Dorket Head Quarry Landfill Environmental Permit

Hydrogeological Risk Assessment

784-B027237

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Prepared on Behalf of Tetra Tech Environment Planning Transport Limited.

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Contents

Drawings

MGL/B027237/LOC/01 – General site layout and permit boundary

MGL/B027237/REC/01 - Receptor Plan

DHS 3/10 Rev A – Proposed restoration plan

MGL/B027237/HYD/01 - Monitoring Infrastructure

MGL/B027237/HYD-02 – Site Engineering Details

MGL/B027237/HYD-03 – Site hydrogeological conceptual model

MGL/B027237/HYD-04, 05 and 06 – Groundwater Contours

Appendices

Appendix A – Drilling logs,

Appendix B – Groundwater level data and plot

Appendix C – Groundwater quality data and plots

1.0 INTRODUCTION

1.1 Report Context

1.1.1 This report presents the Hydrogeological Risk Assessment (HRA) for Dorket Head Quarry which will be ultimately converted into an inert landfill facility. The following chapters have been prepared in support of an Environmental Permit Application for the site currently being compiled by Tetra Tech on behalf of Mick George Ltd (MGL).

1.1.2 The objectives of this document are to assess whether the proposed 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.

1.1.3 The reader is referred to the various documents (ESSD, Operating Techniques, ERA, etc.) submitted as part of this application for detailed information on other aspects relating to the site.

1.2 Site Location

1.2.1 The site lies immediately to the south of the quarry workings at Dorket Head Quarry. Dorket Head Quarry is located on the northern edge of Arnold and the B684 Woodborough Lane. Arnold forms the northern district of the Nottingham urban area, with the city centre lying some 7.5km to the south-west. The Ibstock Dorket Head Brickworks is situated to the west of the quarry site which utilises clays that are extracted from the quarry for the manufacture of bricks.

1.2.2 As part of the quarry workings, FCC Recycling (UK) Limited (FCC) hold an environmental permit (reference EPR/BV4444IQ) to operate a non-hazardous landfill at Dorket Head Quarry to fill the void that has been created from mineral extraction activities.

1.2.3 For identification purposes, Dorket Head Quarry is centred on approximate National Grid Reference (NGR) SK 81389 49495 and the site is centred on NGR SK 59887 46752. The site location and boundary are shown on Drawing Number MGL/B027237/LOC/01.

1.2.4 The surroundings of the site comprise agricultural land to the north, east and west. To the south of the site is Hobbucks Nature Reserve and a housing estate with the closest residential roads Surgeys Lane, Homefield Avenue, Strathmore Road and Shandwick Close.

1.3 Brief Site History and Proposed Development

1.3.1 Clay extraction at and brick making works have been undertaken at Dorket Head for over 175 years with the present factory established in the 1860s.

1.3.2 In 1897 the works was acquired by the Nottingham Patent Brick Company (which later became Nottingham Brick PLC) and remained in their ownership until 1987, when the site was purchased by Marley. Marley were themselves purchased by Tarmac in 1993. Ibstock acquired the site from Tarmac in 1995 and Ibstock Brick Limited remains the owner to date.

1.3.3 The original planning application was granted in 1961 (reference S/1/2169) with further permissions for the extension of the clay extraction working area granted in 1971 and 1974 (reference 7/74/755).

1.3.4 Under planning permission 7/82/755, the restoration of the mineral workings by landfilling the quarry with domestic and industrial wastes was granted in 1983. At the same time, a new vehicle access into the site off Woodborough Lane was permitted.

1.3.5 Further planning permissions for clay extraction were granted in 1986 (for the eastern section of the site, reference 7/01/85/1064) and in 1998 for a southerly extension (reference 7/97/0697). Both of these permissions incorporated restoration of the site by landfill with non-hazardous domestic and industrial wastes.

1.3.6 Two planning permissions were granted in 2013 for an “Eastern extension of the working and extraction of clay and associated minerals with subsequent low-level restoration to include landscaping and diversion of public footpaths” (application reference 7/2013/0760NCC). Planning permission was granted on 17 December 2013. The second planning application (reference 7/2013/0757NCC) was to “Vary conditions 3, 13 and 50 of planning permission 7/2003/0335 to allow a "pause" in the existing landfill to occur and to provide a revised restoration profile which will tie in with the intended low-level restoration of the proposed eastern extension”. Planning permission was issued on 16 December 2013.

1.3.7 As mentioned in Section 1.2.2, the site is adjacent to a non-hazardous landfill site which is operated by FCC. It is understood that this ceased to accept waste circa 2013 and that FCC remain responsible for the ongoing compliance with the permit. Presently works are progressing by FCC to stabilise an eastern flank of their site, also using inert materials. Gas is collected by Inifinis and drawn off to the generation equipment to the north western boundary of the FCC site.

1.3.8 In 2018 planning permission was granted (reference 7/2018/0159NCC) for the proposed southerly extension of the clay workings and extraction of clay and associated minerals, with subsequent restoration by infilling with imported inert waste materials to include landscaping and diversion of public rights of way.

1.3.9 The proposal entails the importation of inert waste to infill and restore the quarry void that will be created following mineral extraction activities in the southerly extension.

1.3.10 The works will be completed in accordance with the restoration scheme (Drawing Number DHS 3/10, Revision A) that was approved under planning permission 7/2018/0159NCC.

1.3.11 The restoration of the site will require approximately ### tonnes (or ###m^3) of material to be brought to the site. It is proposed that up to ### tonnes of material would be brought to the site each year over a ### year period.

1.4 Landfill Design Philosophy

Basal Layer

1.4.1 No mineral liner is required to be constructed for the site due to the presence of a natural geological barrier present at the base comprising of Mercia Mudstone. Therefore, the geological barrier will be formed by leaving the existing clays in place.

1.4.2 Engineered clay will however be used to line the base of the void where either different lithology or skerry bands are exposed in the base following extraction of the overlying mudstone. The proposed basal liner will be 0.5m thick and will have a permeability of 5 x 10^{-8} m/s which is equivalent to a 1m liner with a permeability of 1x10^{-7} m/s. The proposed construction of the engineered base (where required) will be subject 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 and subsequently demonstrated to ensure that the quality of installation is to the required standards

Side Slope Lining

1.4.3 Given the confidence in the low permeability of the Mercia Mudstone between the designated skerry bands, engineered clay will be used to plug any seepage from any skerry bands in the side walls of the landfill. If required, it is proposed to excavate into the seeping band to a point where a minimum 1m with a maximum permeability of 1 x 10^{-7} m/s (or equivalent) of engineered clay will fill the gap to prevent any groundwater ingress into the site. By doing this it will remove any pathways for potential contaminates out of the landfill. The clay plug will tie in above and below with the Mercian Mudstone to form a low permeability seal.

1.4.4 The proposed testing of the clay materials in situ at the moment and the construction of the clay plug would be to the specification detailed in the Construction Quality Assurance (CQA) Plan that will be produced for the site.

1.4.5 The proposed construction of the clay liner would be to the specification detailed in the Construction

Quality Assurance (CQA) Plan that will be submitted to the Agency for approval prior to engineering taking place.

Capping

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

Restoration

1.4.7 As detailed on the restoration scheme (Drawing Number DHS 3/10, Revision A) the site will be restored to rich grassland and broadleaved woodland.

Aftercare

1.4.8 Aftercare will be carried out for a period of 5 years following the completion of restoration of any phase and will provide for the management of the soil resources to establish a sustainable after use.

1.4.9 An annual site meeting between Mick George Ltd and NCC will be undertaken to review the performance of the aftercare scheme for that year and agree on a detailed programme for the following year.

1.4.10 Details regarding the site's aftercare are provided in the Closure and Aftercare Plan (Appendix I of the main application).

1.5 Regulatory Context, Groundwater and Surface Water Protection

Aquifer designation

1.5.1 The Environment Agency's Approach to Groundwater Protection guidance (published February 2018), stipulates that any proposed landfill will be subjected to a quantitative risk assessment if the site is situated within a Principal Aquifer or Groundwater Source Protection Zone (GSPZ) 2 or 3 where the risk assessment demonstrates that active long-term management of the site is essential. In this instance, the site is an inert landfill which does not require active long-term management to prevent groundwater pollution.

1.5.2 According to the Multi Agency Geographic Information for the Countryside (MAGIC) website, the proposed site is not situated within a GSPZ.

1.5.3 In terms of aquifer designation, the MAGIC website shows that the application site overlies a Secondary B aquifer. As such, this development should not pose a significant potential hazard to the quality of the receiving environment i.e. the underlying aquifer.

Licensed and Unlicensed Abstractions

1.5.4 Given the urban setting of the proposed development there is no evidence of either licensed or unlicensed water abstractions facilities within 1km of the site. As detailed in the section below, the operational depths will ensure that the void will be excavated above the water table, thus ensuring that no impact will arise on any potential users.

Water Table

1.5.5 It is proposed that the site shall be worked dry therefore the void will be excavated to ensure that the water table will not be intersected. See discussion in Section 4.1.7 for water strike depths and groundwater water levels. Hence, the installation is described as not being sub-water table.

Hydrology

1.5.6 According to the Flood Map for Planning Service (FMPS), the application site is not situated in an area at risk of flooding.

1.5.7 Within the wider vicinity of the site, there is a pond located approximately 430m north west of the site, Day Dumble Brook is located approximately 800m east, Lambley Dumble located approximately 1.2km southeast and Day Drook located approximately 2.7km southwest.

Ecology

1.5.8 The MAGIC website shows there are no Statutory Designated ecological sites within 2km of the site.

1.5.9 However, there are several Priority Habitats sites of deciduous woodlands located within and on the southern boundary of the site. Drawing MGL/B027237/REC/01 shows the areal distribution of these features.

2.0 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

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

2.1.2 A preliminary schematic CSM for the site is shown on Drawing number MGL-B027237-HYD-01 which is a north-west to south-east cross section of Drawing DHS 3/10, Revision A. This model will be updated as the site develops and more information becomes available.

2.1.3 The CSM development has focused on characterising the relationship between groundwater beneath the site and the proposed engineering activities, in its post restoration period, following clay extraction and then infilling with inert waste.

2.1.4 The source-pathway-receptor scenario is a useful means to generate a conceptual model, which can be used to identify critical pathways to inform the decision whether a more detailed analysis of risk is required. The various stages of the process are presented below:

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. It is realistic to expect that a typical leachate mound within these inert deposits, which consist mostly of clay soils, will not develop due to the greatly diminished permeability of the material following compaction by site machinery and plant. Any potential leachate generated will be retained within the clay matrix due to its increased surface area of the clay particles.

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.

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

3.0 CONCEPTUAL MODEL: SOURCE TERM

3.1.1 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 secondary designation of the potential underlying aquifer units that will remain following removal of the mineral deposits, a leachate source term component will be incorporated into this risk assessment process.

3.1.2 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'.

3.1.3 Details regarding the proposed waste types to be imported, including operational restrictions, are provided in the Operating Techniques (Appendix B of the Environmental Permit Application).

3.1.4 A volume of ### m^3 of imported material (or ### tonnes using a conversion factor of 1.6m^3/tonne) is required in order to restore the site following mineral extraction.

3.1.5 A consideration will be 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. However, due to the inert nature of the material to be used to restore the quarry, it is considered highly unlikely that rainwater coming into contact with the imported material at the site will generate high concentrations of pollutants.

3.1.6 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 considered that hazardous substances are not expected to be present and non-hazardous substances are expected to be low with respect to the background groundwater quality.

3.1.7 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.

3.1.8 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.

3.1.9 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 an on moving machinery. Plant will be inspected daily for possible fuel/grease leaks and repairs will be carried out immediately, alternatively the offending

machine will be taken out of commission until a repair has been completed.

3.1.10 Further consideration to safeguard the risk of contamination is provided by the proposed CQA-supervised engineering works during the construction of the basal barrier and side-slope liner.

4.0 CONCEPTUAL MODEL: PATHWAYS

4.1 Geology

4.1.1 A round of drilling was undertaken to establish a network of monitoring boreholes surrounding the site's boundary and dedicated to measuring groundwater levels and quality (See MGL/B027237/HYD/01).

4.1.2 A total of 4 no. boreholes were installed around the site's perimeter (Borehole logs in Appendix A). In addition to providing basic geological and hydrogeological information these boreholes indicated the depths of exploitable minerals

4.1.3 According to the British Geological Survey's (BGS) 'Geology of Britain Viewer' and site drilling information gathered, the geological sequence beneath the site is composed by approximately up to 0.5m of topsoil and subsequently a sequence of sedimentary strata comprised of mudstone, siltstone and sandstone layers of varying thickness.

4.1.4 These sedimentary deposits represent the Radcliffe and Gunthorpe Members of the Mercia Mudstone Group. Specifically, beneath the site, the bedrock geology comprises predominately of units representing the Gunthorpe Member. There is also a small parcel of land located in the northwest and northeast corners of the site which have a bedrock of Siltstone and Dolomitic Limestone which also belong to the Gunthorpe Member.

4.1.5 The consistency of the different geological units encountered is described in the drillers' logs as being "strong" and "hard". The Mercia Mudstone Group largely consists of red/brown mudstones, silty mudstones, siltstones and occasional relatively thin, pale green, fine to medium grained sandstone horizons; known as 'Skerry Bands'. Given the drillers' description it is concluded that those layers of more competent lithology could be interpreted as skerry bands although is it difficult to identify them as individual units without a petrographic analysis.

4.1.6 According to the results from the BGS' "Geology of Britain Viewer" there is no evidence of any shallow mine activities (subsurface pathways) beneath the site, expect where the Coal Measures Group would be intersected, this is likely to occur at a depth of >60m.

Hydrogeology: Aquifer Designation and Groundwater Vulnerability

4.1.7 Information contained in the available boreholes logs (Appendix A) show that minimal water strikes were recorded in BH1 at 20.5mbgl and 11.5mbgl in BH 3, with a possible strike around 16mbgl in BH2. The insignificant amount of groundwater inflow into the boreholes would ensure that dry working conditions will be maintained should the working level (reported/proposed to be a maximum of 115mAOD) reach these depths.

4.1.8 According to the MAGIC website the application site is underlain by a Secondary B Aquifer (the Mercia Mudstone Group).

4.1.9 Interestingly, the vulnerability potential of this unit is considered to be high risk.

Groundwater Monitoring Boreholes

Groundwater levels

4.1.10 The available groundwater levels data submitted by MGL 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 BH4 in the south of the site, whereas the lowest average levels were measured in boreholes BH1, located in the north west portion of the site.
- From these data the groundwater flow direction can broadly be inferred to have two components, one to be south to north west and another south to north east (MGL/B027237/HYD/01).
- These inferred groundwater levels 10 m below the base of the site do not seem to follow the geological strata which dips to the southeast within a local syncline having its axis along Woodborough Lane. This variation in direction may be due to dewatering activities in other parts of the quarry complex.
- The hydrograph shows no correlation with natural rainfall cycles during the year, probably due to the irregular and limited frequency of the monitoring visits carried out to date.

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

Up-gradient: BH3 and BH4

Down-gradient: BH1 and BH2.

Baseline Groundwater Quality

4.1.12 Groundwater quality data were obtained from the boreholes forming the current monitoring network (MGL/B027237/HYD/01) between September 2020 and June 2021. Raw chemical data presented in Appendix C.

4.1.13 The groundwater quality results for the indicator substances ammoniacal nitrogen (Amm. N), chloride and sulphate are chosen to identify are potential contamination arising from the landfill due to their high mobility (Amm N and chloride) and sulphate as a potential leachable component of inert waste

respectively.

4.1.14 Various metals have also been included in the interpretation of the chemical characteristic of the groundwater.

4.1.15 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".

4.1.16 It should be noted that potential outliers have not been removed at this stage, but statistical analysis has been performed on the data set for the calculation of Compliance Limits in Section 8.2.

Up-gradient boreholes

- The Amm. N chemograph displays a peak in values on one occasion (in Feb. 2021 for BH3). The remaining the data points are in a harmonised linear pattern, with no discernible trends. Average concentrations are recorded between a maximum of 2.1mg/l (recorded in BH3) and a minimum of 0.025mg/l (normalized), however the maximum value could be skewed as a result of the noted peak in BH3. Average concentrations for both boreholes are below the EQS value of 0.5mg/l

- Chloride average concentrations are all below the EQS of 250mg/l for these up-gradient boreholes although a distinctive value of 850mg/l was returned for the February. 2021 sampling round in BH3, which appears to be anomalous against the remaining data set. The trends for BH 3 and BH4 are generally stable and linear which reflect the narrow range in average concentrations of between 136mg/l (BH3) and 102mg/l (BH4).

- Average sulphate values are within a relatively narrow range of between 41mg/l and 50mg/l for BH3 and BH4 respectively, well below the EQS of 250mg/l. The plot of these concentrations displays a relatively stable and linear trends in both boreholes.

- Common metal values up-gradient display similar patterns within the two monitoring boreholes, with cadmium, lead and mercury not detected in all 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.

Down gradient boreholes

- The Amm. N plot is also affected by the noted spurious (anomalous) behavior of values found up-gradient both occurring in April 2021 in both BH1 and BH2. For the remainder of the monitoring period, trends are mostly linear and stable and fall within a very narrow range of values. Average concentrations vary between a minimum of 0.025mg/l and a maximum of 2.67mg/l, although these

values are likely to be affected by the noted peaks in concentration. The EQS value of 0.5mg/l has not been exceeded in either of these monitoring points

- Average chloride concentrations are also all below the EQS value of 250mg/l and fall within an average range of 80mg/l and 51mg/l for BH1 and BH2 respectively. The linear trends displayed in the chemograph by all the monitoring points reflect the narrow plotting series of these boreholes.

- Average sulphate values are also within a relative narrow range of between a maximum of 121mg/l (BH1) and a minimum of 40mg/l (BH2). The plotting behavior of BH1 is rather haphazard and not related to any external factors. Both boreholes display concentrations significantly below the EQS value of 250mg/l.

- Metal values down-gradient display similar patterns to those up-gradient within the four monitoring boreholes. Again, cadmium, lead and mercury have not been detected in all the 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.

4.1.17 As an overall comment, the groundwater quality between the up-gradient and down-gradient monitoring points is identical, as expected to be found within a hydrogeological environment that is anthropogenically undeveloped.

Long Term Hydrogeological Changes

4.1.18 Hydrogeological changes could potentially occur expected within the mineral deposits as a result of the proposed extraction activities. These impacts are predicted as localised changes to recharge characteristics and flow directions; but would not affect resources within the underlaying Mercia Mudstone Group. The impact of the proposed activity on recharge and flow direction are assessed as being minor, but long term, due to the localised nature of the development.

4.1.19 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.

5.0 CONCEPTUAL MODEL: RECEPTORS

5.1 Amenities

5.1.1 Sensitive receptors located within 1km of the application site have been considered in the Environmental Risk Assessment which is provided as Appendix D of the Environmental Permit Application.

5.1.2 Based on evidence from the MAGIC website, the site does not lie within the source protection zone (SPZ) for public water supply.

5.1.3 Therefore, the underlying remaining geological unit(s) i.e. the strata belonging to the Mercia Mudstone Group, is considered to be the principal receptor for this assessment.

5.2 Hydrology

5.2.1 According to the Flood Map for Planning Service (FMPS), the application site is not situated in an area at risk of flooding.

5.2.2 Within the wider vicinity of the site, the following surface water features are located: a pond approximately 430m north west of the site, the Day (Dumble) Brook approximately 800m east, the Lambley Dumble located approximately 1.2km southeast and the Day Brook approximately 2.7km southwest.

5.3 Sites of Ecological or Nature Conservation Significance

5.3.1 There are no Sites of Special Scientific Interest (SSSI) within 3km of the site. However, there are two Local Nature Reserves adjoining the site's boundary i.e. The Hobbucks and Red Hill.

6.0 HYDROGEOLOGICAL RISK ASSESSMENT

6.1 The Nature of the Assessment

6.1.1 This environmental permit application will be submitted for Dorket Head Quarry Landfill 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 EA guidance[1] and legislation, a tiered approach is proposed to the risk assessment process such that the degree of effort and complexity reflects the potential risk posed by a particular site.

6.1.3 The risk assessment starts with risk screening, which is the process used to determine whether a landfill development represents, or potentially represents, a risk to groundwater and surface water resources, and at the planning stage whether the site complies with the EA approach to groundwater protection[2]. The qualitative risk screening should assess whether the potential discharge from the activity is acceptable and whether it will require further assessment as outlined in the guidance[3].

6.1.4 Groundwater can be at significant risk from landfill activities unless the site is suitably located and subject to robust operational controls. The nature and hazard to potential groundwater contamination will depend on the types and quantities of pollutants in the waste.

6.1.5 Unless the whole waste mass is inert, landfills represent a store of pollutants some of which could find their way into the environment. Therefore, the EA approach is to steer development of landfills into less sensitive locations and the risk assessment (risk screening) should consider the following:-

- Determine that the input of hazardous substances into groundwater will be prevented and there will be no pollution of groundwater by non-hazardous pollutants over the whole lifecycle of the landfill;
- Provide the basis for deciding whether the engineering measures and other proposed technical precautions fulfil the requirements of the Landfill Directive and the Groundwater Daughter Directive (GWDD); and
- Ensure that the development complies with both the GWDD and the Landfill Directive.

[1] Landfill developments: groundwater risk assessment for leachate. DEFRA/EA. 1st February 2016;
[2] The Environment Agency's approach to groundwater protection. Environment Agency. Version 1.2. February 2018;
[3] Groundwater risk assessment for your environmental permit. DEFRA/EA. Published 1st February 2018. Updated 3rd April 2018.

6.1.6 The above requirements will be expanded and fulfilled in the qualitative risk screening section below.

6.2 Qualitative Risk Screening

6.2.1 The various properties that will be considered for this risk screening are discussed below:

- The extraction of the mudstone layers within the Mercia Mudstone Group is unlikely to expose water bearing horizons, as described in Section 4.1.7;
- The Mercia Mudstone Group is classified by the EA as a Secondary B Aquifer;
- The site is not shown to be situated within an EA defined groundwater Source Protection Zone (SPZ). There are no licensed potable drinking water abstractions within 2km of the application site at the time of writing this assessment.
- The entire site is to be restored using inert material only which will be subject to a robust Waste Acceptance procedure during the entire operation;
- Upon completion of infilling, infiltration will be limited by the construction of a 'capping' layer using stripped low permeability clay soils and 0.30m thick topsoil layer;
- Potential water bearing units exposed along the sidewall of the quarry are to be isolated using engineered clay with a permeability equivalent to 1 x 10^{-7} m/s to prevent groundwater ingress into the waste mass and lateral leachate migration;
- The low permeability nature of the mudstone layers remaining *in situ* beneath the base of the site will act as a natural geological barrier, providing attenuation and retardation of any low-level contaminants derived from the imported inert material;

6.2.2 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.

6.2.3 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 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.

6.2.4 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.

6.2.5 It is considered that no hazardous substances and low concentrations of non-hazardous substances will be present in leachate migrating from the base of the site and therefore, the restoration of Leicester Quarry complies with the Groundwater Daughter Directive (implemented through the Environmental Permitting Regime, England & Wales, 2016) and Groundwater Regulations 2009.

6.2.6 The EA approach to groundwater protection, positional statement E, provides guidance in respect of the location of landfills during planning and permitting decisions. The landfill position statement (E) indicates the EA would object to landfills being located on Principal Aquifers, within Source Protection Zones and below the water table where groundwater forms a significant contribution to river flow or other sensitive surface waters where active long-term site management is essential to prevent long term groundwater pollution.

6.2.7 The risk screening has demonstrated that the site is not situated in a groundwater SPZ, located on a principal aquifer or below the water table. Therefore, the proposed development is considered to comply with EA positional statement E. Negligible impact from leachate generation from the site is expected to occur within the groundwater receptor.

6.2.8 The proposed development complies with the requirements of Schedule 10 of the Environmental Permitting Regulations (2010) and Groundwater Daughter Directive as it will not result in hazardous substances entering groundwater or surface water and will not result in the introduction of non-hazardous pollutants so as to cause pollution to controlled waters and hence, further detailed hydrogeological assessment is not required.

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 natural geological barrier or artificially engineered barrier where required', 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 counteract any groundwater inflow, especially when the stand-off of 1m unsaturated zone is to be maintained between the void's base and the top of the groundwater levels within the underlying Mercia Mudstone Group aquifer.

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 A surface water management system has been proposed and will be installed around the perimeter of the site in the form of collection drains and any water generated will be conveyed into infiltration ponds located down-gradient of these ditches.

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 MGL/B027237/HYD/01.

8.1.2 The parameters to be sampled and monitoring frequency to be included in the Environmental Permit are presented in Table 1 below. These requirements are considered adequate in providing an ongoing characterisation of the groundwater conditions.

Table 1: 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, Mercury, Selenium and Cyanide	*To include quarterly suites plus:* List 1 Hazardous Substances

Surface Water

8.1.3 There are a series of existing surface water lagoons within the wider Dorket Head quarry site, one of which is located adjacent to the north east corner of the application site and discharged in a controlled manner to the Day (Dumble) Brook located along the eastern boundary of the application site. The design of the existing surface water lagoon is sufficient to accommodate this southern extension. This discharge activity is undertaken under a discharge consent which is controlled by FCC. For the purposes of this Environmental Permit Application, it is proposed that the existing consent will be transferred from FCC to Mick George to facilitate surface water management in the application site.

8.1.4 In light of the above, it is proposed that surface water will be monitored in accordance with the existing discharge consent.

8.1.5 The frequency and sampling suite to be implemented for the characterisation of surface water quality is presented in Table 2.

Table 2: Surface Water Determinants and Sampling Frequency

Quarterly
pH, Chloride, Amm N, Sulphate, COD, BOD, Electrical conductivity, Suspended Solids and Visible Oils and Grease

8.2 Compliance Limits

8.2.1 Compliance limits are set for the chosen down-gradient boreholes, namely BH 1 and BH2 and presented in Table 3.

8.2.2 Hazardous contaminants mercury and cadmium are set at their respective Minimum Reporting Values (MRVs) as defined in current EA guidance[4].

8.2.3 The compliance limits for non-hazardous pollutants have been set at the UKDWS or EQS. Where maximum background concentrations (see Appendix C) are above the respective water quality standards, the maximum background concentration is used as the compliance limit e.g. for Amm N, as the maximum background concentration chosen has already taken care of any seasonal variability.

8.2.4 These limits can be applied equally to the proposed down gradient boreholes, as prescribed in the regulatory requirement in Agency's H1 guidance, Annex J3 since they intersect the same geology.

8.2.5 It is recognised that at this stage of the application the proposed Compliance Limits of Table 3 have been derived from a limited set of data. As the monitoring dataset expands, a more meaningful statistical approach will be applied in the calculation of future revised Compliance Limits. This will be done on an annual frequency, in line with the submission of the yearly monitoring reports which are a standard pre-requisite condition of the Environmental Permit.

Table 3 – Proposed Environmental Compliance Limits

Determinand	Max. Background Conc.	Water Quality Standard (MRV, UKDWS or EQS)	Compliance Limit
Hazardous Substances			
Mercury	<0.01µg/l	0.01µg/l	**0.01µg/l**
Cadmium	<0.11µg/l	0.1µg/l	**0.1µg/l**
Non-hazardous Pollutants			
Amm N	2.10mg/l	0.5mg/l	**2.10mg/l**
Chloride	130mg/l	250mg/l	**250mg/l**
Nickel	14µg/l	20µg/l	**20µg/l**
Sulphate	75mg/l	250mg/l	**250mg/l**

8.3 Contingency Action Plan

8.3.1 An annual review of the proposed compliance limits should be carried out and any alterations in the

[4] Groundwater risk assessment for your environmental permit. DEFRA/EA. Published 1st February 2016. Updated 3rd April 2018 - https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit [Accessed 1 September 2018]

compliance levels discussed and agreed with the EA.

8.3.2 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 Environment Agency, are presented in Table 4.

Table 4: Suggested Contingency Actions

Appropriate Contingency Action	Timescale
Advise Site Management	Immediately
Advise Operator's Environmental Manager	1 Week
Advise Environment Agency	1 Week
Confirm by repeat sampling and analysis	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

9.1.1 This HRA has demonstrated that the site is not a) situated in a groundwater SPZ, b) located on a principal aquifer or c) situated below the water table and therefore complies with the Environment Agency's Landfill Positional Statement E1.

9.1.2 Negligible impact from leachate generation from the site is expected to occur to the groundwater system, this being the main receptor.

9.1.3 Surface water runoff is to be controlled under a discharge consent which is currently controlled by FCC but will be transferred to Mick George to facilitate surface water management on site.

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

9.1.5 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.

9.1.6 Compliance limits for groundwater have been derived and a robust monitoring network has been installed to ensure that the future performance of the site will be correctly monitored and managed.

9.1.7 The requirements of schedule 10 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 8.

Drawings

MGL/B027237/LOC/01 – General site layout and permit boundary

MGL/B027237/REC/01 - Receptor Plan

DHS 3/10 Rev A – Proposed restoration plan

MGL/B027237/HYD/01 - Monitoring Infrastructure

MGL/B027237/HYD-02 – Site Engineering Details

MGL/B027237/HYD-03 – Site hydrogeological conceptual model

MGL/B027237/HYD-04, 05 and 06 – Groundwater Contours

Appendices

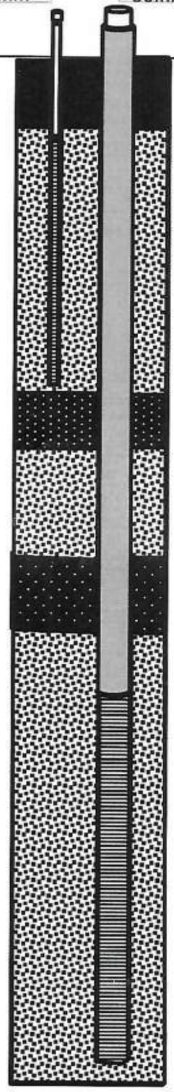
Appendix A – Drilling logs,

Appendix B – Groundwater level data and plot

Appendix C – Groundwater quality data and plots

Appendix A – Drilling logs

FROM	TO	RECOVERED	CASING	TIME	RETURN



WATER LEVELS	Depth	Casing	Time
Morning	/	/	/
Afternoon			
Evening			
Other			

CORING			
Depth (M) From	To	Core Diameter	Casing Diameter
NONE TAKEN		89.5	160

Water Encountered	1	2	3
Depth Struck	/	/	/
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time Reason	HRS
FILL WATER TANK 745 – 845	1Hr.

COMMENTS / REMARKS

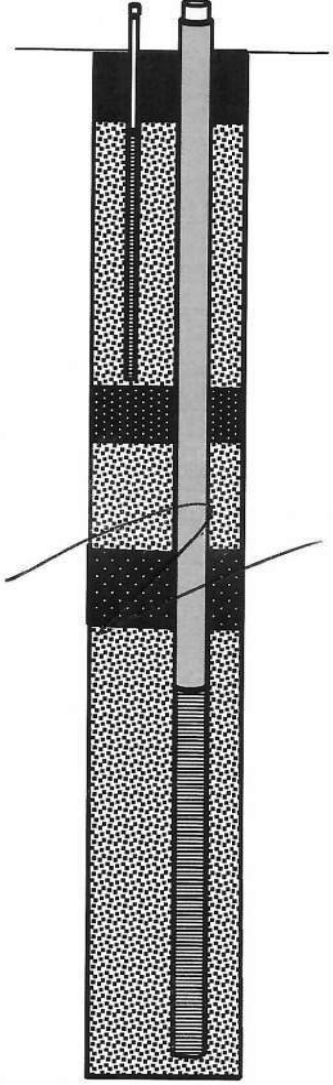
LOAD RIG ONTO TRAILER TO TAKE from B/H 2 TO B/H 1.

BH NO	1		
Job Title/Site	IBSTOCK DORKET HEAD		N/A.
Date	11. 9. 2020.		
Plant Used	MC205/A		
Crew	MG/GC		
Sheet No	1 of 3.		

SIS Drill (UK) Ltd
The Coach House, 1 Long Lane, Willoughton, Gainsborough, DN21 5SQ

ROTARY DAILY RECORD

0.00	TOP SOIL
0.40	STIFF TO VERY STIFF BROWN CLAY.
0.80	STIFF BROWN TO REDDISH BROWN WEATHERED MUD-STONE.
2.00	STRONG REDDISH BROWN MUDSTONE WITH THIN BANDS OF LT GRY AND PINK SILTSTONE, FREQUENT FRACTURED BANDS.
16.30	HARD DARK BROWN MUD STONE WITH THICKENING BANDS OF DARK BROWN SANDSTONE WITH ORANGE SANDSTONE PEBBLES
17.50	STRONG THICKENING BANDS OF LT GRY AND BROWN SANDSTONE WITH INTER BEDED BROWN MUDSTONE
18.00	FINISH AT END OF DAY.
18.00	AT END OF DAY.



1.50	3.0	95%	1.40	20	600
3.00	4.50	100%	"	"	"
4.50	6.00	80%	"	"	"
6.00	7.50	100%	1.40	"	"
7.50	9.00	80%	"	20	"
9.00	10.50	100%	"	"	600
10.50	12.00	90%	1.40	"	"
12.00	13.50	80%	"	"	"
13.50	15.00	80%	"	20	"
15.00	16.50	90%	"	"	"
16.50	18.00	100%	1.40	20	600

WATER LEVELS

	Depth	Casing	Time
Morning	N/A.		
Afternoon	N/A		
Evening	N/A		
Other	N/A.		

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
1.50	18.0	89.5	160

Water Encountered

	1	2	3
Depth Struck	16.0	?	
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

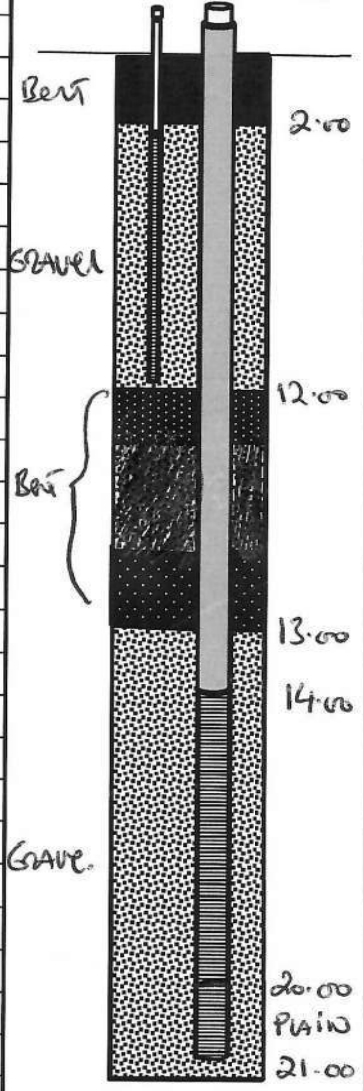
Reason	HRS
FILL WATER TANK 7.45 TO 8.45	1Hr

COMMENTS / REMARKS

Air, mist, foam flush used throughout.

BH NO	2
Job Title/Site	IBSTOCK DORKET HEAD
Date	10.9.2020
Plant Used	MC205/A
Crew	MG/GC
Sheet No	1 of 2

18.00	STRONG LT GREY AND BROWN BANDED MUDSTONE AND SANDSTONE.
21.00	FINISH



FROM	TO	RECOVERED	CASING	TIME	RETURN
1500	1950	100%	1.40	1/2	YES
1950	2100	100%	1.40	1/2	YES

WATER LEVELS

	Depth	Casing	Time
Morning	N/A		
Afternoon			
Evening			
Other			

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
18.0	21.0	89.5	160

Water Encountered

	1	2	3
Depth Struck	?		
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

Reason	HRS
FILL WATER TANK	

COMMENTS / REMARKS

N/A.

BH NO	2
Job Title/Site	IBSTOCK DORKET HEAD
Date	11. 9. 20. 20
Plant Used	MC205/A
Crew	MG/GC
Sheet No	2 of 2.

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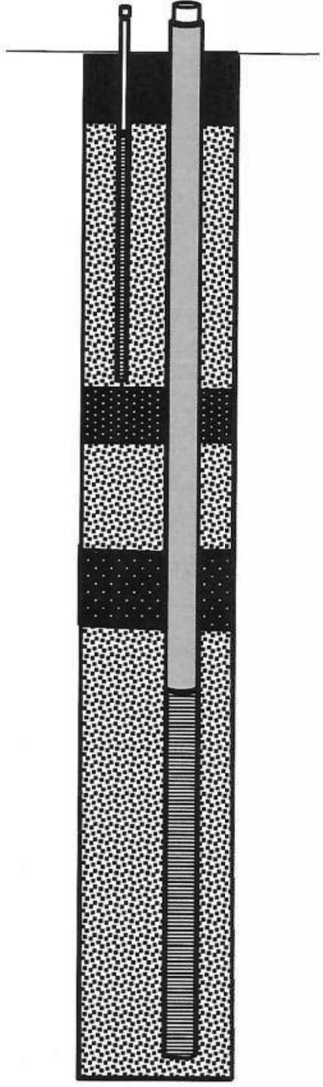
The Coach House, 1 Long Lane, Willoughton, Gainsborough, DN21 5SQ

ROTARY DAILY RECORD

0.00	TOP SOIL
0.40	REDDISH BROWN SANDY CLAY.
1.40	WEAK REDDISH BROWN MUDSTONE
1.80	MOD STRONG LT BROWN AND GREY MUDSTONE
8.10	STRONG RED MUDSTONE
8.50	LT GREY SILTSTONE
8.80	STRONG RED/BROWN MUDSTONE
9.40	HARD LT GREY BROWN SILTSTONE
10.80	REDDISH BROWN MUDSTONE
11.50	WATER, TRACE ONLY.
19.00	FINISH AT END OF DAY.
19.00	AT END OF DAY.



WATER LEVELS

	Depth	Casing	Time
Morning			
Afternoon			
Evening			
Other			

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
NONE TAKEN		89.5	160

COMMENTS / REMARKS

Water Encountered

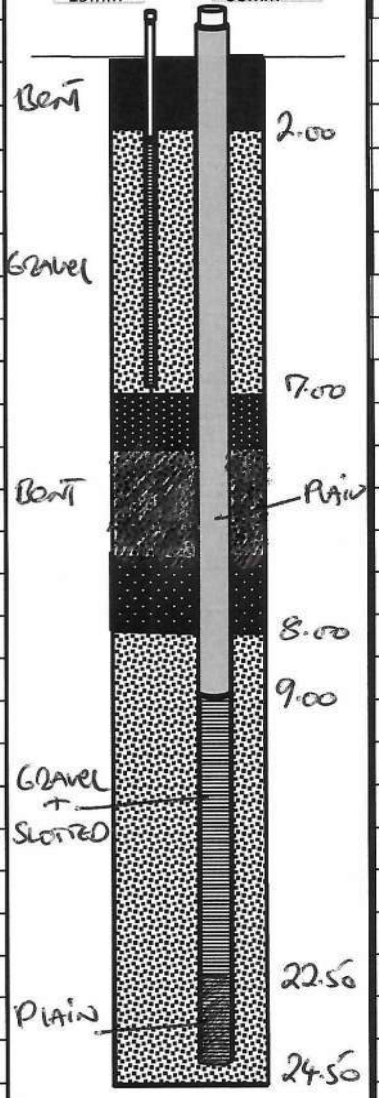
	1	2	3
Depth Struck	11.50		
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

Reason	HRS
WAIT FOR FENCING TO BE TAKEN DOWN BY IBSTOCK 1.PM – 2PM	1Hr.
FILL WATER TANK N/A.	
WATER LEVELS x 2.	1Hr.

BH NO	3
Job Title/Site	IBSTOCK DORKET HEAD
Date	8.9.2020.
Plant Used	MC205/A
Crew	MG/GC
Sheet No	1 OF 2

19.00	START OF DAY — B/H DAMP.
20.80	LT GREYISH + PINK SILT-STONE
23.50	LT GREY SILTSTONE.
24.50	FINISH
24.5	FINISH



FROM	TO	RECOVERED	DATE	TIME	REMARKS

WATER LEVELS

	Depth	Casing	Time
Morning	TRACE.		
Afternoon			
Evening			
Other			

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
NONE TAKEN		89.5	160

Water Encountered

	1	2	3
Depth Struck	19.0	?	
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

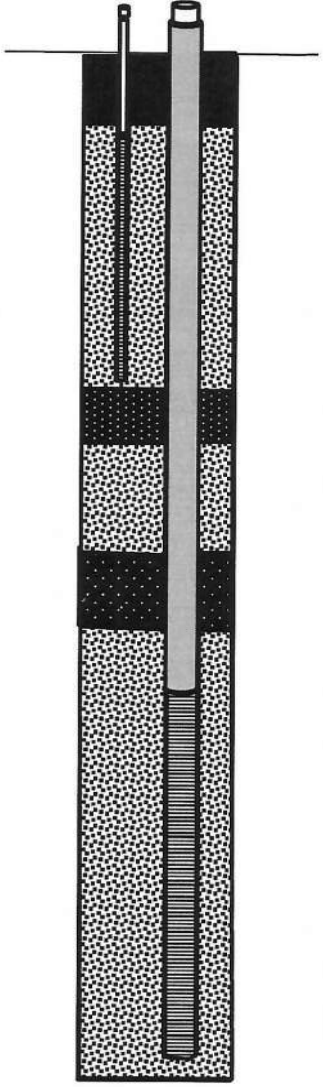
Reason	HRS
FLUSH B/H WITH WATER FOAM MIX 10AM TO 10.30	1/2
FILL WATER TANK 7.45 - 8.45	1H

COMMENTS / REMARKS

BREAK DOWN = 11.30AM TO 3pm DUE TO BURST AIR HOSE

BH NO	3
Job Title/Site	IBSTOCK DORKET HEAD
Date	9.9.2020
Plant Used	MC205/A
Crew	MG/GC
Sheet No	2 of 2

0.00	TOP SOIL
0.20	RED BROWN CLAY WITH BRICK RUBBLE
1.40	STIFF RED/BROWN WEATHERED MUDSTONE
2.80	STRONG LT GREY SILT-STONE
3.10	MOD, STRONG REDDISH BROWN MUDSTONE
4.00	HARD LT GREYISH/PINK MUDSTONE
5.10	HARD REDDISH BROWN MUDSTONE
6.40	STRONG LT GREYISH BROWN MUDSTONE
7.00	STRONG PINK MUD-STONE
10.50	STRONG LT GRY/PINK MUDSTONE
11.80	STRONG REDDISH BROWN MUDSTONE.
16.50	FINISH AT END OF DAY.
16.50	



WATER LEVELS

	Depth	Casing	Time
Morning	N/A	—	—
Afternoon	N/A	—	—
Evening	TRACE	DNM	
Other			

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
NONE.		89.5	160

Water Encountered

	1	2	3
Depth Struck	16.00	?	
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

Reason	HRS
INDUCTIONS 8AM TO 10AM	2H
MOVE ONTO SITE 10AM TO 11AM	1H
FILL WATER TANK 2.PM-2.30	1/2

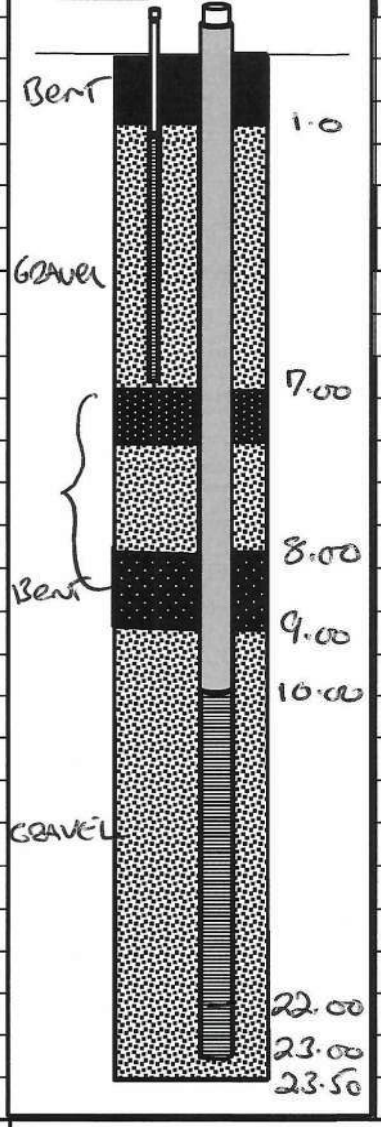
COMMENTS / REMARKS

RIG BREAK DOWN - 1.45PM TO 3.30PM VISITED BY RIG SERVICES MECH.

NOTE: BOTH SETS OF FENCING MADE SAFE AT END OF DAY.

BH NO	4
Job Title/Site	IBSTOCK DORKET HEAD
Date	7.9.2020
Plant Used	MC205/A
Crew	MG/GC
Sheet No	1 of 2

16.50	AT START OF DAY — STRONG REDDISH BROWN BANDED MUDSTONE WITH HARD LAYERS OF PINK / GREY MUDSTONE
23.50	finish
23.5	finish



WATER LEVELS

	Depth	Casing	Time
Morning	16.50	—	9.AM
Afternoon	/		
Evening	/		
Other	/		

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
NONE TAKEN		89.5	160

Water Encountered

	1	2	3
Depth Struck			
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

Reason	HRS
FILL WATER TANK 7.45 AM TO 8.45 AM	1HR

COMMENTS / REMARKS

BH NO	4
Job Title/Site	IBSTOCK DORKET HEAD
Date	8.9.2020
Plant Used	MC205/A
Crew	MG/GC
Sheet No	2 OF 2

N/A

Strata Record

DEPTH	DESCRIPTION
0.00	RED BROWN CLAY MADE GROUND
1.20	REDDISH BROWN SANDY MARL
1.40	STRONG LT GREY MUD/SILTSTONE
1.80	STRONG REDDISH BROWN BANDED MUDTONE WITH
	LENSES OF PINKISH GREY SILT AND MUDSTONE
20.50	SLIGHT WATER STRIKE
22.00	STRONG BROWN AND GREY MUDSTONE WITH THICKENING
	BANDS OF GREY AND BROWN SANDSTONE
22.50	FINISH AT END OF DAY
22.5	AT END OF DAY

MONITORING WELL DETAILS

BLOWS FOR PENETRATION					
0 TO 75	75 TO 150	150 TO 225	225 TO 300	300 TO 375	375 TO 400

CORING

DEPTH (M)		LENGTH RECOVERED	DEPTH OF CASING	DRILLING TIME	FLUID RETURN
FROM	TO				
1.50	3.00	1.40	1.40	N/A	YES
3.00	4.50	1.50	1.4	N/A	YES
4.50	6.00	1.50	1.40	N/A	YES
6.00	7.50	1.45	1.40	N/A	YES
7.50	9.00		1.40	N/A	YES
9.00	10.50			N/A	YES
10.50	12.00	1.50		N/A	YES
12.00	13.50	1.40		N/A	YES
13.50	15.00	1.5		N/A	YES
15.00	16.50	1.45		N/A	YES
16.50	18.00	1.4		N/A	YES
18.00	19.50	1.5		N/A	YES
19.50	21.00	1.5		N/A	YES
21.00	22,5	1.5	1.4	N/A	YES

WATER LEVELS

	Depth	Casing	Time
Morning	N/A		
Afternoon			
Evening			
Other			

CORING

Depth (M)		Core Diameter	Casing Diameter
From	To		
1.50	22.50	76.5	160

AIR /FOAM FLUSH USED THROUGH OUT CORING PROCESS

Water Encountered

	1	2	3
Depth Struck	20.5		
Casing Depth	1.4		
Inflow	SLOW		
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at	O		

Dayworks/Standing Time

Reason	HRS
FILL WATER TANK	1 HR

BH N0	1
Job Title/Site	IBSTOCK DORKET HEAD
Date	15/09/2020
Plant Used	COMMACHIO 205/A
Crew	MG / AM
Sheet No	1 OF 2

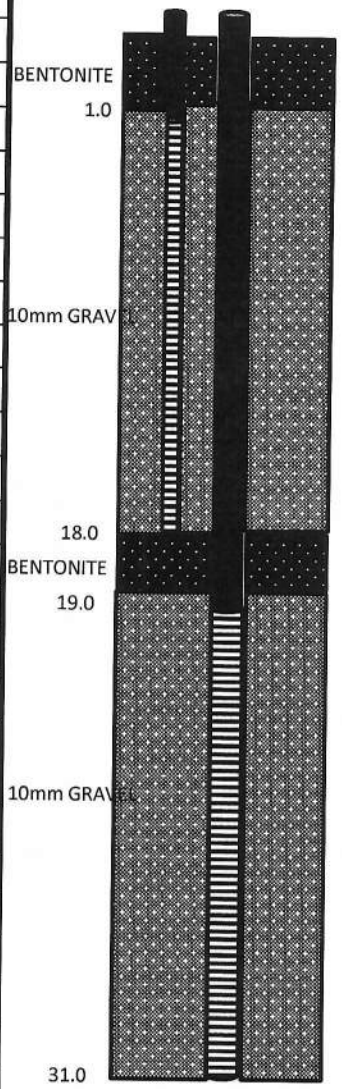
SIS Drill (UK) Ltd
The Coach House, 1 Long Lane, Willoughton, Gainsborough, DN21 5SQ

ROTARY DAILY RECORD

Strata Record

DEPTH	DESCRIPTION
22.50	START OF DAY
24.50	STRONG LIGHT GREY SAND/SILTSTONE
25.60	STRONG DARK REDISH BROWN SANDY MUDSTONE WITH
	SHALEY BANDS
31.00	FINISH
	BH REDRILLED FROM SURFACE WITH 150MM DIA TRI-CONE
	DRILL BIT TO FINISHING DEPTH OF 31.00 M
31.5	FINISH

MONITORING WELL DETAILS



CORING

DEPTH (M) FROM	DEPTH (M) TO	LENGTH RECOVERED	DEPTH OF CASING	DRILLING TIME	FLUID RETURN

WATER LEVELS

	Depth	Casing	Time
Morning			
Afternoon			
Evening			
Other			

CORING

Depth (M) From	Depth (M) To	Core Diameter	Casing Diameter
		N/A	160

AIR /FOAM FLUSH USED THROUGH OUT DRILLING PROCESS

Water Encountered

	1	2	3
Depth Struck			
Casing Depth			
Inflow			
Depth 5 mins			
Depth 10 mins			
Depth 15 mins			
Depth 20 mins			
Cut off at			

Dayworks/Standing Time

Reason	HRS
FILL WATER TANK	1 HR

BH NO	1
Job Title/Site	IBSTOCK DORKET HEAD
Date	16/09/2020
Plant Used	COMMACHIO 205/A
Crew	MG / AM/ DL
Sheet No	2 OF 2

SIS Drill (UK) Ltd
The Coach House, 1 Long Lane, Willoughton, Gainsborough, DN21 5SQ

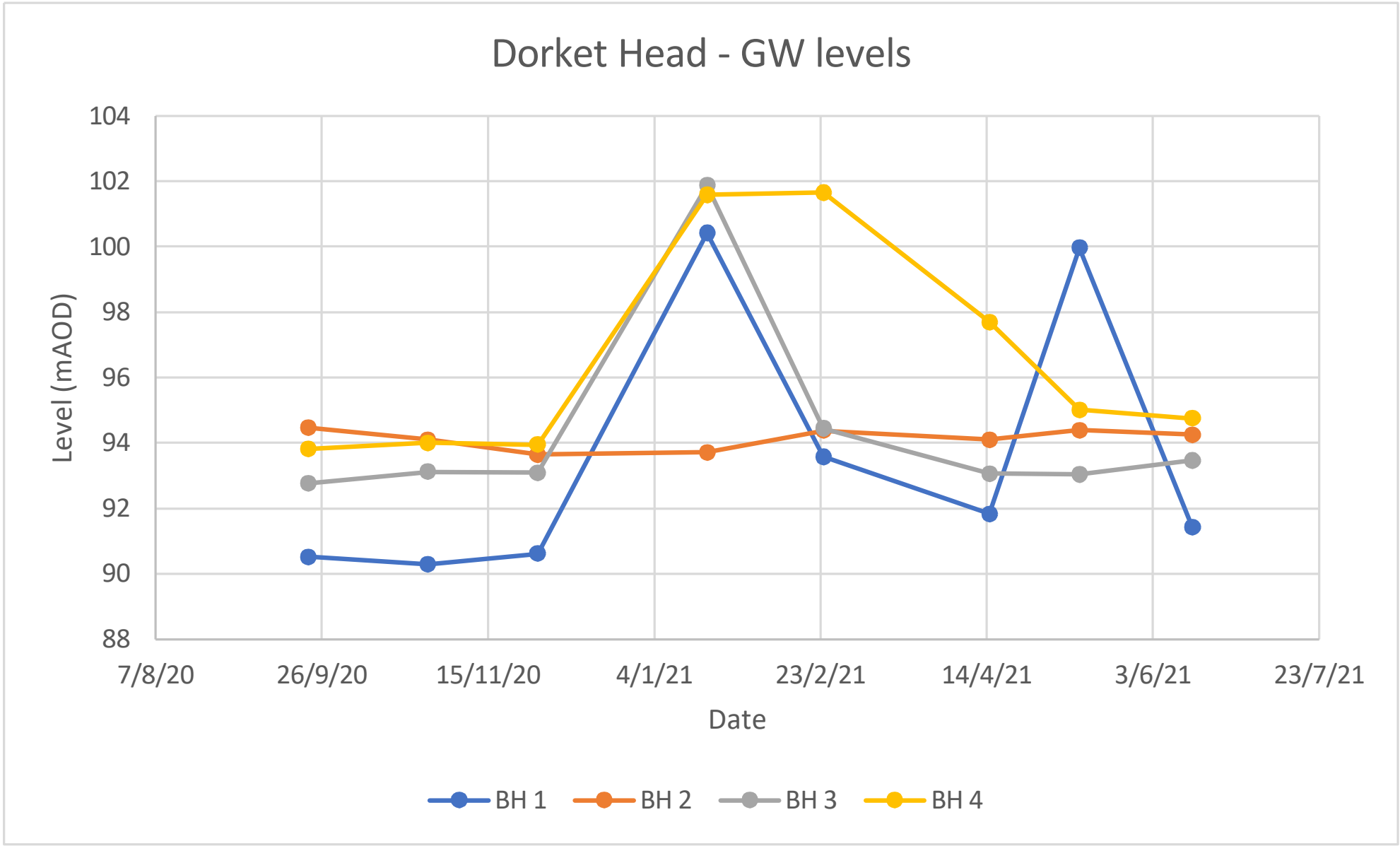
ROTARY DAILY RECORD

Appendix B – Groundwater Levels Data and Plot

Groundwater levels data
Groundwater levels plot

Groundwater levels - Dorket Head

	BH 1	BH 2	BH 3	BH 4
22/9/20	90.51	94.47	92.76	93.82
28/10/20	90.29	94.1	93.12	94
30/11/20	90.62	93.65	93.09	93.95
20/1/21	100.42	93.72	101.87	101.59
24/2/21	93.58	94.37	94.44	101.66
15/4/21	91.83	94.09	93.07	97.7
12/5/21	99.97	94.39	93.04	95.01
15/6/21	91.42	94.25	93.47	94.75
Ave	93.58	94.13	94.36	96.56


Dorket Head - GW levels
104
102
100
98
96
94
92
90
88
Level (mAOD)
7/8/20
26/9/20
15/11/20
4/1/21
23/2/21
14/4/21
3/6/21
23/7/21
Date
BH 1
BH 2
BH 3
BH 4

Appendix C – Groundwater Quality Data and Plots

Groundwater chemical data
Groundwater plots – Amm N
Groundwater plots – Chloride N
Groundwater plots – Sulphate
Groundwater data – metals
Groundwater data – Outliers down gradient
Groundwater data – Outliers up gradient

Dorket Head - Metals

				Date	22/09/20		Date	28/10/20			Date			Date	20/1/21			Date	24/2/21			Date	15/4/21			Date	12/5/21			Date	15/6/21
Sample Po	**Units**	**BH 1**	**BH 2**	**BH 3**	**BH 4**	**BH 1**	**BH 3**	**BH 4**	**BH 1**	**BH 2**	**BH 3**	**BH 1**	**BH 2**	**BH 3**	**BH 4**	**BH 1**	**BH 2**	**BH 3**	**BH 4**	**BH 1**	**BH 2**	**BH 3**	**BH 4**	**BH 1**	**BH 2**	**BH 3**	**BH 4**	**BH 1**	**BH 2**	**BH 3**	**BH 4**
Cadmium (Dissolved)	µg/l	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11	< 0.11
Chromium (Dissolved)	µg/l	8.5	7.2	9.2	9.0	10	9.1	16	4.8	1.4	1.6	4.2	7.6	7.1	4.8	6.9	2.4	4.3	0.55	6.8	7.8	3.6	2.0	31	27	23	33	5.8	6.6	6.6	3.3
Copper (Dissolved)	µg/l	2.0	1.7	< 1.0	1.3	2.2	< 1.0	< 1.0	1.5	< 1.0	< 1.0	1.3	1.7	1.4	1.6	2.7	2.0	1.6	1.5	< 0.50	0.52	< 0.50	< 0.50	1.9	1.8	1.7	2.3	2.8	1.0	0.81	0.93
Iron (Dissolved)	µg/l	180	140	170	200	470	330	420	310	210	240	340	250	250	360	< 5.0	< 5.0	< 5.0	< 5.0	23	72	51	14	93	93	83	110	< 5.0	< 5.0	< 5.0	< 5.0
Manganese (Dissolved)	µg/l	14	10	30	22	18	3.5	2.3	59	3.6	6.3	1.9	1.1	1.2	1.6	94	1.6	1.5	2.7	< 0.50	0.67	3.5	< 0.50	8.8	5.8	11	5.6	30	1.2	1.1	5.0
Nickel (Dissolved)	µg/l	1.5	1.0	3.0	3.0	2.3	1.3	2.1	2.7	1.1	1.0	1.1	1.1	< 1.0	1.6	2.9	0.67	< 0.50	1.4	1.3	0.81	< 0.50	1.0	11	11	10	14	2.4	< 0.50	< 0.50	1.2
Lead (Dissolved)	µg/l	< 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	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Selenium (Dissolved)	µg/l	3.2	1.1	< 1.0	1.5	3.4	1.1	1.7	2.8	1.2	1.2	2.6	1.4	1.1	2.8	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.58	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Zinc (Dissolved)	µg/l	3.1	2.2	1.3	4.3	8.6	3.4	5.3	4.7	1.5	1.9	5.3	6.5	17	12	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	3.1	< 3.0	5.4	< 2.5	< 2.5	< 2.5	4.3
Mercury Low Level	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Outliers analysis - Down gradient boreholes

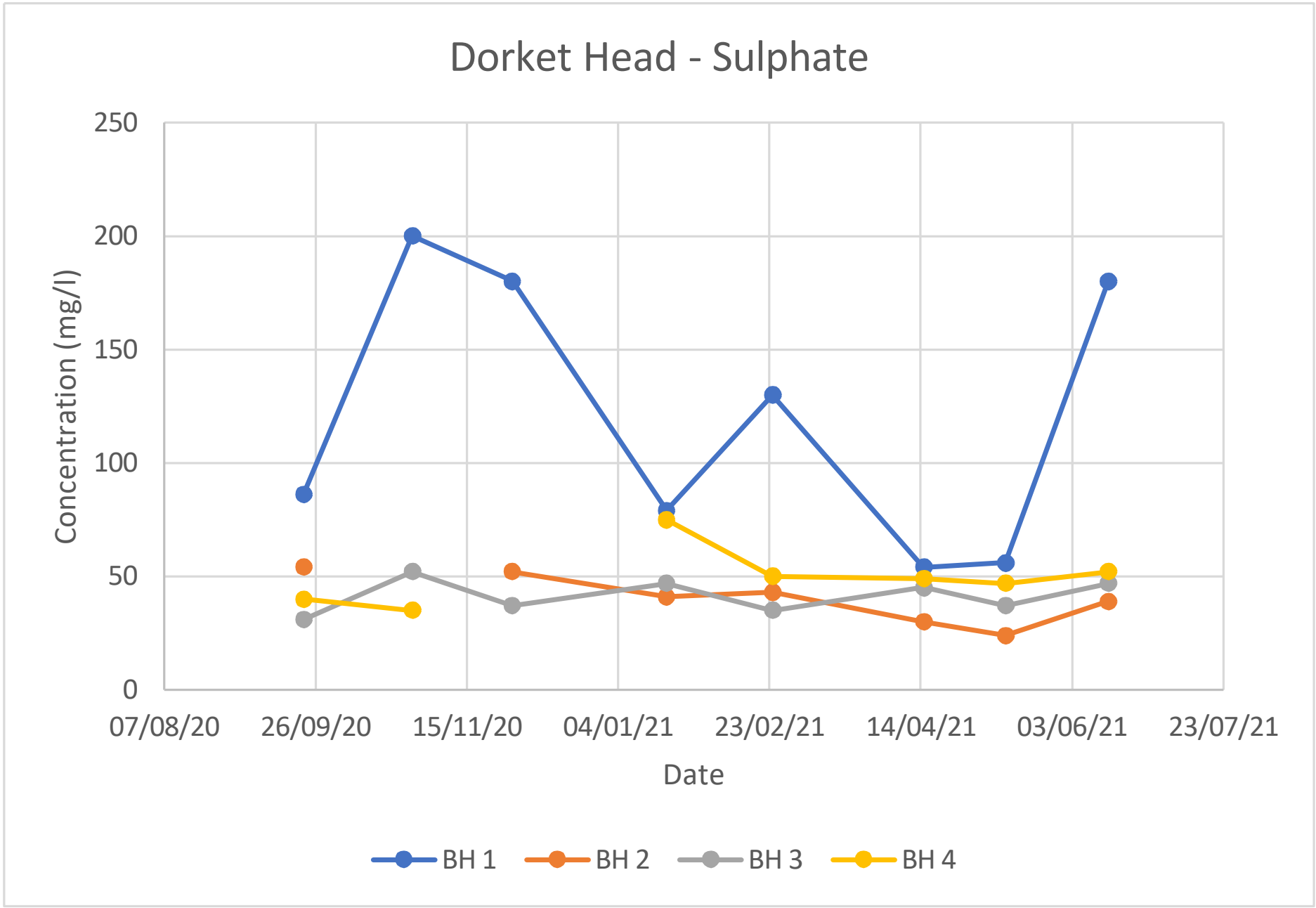
Sample Point No.:	Units	22/09/20	28/10/20	30/11/20	20/1/21	24/2/21	15/4/21	12/5/21	15/6/21	22/09/20	30/11/20	20/1/21	24/2/21	15/4/21	12/5/21	15/6/21	Min	Max	Ave
		BH1								BH2									
Chloride	mg/l	51	56	51	110	81	120	99	73	25	26	39	170	33	27	36	25	170	66
Ammoniacal Nitrogen	mg/l	0.065	< 0.050	0.063	< 0.050	0.24	2.6	< 0.050	< 0.050	0.12	0.15	< 0.050	0.60	2.1	< 0.050	< 0.050	0.1	2.6	0.7
Sulphate	mg/l	86	200	180	79	130	54	56	180	54	52	41	43	30	24	39	24	200	83
Cadmium (Dissolved)	µg/l	< 0.080	< 0.080	< 0.080	< 0.080	< 0.12	< 0.12	< 0.11	< 0.11	< 0.080	< 0.080	< 0.080	< 0.12	< 0.12	< 0.11	< 0.11	0	0	<0.1
Chromium (Dissolved)	µg/l	8.5	10	4.8	4.2	6.9	6.8		5.8	7.2	1.4	7.6	2.4	7.8	27	6.6	1.4	27.0	7.6
Copper (Dissolved)	µg/l	2.0	2.2	1.5	1.3	2.7	< 0.50	1.9	2.8	1.7	< 1.0	1.7	2.0	0.52	1.8	1.0	0.5	2.8	1.8
Iron (Dissolved)	µg/l	180	470	310	340	< 5.0	23	93	< 5.0	140	210	250	< 5.0	72	93	< 5.0	23	470	198
Nickel (Dissolved)	µg/l	1.5	2.3	2.7	1.1	2.9	1.3	11	2.4	1.0	1.1	1.1	0.67	0.81	11	< 0.50	1	11	3
Lead (Dissolved)	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 0.50	< 0.50	< 0.50	< 0.50	< 1.0	< 1.0	< 1.0	< 0.50	< 0.50	< 0.50	< 0.50	0	0	<0.5
Selenium (Dissolved)	µg/l	3.2	3.4	2.8	2.6	< 0.50	< 0.50	< 0.50	< 0.50	1.1	1.2	1.4	< 0.50	0.58	< 0.50	< 0.50	0.6	3.4	2.0
Zinc (Dissolved)	µg/l	3.1	8.6	4.7	5.3	< 3.0	< 3.0	< 3.0	< 2.5	2.2	1.5	6.5	< 3.0	< 3.0	3.1	< 2.5	1.5	8.6	4.4
Mercury Low Level	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0	0	<0.01

Data removed as an outlier

Outliers analysis - Up gradient boreholes

		Date	22/09/20	Date	28/10/20	Date	Date	20/1/21	Date	24/2/21	Date	15/4/21	Date	12/5/21	Date	15/6/21			
Sample Point No.:	**Units**	**BH 3**	**BH 4**	**BH 3**	**BH 4**	**BH 3**	**BH 3**	**BH 4**	**BH 3**	**BH 4**	**BH 3**	**BH 4**	**BH 3**	**BH 4**	**BH 3**	**BH 4**	Min	Max	Ave
Chloride	**mg/l**	**33**	**78**	**31**	**66**	**28**	**36**	**98**		**130**	**39**	**120**	**33**	**110**	**34**	**110**	**28**	**130**	**68**
Ammoniacal Nitrogen	**mg/l**	**0.069**	**0.058**	**< 0.050**	**< 0.050**	**< 0.050**	**< 0.050**	**< 0.050**	**2.1**	**0.078**	**0.64**	**0.58**	**< 0.050**	**< 0.050**	**< 0.050**	**< 0.050**	**0.1**	**2.1**	**0.6**
Sulphate	**mg/l**	**31**	**40**	**52**	**35**	**37**	**47**	**75**	**35**	**50**	**45**	**49**	**37**	**47**	**47**	**52**	**31**	**75**	**45**
Cadmium (Dissolved)	**µg/l**	**< 0.080**	**< 0.080**	**< 0.080**	**< 0.080**	**< 0.080**	**< 0.080**	**< 0.080**	**< 0.12**	**< 0.12**	**< 0.12**	**< 0.12**	**< 0.11**	**< 0.11**	**< 0.11**	**< 0.11**	**0.00**	**0.00**	**<0.1**
Chromium (Dissolved)	µg/l	9.2	9.0	9.1	16	1.6	7.1	4.8	4.3	0.55	3.6	2.0	23	33	6.6	3.3	0.6	33.0	8.9
Copper (Dissolved)	µg/l	< 1.0	1.3	< 1.0	< 1.0	< 1.0	1.4	1.6	1.6	1.5	< 0.50	< 0.50	1.7	2.3	0.81	0.93	0.8	2.3	1.5
Iron (Dissolved)	µg/l	170	200	330	420	240	250	360	< 5.0	< 5.0	51	14	83	110	< 5.0	< 5.0	14	420	203
Nickel (Dissolved)	**µg/l**	**3.0**	**3.0**	**1.3**	**2.1**	**1.0**	**< 1.0**	**1.6**	**< 0.50**	**1.4**	**< 0.50**	**1.0**	**10**	**14**	**< 0.50**	**1.2**	**1**	**14**	**4**
Lead (Dissolved)	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.00	0.00	<0.5
Selenium (Dissolved)	µg/l	< 1.0	1.5	1.1	1.7	1.2	1.1	2.8	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1.1	2.8	1.6
Zinc (Dissolved)	µg/l	1.3	4.3	3.4	5.3	1.9	17	12	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	5.4	< 2.5	4.3	1.3	17.0	6.1
Mercury Low Level	**µg/l**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**< 0.010**	**0.00**	**0.00**	**<0.01**

Data removed as an outlier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200
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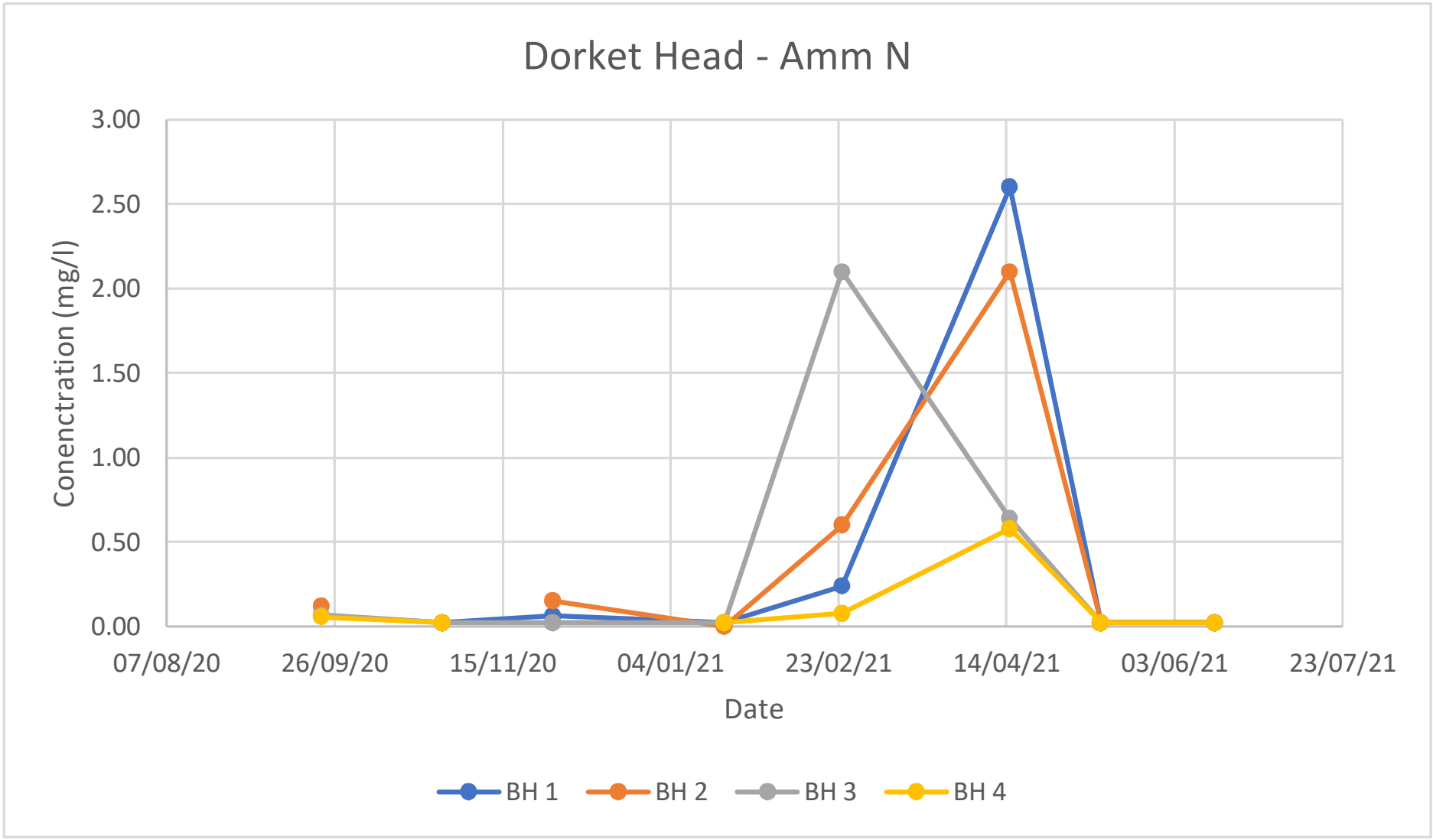
Concentration (mg/l)
07/08/20
26/09/20
15/11/20
04/01/21
23/02/21
14/04/21
03/06/21
23/07/21
Date
BH 1
BH 2
BH 3
BH 4


Dorket Head - Amm N
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2.50
2.00
1.50
1.00
0.50
0.00
Conenctration (mg/l)
07/08/20
26/09/20
15/11/20
04/01/21
23/02/21
14/04/21
03/06/21
23/07/21
Date
BH 1
BH 2
BH 3
BH 4

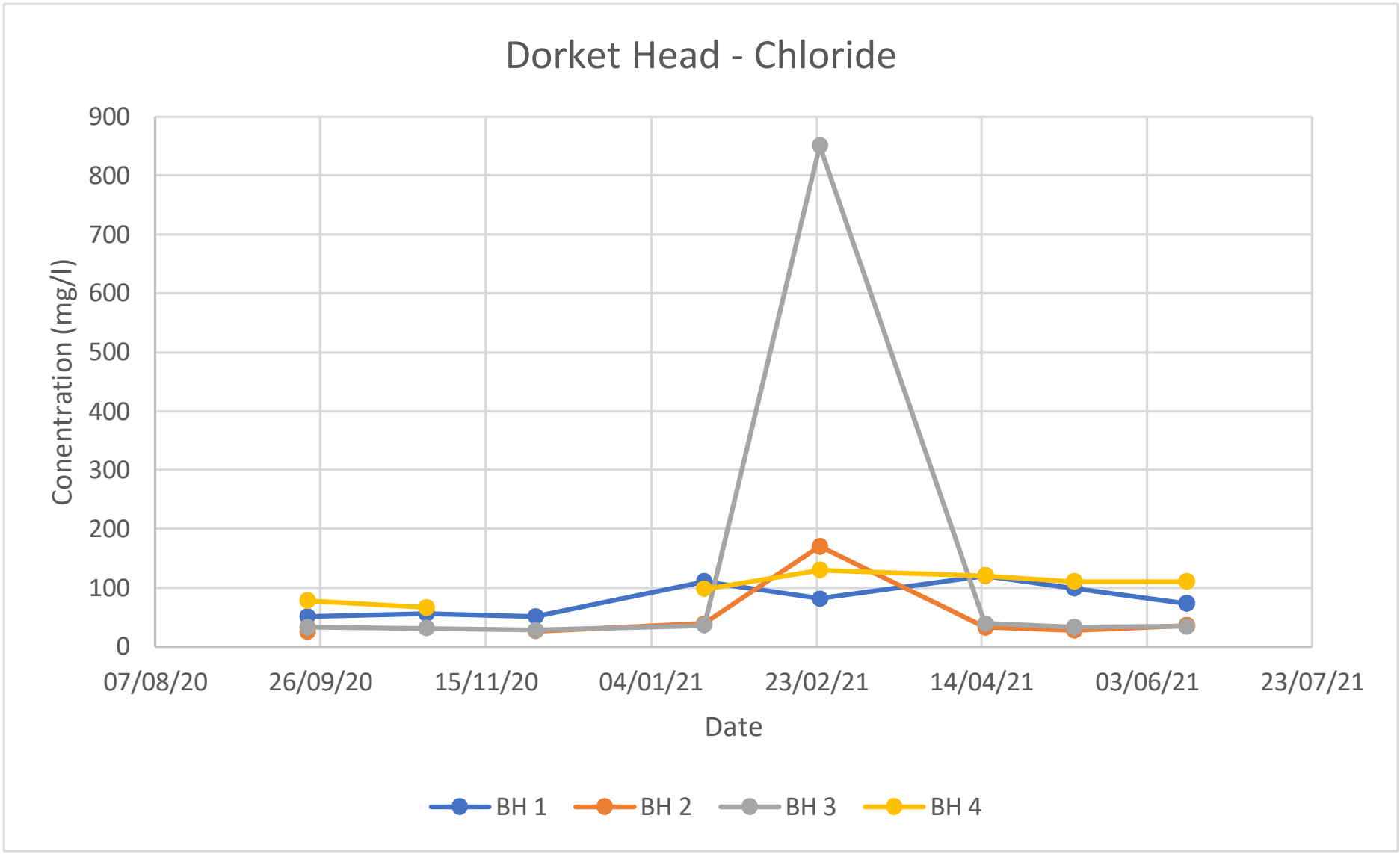
Dorket Head - Raw chemical results

Sample Po	Units	Date	22/09/20			Date	28/10/20			Date	30/11/20			Date	20/1/21			Date	24/2/21		
			BH 1	BH 2	BH 3	BH 4	BH 1	BH 2	BH 3	BH 4	BH 1	BH 2	BH 3	BH 4	BH 1	BH 2	BH 3	BH 4	BH 1	BH 2	BH 3	BH 4
pH			7.7	7.7	7.6	7.4	8.0	No sample	8.2	7.9	7.6	7.6	7.6	No sample	8.0	8.1	8.2	7.9	8.0	8.0	8.0	7.9
Electrical Conductivity	µS/cm		890	690	760	1000	1000		750	920	1100	680	740		1100	800	780	1200	1100	860	790	790
Alkalinity (Total)	mg/l		380	340	410	470	360		350	410	500	420	480		360	350	370	470	450	460	560	570
Chloride	mg/l		51	25	33	78	56		31	66	51	26	28		110	39	36	98	81	170	850	130
Ammonia (Free)	mg/l		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	0.16	< 0.050
Ammoniacal Nitrogen	mg/l		0.065	0.12	0.069	0.058	< 0.050		< 0.050	< 0.050	0.063	0.15	< 0.050		< 0.050	< 0.050	< 0.050	< 0.050	0.24	0.60	2.1	0.078
Sulphate	mg/l		86	54	31	40	200		52	35	180	52	37		79	41	47	75	130	43	35	50
Potassium	mg/l		4.1	2.5	2.1	3.0	110		69	480	130	86	85		94	73	72	120	140	100	110	150
Magnesium	mg/l		44	37	33	55	2.0		1.9	2.8	2.3	2.3	2.0		2.5	2.0	1.9	2.3	2.5	1.9	2.1	2.5
Sodium	mg/l		17	9.1	7.1	14	47		35	250	56	40	42		48	38	35	56	62	52	50	71
Total Calcium	mg/l		96	77	76	98	20		8.9	26	25	10	9.1		15	9.0	8.1	18	23	11	9.7	19
Cadmium (Dissolved)	µg/l		< 0.080	< 0.080	< 0.080	< 0.080	< 0.080		< 0.080	< 0.080	< 0.080	< 0.080	< 0.080		< 0.080	< 0.080	< 0.080	< 0.080	< 0.12	< 0.12	< 0.12	< 0.12
Chromium (Dissolved)	µg/l		8.5	7.2	9.2	9.0	10		9.1	16	4.8	1.4	1.6		4.2	7.6	7.1	4.8	6.9	2.4	4.3	0.55
Copper (Dissolved)	µg/l		2.0	1.7	< 1.0	1.3	2.2		< 1.0	< 1.0	1.5	< 1.0	< 1.0		1.3	1.7	1.4	1.6	2.7	2.0	1.6	1.5
Iron (Dissolved)	µg/l		180	140	170	200	470		330	420	310	210	240		340	250	250	360	< 5.0	< 5.0	< 5.0	< 5.0
Manganese (Dissolved)	µg/l		14	10	30	22	18		3.5	2.3	59	3.6	6.3		1.9	1.1	1.2	1.6	94	1.6	1.5	2.7
Nickel (Dissolved)	µg/l		1.5	1.0	3.0	3.0	2.3		1.3	2.1	2.7	1.1	1.0		1.1	1.1	< 1.0	1.6	2.9	0.67	< 0.50	1.4
Lead (Dissolved)	µg/l		< 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	< 0.50	< 0.50	< 0.50	< 0.50
Selenium (Dissolved)	µg/l		3.2	1.1	< 1.0	1.5	3.4		1.1	1.7	2.8	1.2	1.2		2.6	1.4	1.1	2.8	< 0.50	< 0.50	< 0.50	< 0.50
Zinc (Dissolved)	µg/l		3.1	2.2	1.3	4.3	8.6		3.4	5.3	4.7	1.5	1.9		5.3	6.5	17	12	< 3.0	< 3.0	< 3.0	< 3.0
Mercury Low Level	µg/l		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

			Date	15/4/21
BH 1	**BH 2**	**BH 3**	**BH 4**	
7.8	7.9	8.0	7.7	
940	740	780	1100	
330	380	410	460	
120	33	39	120	
0.083	0.087	< 0.050	< 0.050	
2.6	2.1	0.64	0.58	
54	30	45	49	
88	68	76	100	
2.6	2.1	2.3	2.4	
56	47	48	70	
16	11	13	19	
< 0.12	< 0.12	< 0.12	< 0.12	
6.8	7.8	3.6	2.0	
< 0.50	0.52	< 0.50	< 0.50	
23	72	51	14	
< 0.50	0.67	3.5	< 0.50	
1.3	0.81	< 0.50	1.0	
< 0.50	< 0.50	< 0.50	< 0.50	
< 0.50	0.58	< 0.50	< 0.50	
< 3.0	< 3.0	< 3.0	< 3.0	
< 0.010	< 0.010	< 0.010	< 0.010	

			Date	12/5/21
BH 1	**BH 2**	**BH 3**	**BH 4**	
8.0	8.2	8.1	8.0	
810	560	640	920	
320	380	370	470	
99	27	33	110	
< 0.050	< 0.050	< 0.050	< 0.050	
< 0.050	< 0.050	< 0.050	< 0.050	
56	24	37	47	
100	81	89	130	
2.5	2.1	2.0	2.3	
52	41	44	62	
15	11	9.6	17	
< 0.11	< 0.11	< 0.11	< 0.11	
31	27	23	33	
1.9	1.8	1.7	2.3	
93	93	83	110	
8.8	5.8	11	5.6	
11	11	10	14	
< 0.50	< 0.50	< 0.50	< 0.50	
< 0.50	< 0.50	< 0.50	< 0.50	
< 3.0	3.1	< 3.0	5.4	
< 0.010	< 0.010	< 0.010	< 0.010	

			Date	15/6/21
BH 1	**BH 2**	**BH 3**	**BH 4**	
8.0	8.1	8.2	7.9	
960	730	750	1100	
400	390	380	510	
73	36	34	110	
< 0.050	< 0.050	< 0.050	< 0.050	
< 0.050	< 0.050	< 0.050	< 0.050	
180	39	47	52	
130	83	88	140	
2.6	2.2	2.0	2.9	
61	44	43	69	
30	14	11	20	
< 0.11	< 0.11	< 0.11	< 0.11	
5.8	6.6	6.6	3.3	
2.8	1.0	0.81	0.93	
< 5.0	< 5.0	< 5.0	< 5.0	
30	1.2	1.1	5.0	
2.4	< 0.50	< 0.50	1.2	
< 0.50	< 0.50	< 0.50	< 0.50	
< 0.50	< 0.50	< 0.50	< 0.50	
< 2.5	< 2.5	< 2.5	4.3	
< 0.010	< 0.010	< 0.010	< 0.010	


Dorket Head - Chloride
900
800
700
600
500
400
300
200
100
0
Conentration (mg/l)
07/08/20
26/09/20
15/11/20
04/01/21
23/02/21
14/04/21
03/06/21
23/07/21
Date
BH 1
BH 2
BH 3
BH 4