0.312	0.3	0.28	0.347
Sulphate	mg/l	736	610	825	649	680	98.4	76.2	67.3	83.5	69	710	711	692	749	745	585	710	57	62.2	65	56.5	60.8	328	64	825
Barium	mg/l	0.0147	0.0206	0.0122	0.0111		0.1482	0.0905	0.0784	0.0674		0.0112	0.0049	0.0132	0.0134	0.0114	0.0112	0.0121	0.0807	0.0744	0.0809	0.0928	0.079	0.0826	0.0829	0.1482
Cadmium	mg/l	0.0008	0.0008	0.0008	0.0008	0.001	0.0008	0.0008	0.0008	0.0008	0.001	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.001
Chromium	mg/l	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.005	0.001	0.008	0.001	0.001	0.001	0.008	0.008	0.001	0.007	0.001	0.001	0.001	0.004	0.002	0.008
Mercury	mg/l	0.0001	0.0001	0.0001	0.0001		0.0001	0.0001	0.0001	0.0001		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Molybdenum	mg/l	0.005	0.01	0.008	0.002		0.017	0.02	0.011	0.01		0.001	0.011	0.001	0.008	0.008	0.002	0.001	0.004	0.011	0.009	0.006	0.011	0.013	0.008	0.02
Nickel	mg/l	0.0008	0.0031	0.0008	0.0008		0.0111	0.0128	0.0066	0.0057		0.0008	0.0037	0.0008	0.0008	0.0008	0.0015	0.0022	0.0008	0.006	0.0015	0.0008	0.0019	0.0053	0.0039	0.0128
Zinc	mg/l	0.002	0.005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.005
Antimony (dissolved)	µg/l	1.6	0.8	0.9	0.6	0.4	1.3	0.9	0.9	0.6	0.4	1	1.7	0.80	0.5	0.7	0.4	0.5	0.7	0.4	0.5	0.6	0.6	0.5	1.1	1.7
Arsenic (dissolved)	µg/l	5.97	1.07	0.74	0.56	0.85	0.46	0.7	0.52	0.15	0.57	2.33	4.48	2.01	0.69	0.62	0.38	0.55	0.6	1.44	0.6	0.25	0.31	0.17	0.25	5.97
Copper (dissolved)	µg/l	3.7	2.4	2.8	1.8	11	2.4	1.4	1.2	0.8	2.7	4.6	7.8	1.80	1.2	2.3	6.4	3.8	1.2	6	2.2	2.9	2.3	1.7	1.1	11
Lead (dissolved)	µg/l	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.20
Selenium (dissolved)	µg/l	1.5	1.3	2.1	1.6	1.2	1.6	1.4	2.5	2.1	2	1.2	1.8	1.20	0.7	2.1	2	1.2	1.8	2.3	1.5	0.8	2.4	2.3	2	2.5
Phenol	ug/l	1	1	1	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Amm N	mg/l	1.1	0.41	2.5	1.4	1.3	1.2	1.5	1.8	1.7	1.4	1.3	1.6	0.0015	0.0260	0.1900	0.0260	0.0220	0.0460	0.0015	0.2300	0.0015	0.0015	0.0230	0.0015	2.5

Table D –LandSim parameters

Infiltration parameters

Parameter	Units	Distribution	Justification
Cap design infiltration	mm/yr	Normal (50,5)	Accepted EA's values Derived for effective rainfall values
Infiltration to open waste	mm/yr	Normal (235,23.5)	
End of filling	years	Single (17)	Model assumes a relatively rapid filling of the void

Site geometry

Cell	Input values	Justification
Installation average basal width – area (m^2)	150	Based on proposed cell layout
Installation average basal length – area (m^2)	210	Based on proposed cell layout
Final waste thickness (m)	Uniform (10,20)	Final elevation to achieve settlement levels
Waste Porosity (fraction)	Un (0.3,0.4)	Representative of potential waste variability
Waste Dry Density (kg/l)	Un (0.5,0.6)	Typically accepted values for inert materials
Waste Field Capacity (Fraction)	Un (0.2,0.3)	Typically accepted values for inert materials
Head of leachate when surface breakout occurs (m)	20	Estimated from minimum distance between the base of lining system and surrounding ground level.

Kd values)

Determinand	Distribution	Justification
Amm N	LogUn (0.5,2)	LandSim suggested value range
Arsenic	LogUn (39.8,19,952)	EPA/600/R-05/074 July 2005
Cadmium	LogUn (1.6,1,500)	LandSim suggested value range
Zinc	LogUn (31.6,63,095)	LandSim suggested value range
Barium	LogUn (7.94, 1585)	EPA/600/R-05/074 July 2005
Chromium VI	LogUn (79,794,328)	EPA/600/R-05/074 July 2005
Lead	LogUn (100,39,811)	EPA/600/R-05/074 July 2005
Mercury	LogUn (450,3,835)	LandSim suggested value range
Antimony	LogUn (3.98, 63,095)	EPA/600/R-05/074 July 2005
Nickel	LogUn (2,10,000)	EPA/600/R-05/074 July 2005
Selenium	LogUn (10, 10,000)	EPA/600/R-05/074 July 2005

Clay liner properties

	Units	Distribution	Justification
Moisture Content	% (vol.)	Un (0.15,0.2)	Tetra Tech assumption.
Hydraulic Conductivity	m/s	Single (1.0e-7)	Assumed hydraulic conductivity based on 1m thickness.
Design Thickness	m	Single (1)	Specification range
Longitudinal Dispersivity	m	Single (0.1)	10% of pathway length.

Unsaturated zone properties

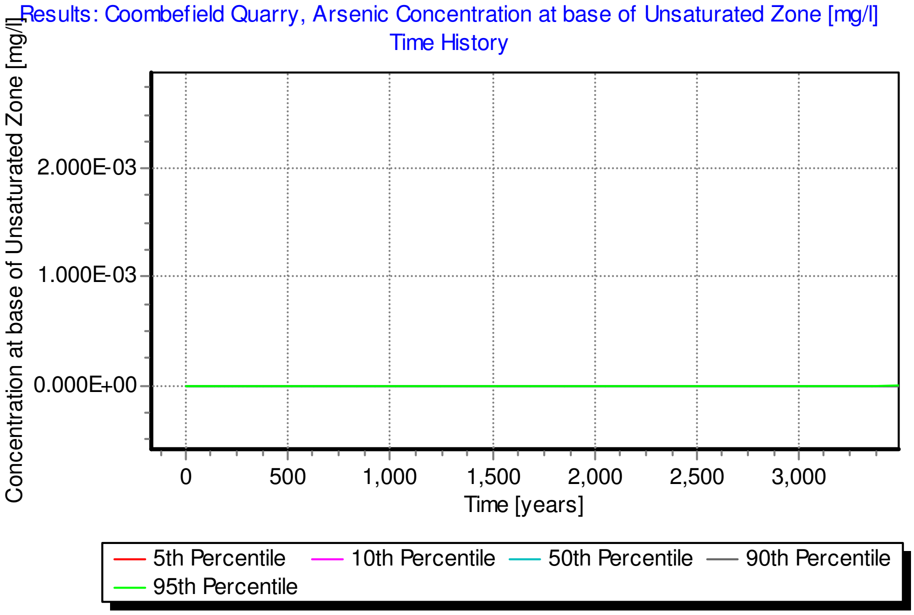
Parameter	Units	Distribution	Justification
Matrix			
Length	m	Single (24)	Minimum allowed by planning conditions
Matrix hydraulic conductivity	m/s	LogUn (4e-8,1e-7)	Assumed range based on values presented in LandSim Help Files
Matrix porosity	Fr	Tr (0.27,0.34,0.43)	10, 50 & 90%ile values presented in GBS Aquifer properties manual
Fracture			
Hydraulic conductivity	m/s	LogUn (1.3e-7, 1.3e-6)	Conservative value based on saturated hydraulic permeability for Chalk (Reference BGS Aquifer properties manual)
Fracture porosity	Fr	Un (0.001,0.01)	Assumed range of 0.1% to 1%
Longitudinal dispersivity	m	0.01	1% of pathway length to site boundary

Aquifer properties

Parameter	Distribution	Justification
Aquifer thickness (m)	Single (30)	Assumed average thickness of fissured Limestone
Porosity (fraction)	Uniform (0.21,0.41)	Estimated from BGS site http://www.bgs.ac.uk
Hydraulic Conductivity (m/s)	LogUn (3.8e-5, 0.0022)	Estimated from BGS site on Chalk aquifer properties - http://www.bgs.ac.uk/research/ groundwater/waterResources/thames/chalk.html
Hydraulic gradient (-)	0.02	Based on groundwater contour plots for levels in 2022
Longitudinal Dispersion (m)	Single (3)	10% pathway length to site boundary

Parameter	Distribution	Justification
Transverse Dispersion (m)	Single (0.3)	1% of longitudinal dispersivity

Aquifer Properties: The aquifer pathway is only used in the assessment of Non-hazardous pollutants at the site boundary. The aquifer comprises the fractured limestone. The parameters presented in the table reflect the fracture properties of the limestone. It is widely accepted that the permeability of the limestone decreases with increasing depth and therefore the model assumes that flow will be limited to the saturated upper 30m.



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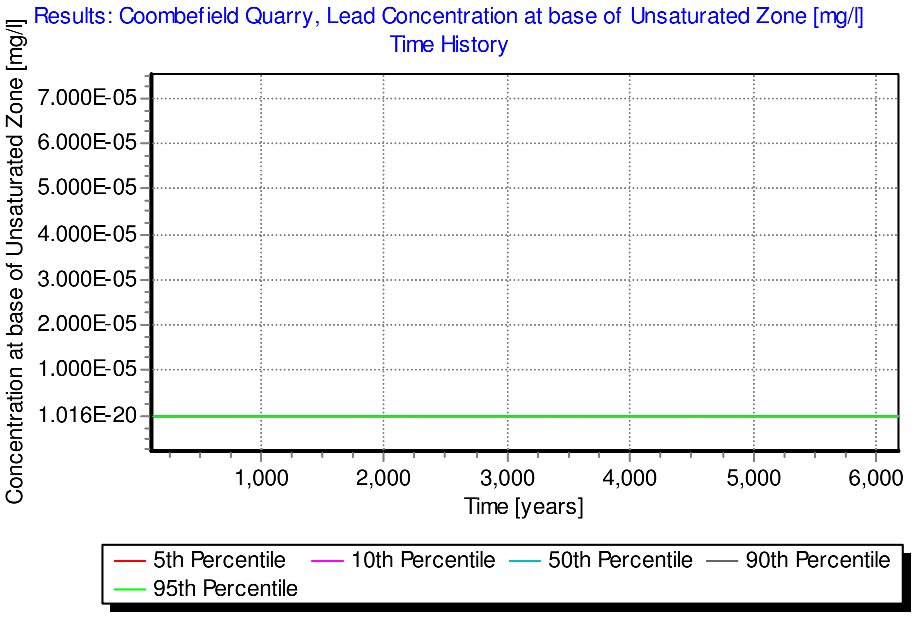

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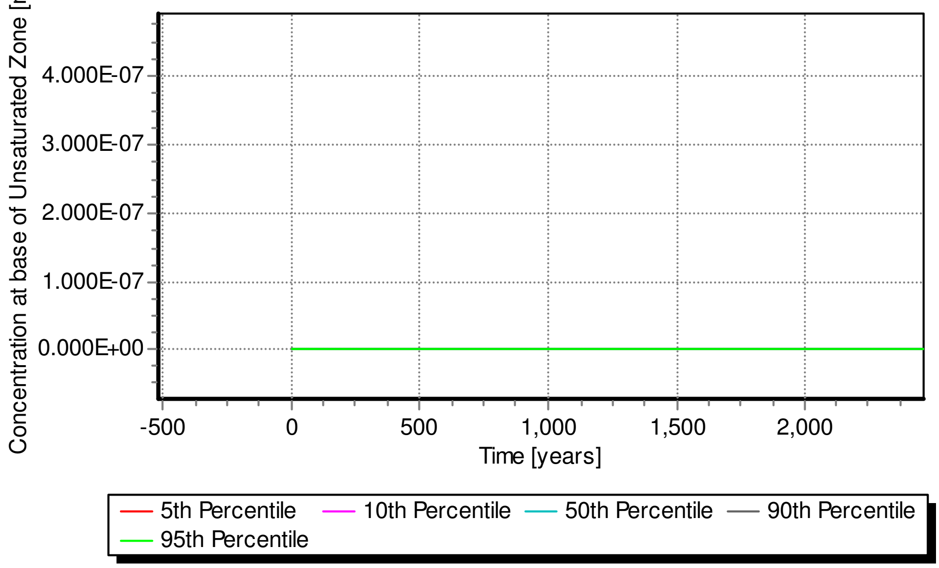
Results: Coombefield Quarry, Mercury Concentration at base of Unsaturated Zone [mg/l]
Time History



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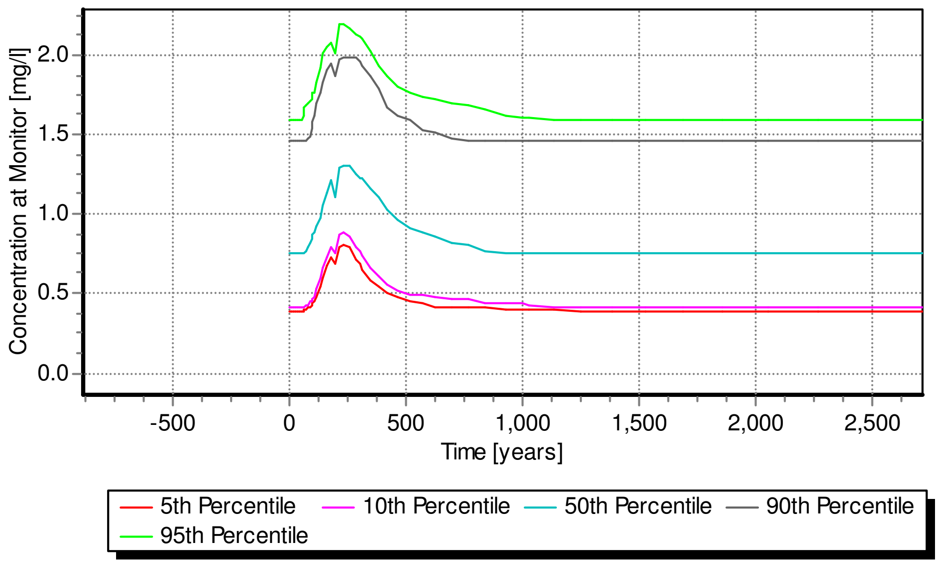
Results: Coombefield Quarry, Ammoniacal_N Concentration at Monitor [mg/l]
Time History



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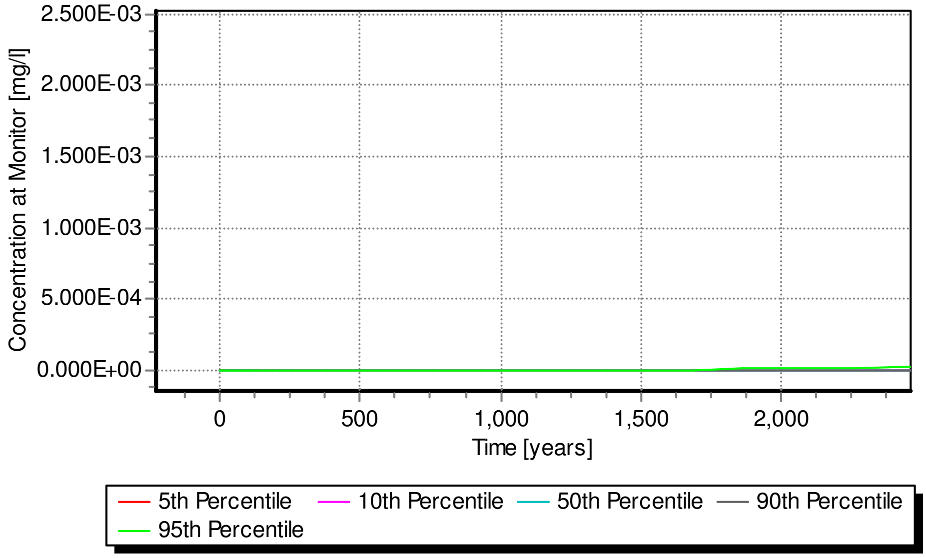
Results: Coombefield Quarry, Antomony Concentration at Monitor [mg/l]
Time History



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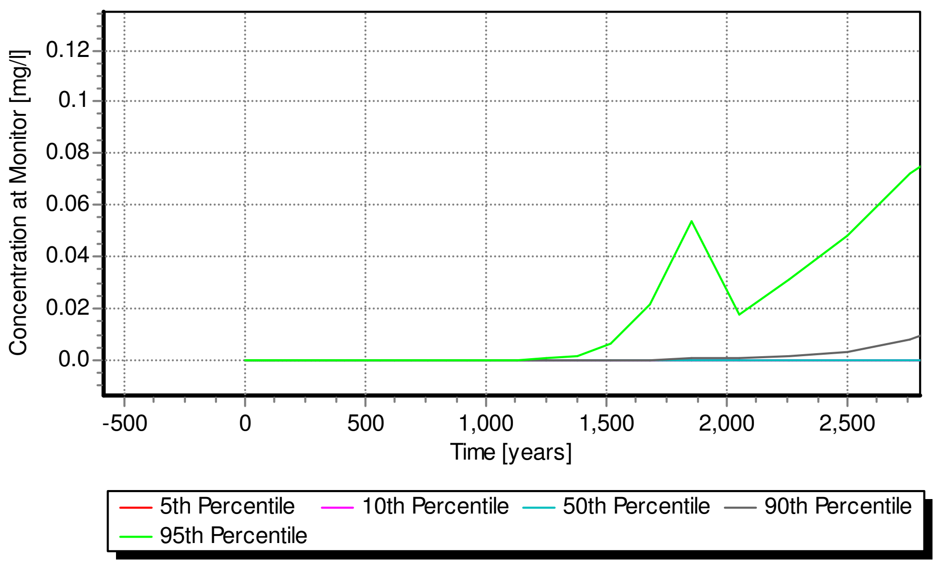
Results: Coombefield Quarry, Barium Concentration at Monitor [mg/l]
Time History



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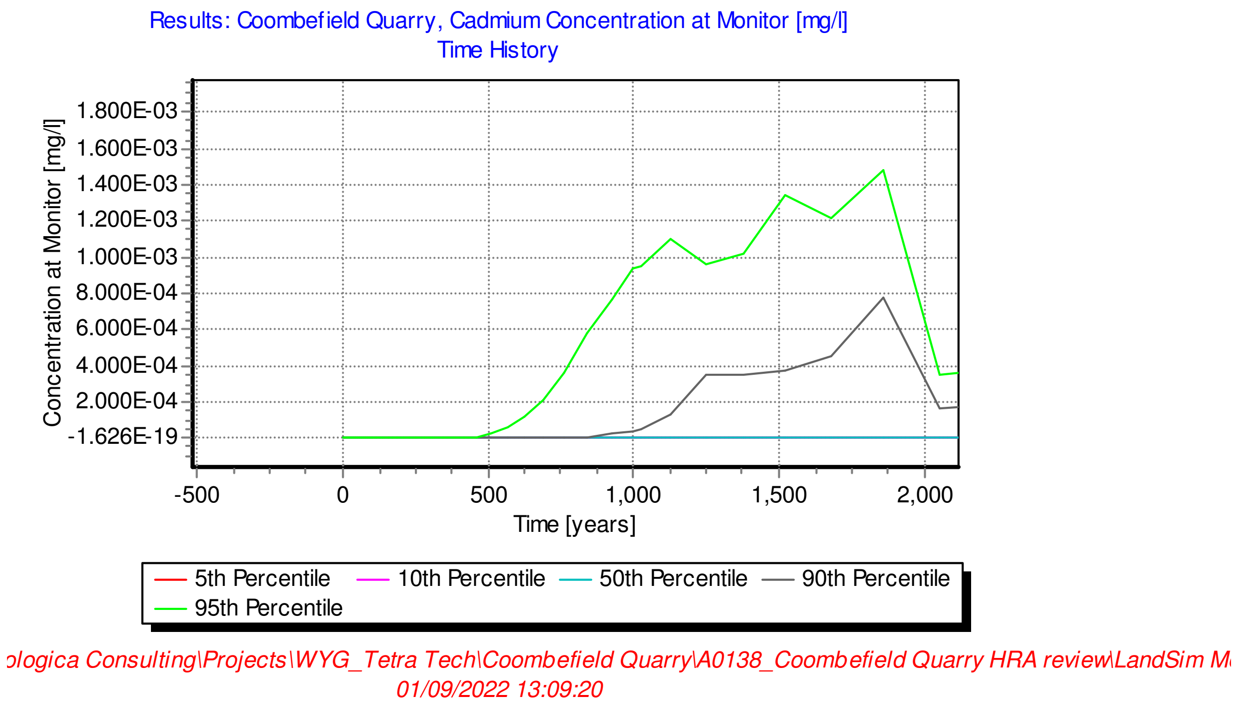
Results: Coombefield Quarry, Cadmium Concentration at Monitor [mg/l]
Time History
Concentration at Monitor [mg/l]
1.800E-03
1.600E-03
1.400E-03
1.200E-03
1.000E-03
8.000E-04
6.000E-04
4.000E-04
2.000E-04
-1.626E-19
-500
0
500
1,000
1,500
2,000
Time [years]
5th Percentile
10th Percentile
50th Percentile
90th Percentile
95th Percentile
ologica Consulting\Projects\WYG_Tetra Tech\Coombefield Quarry\A0138_Coombefield Quarry HRA review\LandSim M
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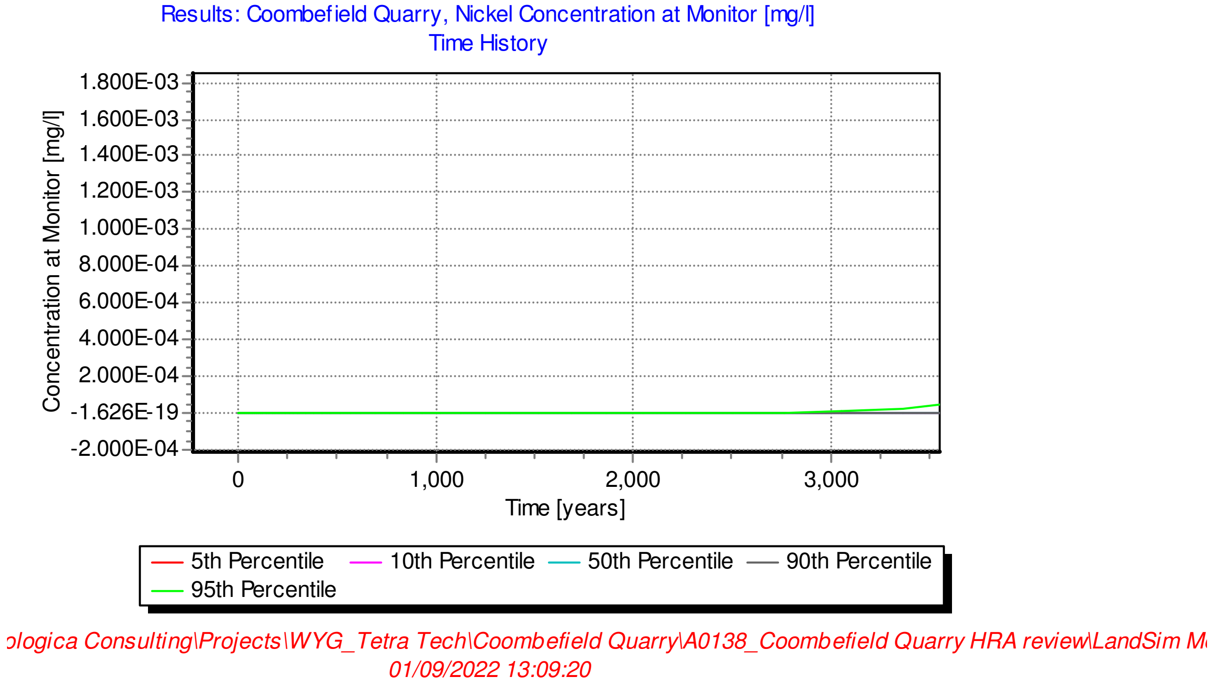
Results: Coombefield Quarry, Nickel Concentration at Monitor [mg/l]
Time History
Concentration at Monitor [mg/l]
1.800E-03
1.600E-03
1.400E-03
1.200E-03
1.000E-03
8.000E-04
6.000E-04
4.000E-04
2.000E-04
-1.626E-19
-2.000E-04
0
1,000
2,000
3,000
Time [years]
5th Percentile
10th Percentile
50th Percentile
90th Percentile
95th Percentile
ologica Consulting\Projects\WYG_Tetra Tech\Coombefield Quarry\A0138_Coombefield Quarry HRA review\LandSim M
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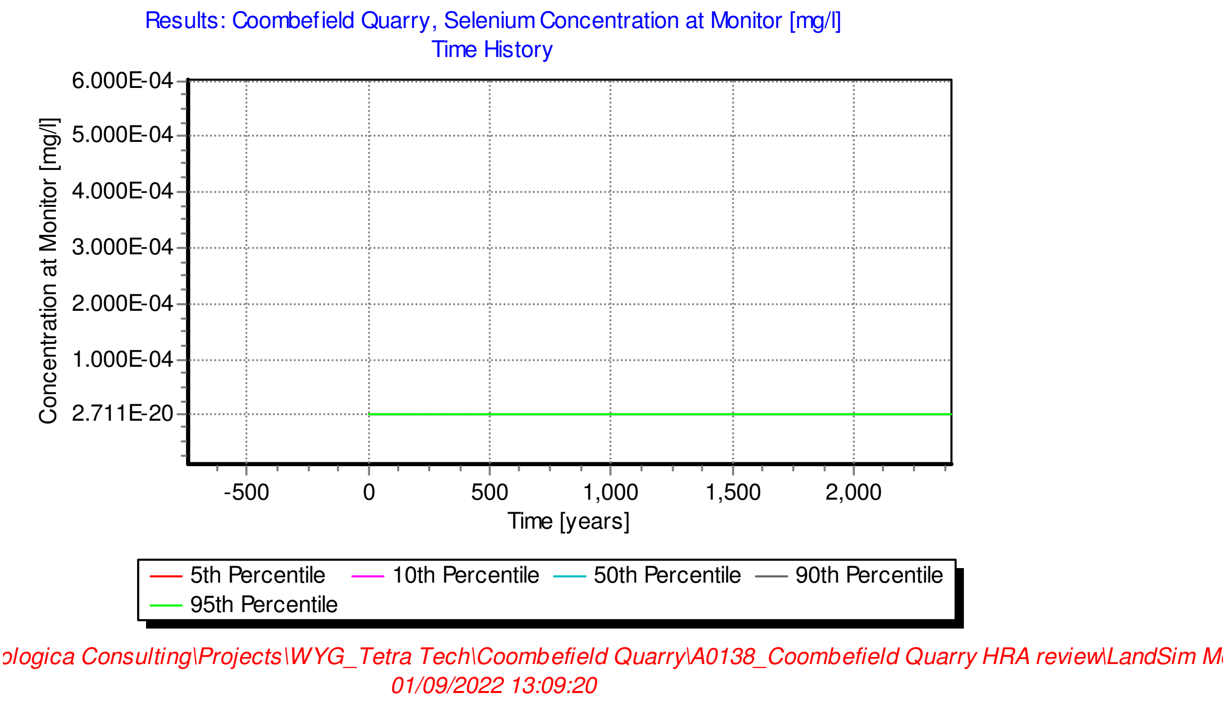
Results: Coombefield Quarry, Selenium Concentration at Monitor [mg/l]
Time History
6.000E-04
5.000E-04
4.000E-04
3.000E-04
2.000E-04
1.000E-04
2.711E-20
Concentration at Monitor [mg/l]
-500
0
500
1,000
1,500
2,000
Time [years]
5th Percentile
10th Percentile
50th Percentile
90th Percentile
95th Percentile
ologica Consulting\Projects\WYG_Tetra Tech\Coombefield Quarry\A0138_Coombefield Quarry HRA review\LandSim M
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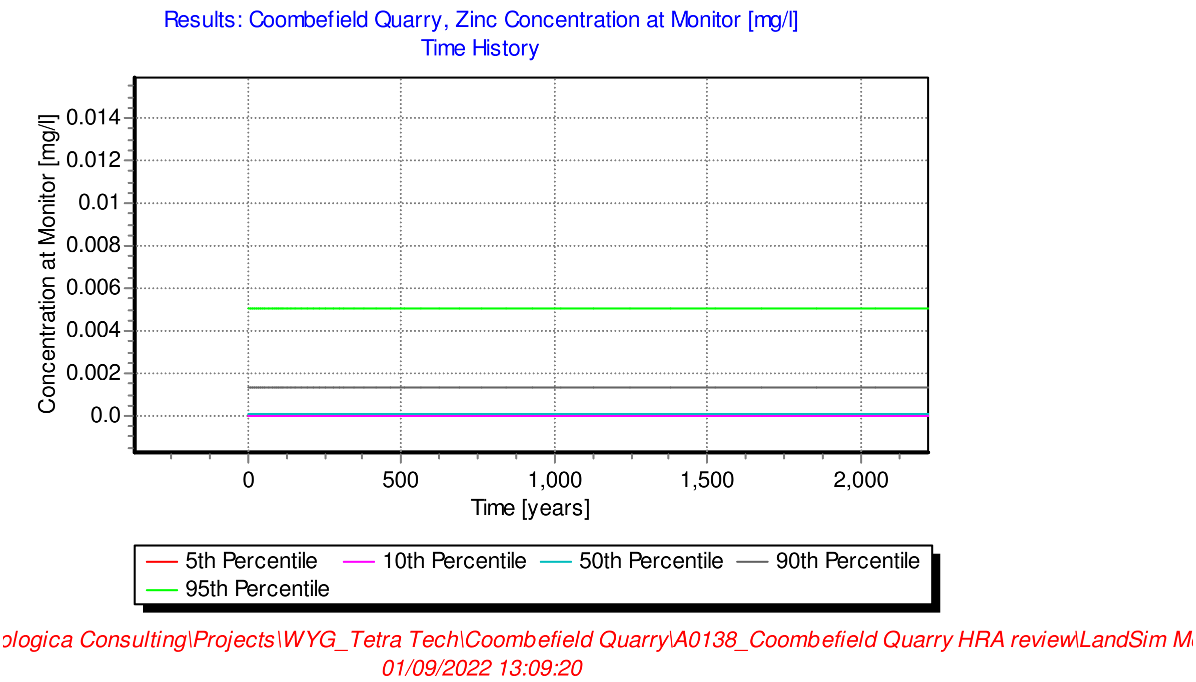
Results: Coombefield Quarry, Zinc Concentration at Monitor [mg/l]
Time History
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0.0
Concentration at Monitor [mg/l]
0
500
1,000
1,500
2,000
Time [years]
5th Percentile
10th Percentile
50th Percentile
90th Percentile
95th Percentile
ologica Consulting\Projects\WYG_Tetra Tech\Coombefield Quarry\A0138_Coombefield Quarry HRA review\LandSim M
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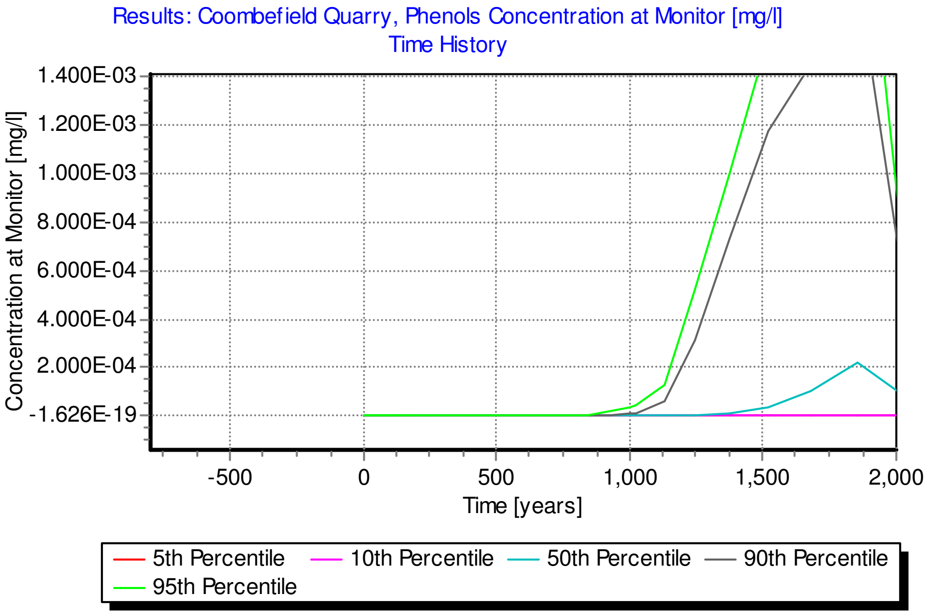

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