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THOMPSONS OF PRUDHOE

SILVERTOP QUARRY, HALLBANKGATE

HYDROGEOLOGICAL RISK ASSESSMENT

APRIL 2020

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Wardell Armstrong
Sir Henry Doulton House, Forge Lane, Etruria, Stoke-on-Trent, ST1 5BD, United Kingdom
Telephone: +44 (0)845 111 7777 Facsimile: +44 (0)845 111 8888 www.wardell-armstrong.com

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APRIL 2020

PREPARED BY:

Joe Skuse	Hydrogeologist	
Andrew Apanasionok	Hydrogeologist	

REVIEWED BY:

Thea McCready	Senior Hydrogeologist	
Anna Saich	Principal Geoscientist	

APPROVED BY:

Lauren Ballarini	Technical Director	

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1 INTRODUCTION

1.1 Report Context

1.1.1 Wardell Armstrong (WA) have been commissioned by Thompsons of Prudhoe to prepare an application for a Waste Recovery Permit for the proposed restoration of an existing quarry void within the western part of Silvertop Quarry, Hallbankgate, Cumbria (Drawing NT12629-013). This Hydrogeological Risk Assessment (HRA) report has been prepared to support the permit application.

1.1.2 For the purpose of this report the western part of the quarry is referred to as "the Site" and the remainder of Silvertop Quarry as the "wider quarry". The Site location is shown on Drawing NT12629-012.

1.1.3 The application is for a Bespoke Waste Recovery Permit, with the aim of continuing restoration at the Site in the same manner as approved for the existing excavation areas in the wider quarry. The application follows preparation of a Waste Recovery Plan for the Site (WA report reference NT12629/003, dated January 2019), which was approved by Environment Agency (EA) on 4 April 2019 (EA reference EPR/EB3204UZ/A001).

1.2 Purpose and Basis of Report

1.2.1 The purpose of this report is to develop the current Conceptual Hydrogeological Site Model (CHSM) for the Site and undertake an HRA to assess the risk the Site may pose to potential groundwater and surface water receptors on-site and within the surrounding area.

1.2.2 This report is based on:

- Geological and hydrogeological information provided by Thompsons of Prudhoe; and
- Data acquired from third party sources:
  - Envirocheck[1] data request, including information on groundwater and surface water abstractions and discharges, historic and licenced landfills, historic groundwater abstractions; and
  - British Geological Survey (BGS) superficial, bedrock and hydrogeological maps and historic borehole records.

[1] Landmark Information Group. Envirocheck Report 205627403_1_1. 29/05/2019.

1.3 Report Structure

1.3.1 The Site conditions are described in the Environmental Setting and Site Design (ESSD) Report[2] and summarised in Section 2 of this report. The findings have been interpreted to form a CHSM, which is discussed in Section 3. The HRA is presented in Section 4 and requisite surveillance discussed in Section 5.

[2] Wardell Armstrong. Silvertop Quarry, Hallbankgate, Application for an Environmental Permit, Environmental Setting and Site Design Report. NT12629/04/R001. March 2020.

2 SITE CONDITIONS

2.1 Site Location

2.1.1 The Site is located approximately 0.7km north-east of Hallbankgate village, which is approximately 5km east of Brampton, Cumbria (National Grid Reference (NGR): NY 58800 60500).

2.2 Site Description

2.2.1 The Site is an inactive limestone quarry which is being restored, using a combination of site-based overburden and imported inert materials. Prior to development as a limestone quarry, the Site was undeveloped comprising hill pasture surrounded by agricultural land. The Site was worked under a variation of the planning consent and is subject to an obligation to restore back to original surface levels. The restoration will restore the quarry back to agriculture, incorporating grassland and woodland. The Site would be returned to original ground levels ranging in elevation from 250m Above Ordnance Datum (AOD) in the north-west corner down to 195m AOD in the south east.

2.2.2 The existing main quarry void in the wider quarry has been subject to a standard rules permit (EA reference SR2015 N0.39) for waste recovery, allowing the importation of 60,000m^3 of material. The application is for a Bespoke Waste Recovery Permit, with the aim of continuing restoration at the Site in the same manner as approved for the existing excavation areas in the wider quarry.

2.3 Topography

2.3.1 The Site is located on a south facing slope profile, which decreases from approximately 250m AOD in the north of the Site to approximately 195m AOD in the south-eastern corner of the Site, towards the base of the main quarry excavation. An area of the wider quarry that has been restored lies adjacent to the eastern boundary of the Site, topography within this area decreases in a southerly direction. Topography falls gently away from Site to the south, before increasing to the south of Milton Beck. To the north and west of the Site topography decreases.

2.4 Site Setting

2.4.1 Aside from the existing quarry at Silvertop Quarry there are no records of historic and authorised landfills within 1km of the waste recovery operation[1].

2.5 Site Investigations

2.5.1 Various phases of Site Investigation (SI) have been undertaken throughout the wider quarry, both to assess reserves of limestone and for the installation of groundwater monitoring boreholes (WW01 to WW06). In 2019 two additional groundwater monitoring boreholes, one with a dual installation, (WW08 and WW09) were installed at the Site. Borehole logs are available for boreholes WW04-WW06, WW08 and WW09 and are included in Appendix 1. No borehole logs are available for boreholes WW01-WW03. Table 2.1 summarises the groundwater monitoring boreholes at the Site and wider quarry and the locations are shown on Drawing NT12629-006.

Table 2.1: Summary of Groundwater Monitoring Boreholes

Borehole	Year Drilled	Top of Casing (mAOD)	Drill Depth m)	Groundwater Monitoring Installation
WW01	2016	206.01	39.80	Unknown*
WW02	2016	204.95	41.00	Unknown*
WW03	2016	222.74	43.60	Unknown*
WW04	2016	232.00	42.50	Alston Formation – Multiple Beds
WW05	2016	241.50	25.00	Alston Formation – Multiple Beds
WW06	2016	251.00	30.50	Alston Formation – Mudstone and Shale
WW08N (Shallow)**	2019	219.42	24.10	Alston Formation – Sandstone
WW08S (Deep)**	2019	219.42	43.00	Alston Formation – unknown strata (poor recovery)
WW09	2019	214.20	22.30	Alston Formation – Sandstone and Mudstone

Notes:
* No borehole log available
** Dual installation

2.6 Geology

Superficial Geology

2.6.1 According to British Geological Survey (BGS) 1:50,000 scale mapping[3] the Site and surrounding area is overlain by Glacial Till (formerly known as boulder clay). However, these deposits have been removed during quarrying excavations with the Site and in the wider quarry.

2.6.2 Groundwater monitoring boreholes drilled round the perimeter of the Site encountered Glacial Till deposits. Glacial Till deposits are generally thin throughout the area of the Site, although have been recorded at a thickness of 7.2m in borehole WW08. Glacial Till was described to comprise yellow/brown stiff clays with limestone boulders however, it may include local sandy horizons.

Bedrock Geology

2.6.3 According to BGS 1:50,000 Scale mapping[3], the bedrock geology underlying the Site and within the surrounding area of the Site is Carboniferous strata of the Alston Formation comprised of limestone, sandstone, siltstone, mudstone and rare coal[4] part of the Yordale Group.

2.6.4 There are a number of named limestone beds in the local area, of which the Four Fathom Limestone Member subcrops at the Site. The limestone dips to the south at an angle of between 5° and 15° to the horizontal, shallower towards the north and upper part of the excavation. The underlying Three Yard, Five Yard and Scremerston limestones all subcrop to the north of the Site. Of these limestone beds only the Scremerston Limestone has been identified by exploratory drilling to be economically viable, at up to 12m thickness, this limestone bed is worked further north within the wider quarry.

2.6.5 According to SI at the Site and in the wider quarry area, the limestone beds are interbedded with beds of sandstone, shales and mudstones.

[3] British Geological Survey (2020). Geoindex – Superficial Geology 1:50,000 Scale Mapping. Last Accessed 20/03/2020. Available at: http://mapapps2.bgs.ac.uk/geoindex/home.html
[4] British Geological Survey (2020). The BGS Lexicon of named rock untis – Alston Formation. Last Accessed 20/03/2020. Available at: https://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=AG

2.6.6 A summary of the geology underlying the Site and wider quarry can be found in Table 2.2.

Table 2.2: Summary of Superficial and Bedrock Geology		
Geological Formation	**Description[1,2]**	**Approximate Thickness (m)[1,2]**
Superficial		
Glacial Till	Stiff clay with limestone boulders	Up to 9.00
Bedrock		
Alston Formation[2]	Limestone, sandstone, mudstone, siltstone and rare coal	Up to 340.00
Notes: 1. Base on borehole logs 2. British Geological Survey (2020). The BGS Lexicon of named rock untis – Alston Formation. Last Accessed 20/03/2020. Available at: https://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=AG 3. Alston Formation		

2.7 Hydrology

2.7.1 There are no watercourses present on the Site. The nearest watercourse to the Site is the Milton Beck, which is located approximately 360m south of the Site and Coalfell Beck, which is located approximately 1km to the south-east. The Milton Beck flows from east to west towards Kirkhouse, before turning north towards Brampton and forming a tributary of the River Irthing. The River Irthing flows west joining the River Eden just before Carlisle.

2.7.2 A small unnamed stream is present to the north of the Site, flowing north-west away from the Site. There is a small wetland area located close to the quarry entrance and the headwaters of the Milton Beck. A spring is located at NGR: NY 58660 61321, approximately 620m to the north of the Site, in a different surface water catchment area. The spring is located up groundwater gradient, therefore unlikely to be affected by the proposed restoration works.

2.7.3 There are no EA Main Rivers within 2km of the Site[5].

2.7.4 The Site lies within the Solway Tweed River Basin District, the Eden and Esk Management Catchment, the Esk and Irthing Operational Catchment and the Quarry Beck Surface Waterbody (Catchment) (ID: GB102076074050)[6]. This waterbody is

[5] Environment Agency (2019). Main River Map. Last Accessed: 24/09/2019. Available at: https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386

[6] Environment Agency (2019). Data Catchment Explorer. Last Accessed: 24/09/2019. Available at: https://environment.data.gov.uk/catchment-planning/WaterBody/GB102076073981

monitored by the EA under the Water Framework Directive (WFD) as part of the River Basin Management Plan (RBMP). A different surface water catchment (the Irthing DS Crammel Linn Waterfall) is located along the northern boundary of the Site[6]. The wider quarry area, to the east of the Site also lies within a different catchment area (Northumbria River basin district, the Tyne Management Catchment, the South Tyne Upper Operational Catchment and the Hartley Burn from Source to Black Burn Waterbody (Catchment) (ID: GB103023075470)).

2.7.5 The current ecological status of the Quarry Beck Surface Waterbody (Catchment) (ID: GB102076074050), in which the Site lies, is classified as Poor due to biological quality elements associated with poor soil management. The chemical status is classified as Good.

2.7.6 According to EA Flood Risk Mapping, the Site is located in a Very Low Risk area defined as "each year this area has a chance of flooding of less than 0.1%"[7].

Surface Water Abstractions

2.7.7 The Envirocheck report records two surface water abstractions within 2km of the Site (Table 2.3). Both surface water abstractions are located down gradient of the Site.

Table 2.3: Summary of Surface Water Abstractions within 2km of the Waste Recovery Operation

Abstraction Licence Number	National Grid Reference	Approximate Distance from Site (m)	Operator	Source	Use
2776008041	3565 5599	1,909 NW	Kirkhouse Coal Co. Ltd.	Surface water	Coal Washing
2776008024	3579 5626	1,923 N	Mr J A Blaylock	Surface water	General Farming and domestic

Discharge Consents

2.7.8 The Envirocheck report records four surface water discharge consents within 1km of the Site (Table 2.4).

[7] Environment Agency (2019). Flood Risk Mapping. Last accessed: 24/09/2019. Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

Table 2.4: Summary of Surface Water Discharge Consents within 1km of the Site					
Permit Number	**National Grid Reference**	**Approximate Distance from Site (m)**	**Site Name**	**Discharge Type**	**Discharge Environment**
017690376	359610 560300	143 SE	Silvertop Quarry	Trade Discharge – Process water	Freshwater Stream/River
01440*	358006 560438	313 W	New Garth	Sewage Discharges – Treated Effluent – Not Water Company	Freshwater Stream/River
017670092 (multiple discharge points)	357985 559805	672 SW, 677 SW, 679 SW, 683 SW	Hallbankgate STW	Sewage Discharges – Treated Effluent	Freshwater Stream/River
232/C/0209 (Revoked 1972)	3589 5595	993 SE	Clowsgill Home Farm	Clowsgill Holme Farm	Freshwater Stream/River

2.8 Hydrogeology

Overview

2.8.1 The Site lies within Solway Tweed River Basin District, the Solway Tweed Groundwater Management Catchment, the Eden and Esk Lower Palaeozoic and Carboniferous Aquifer Operational Catchment and the Eden and Esk Lower Palaeozoic and Carboniferous Aquifers groundwater body (ID: GB40202G102300)[6]. To the east of the Site, within the wider quarry there is a groundwater catchment divide. Groundwater to the east lies within the Northumbria River Basin District, the Northumbria Groundwater Management Catchment, the Tyne Carboniferous Limestone and Coal Measures Operational Catchment and the Tyne Carboniferous Limestone and Coal Measures groundwater body (ID: GB40302G701500)[6].

2.8.2 The superficial (Glacial Till) deposits are thin, typically less than 5m, within the Site the superficial deposits have been removed during quarrying operations. Where clays are present, superficial deposits are likely to be of low permeability and will potentially limit groundwater recharge. Where clays are thin or there are more permeable horizons present (sands and gravels), deposits will likely permit groundwater recharge. The Glacial Till is classified by the EA as Secondary (Undifferentiated) Aquifer[8].

2.8.3 The bedrock geology (Alston Formation) underlying the Site is comprised of limestones, sandstones, mudstones and shales. Sandstone and limestone beds will likely permit groundwater flow, whilst mudstones and shales are likely to limit groundwater flows and vertical migration. Groundwater within sandstone beds is likely to flow through the

formation's intergranular permeability (between sand grains) whilst groundwater flow within the limestone beds will likely flow through the units secondary permeability (fractures, joints etc). The Alston Formation is classified by the EA as Secondary A Aquifer, defined as "permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers"[8].

2.8.4 A summary of the aquifer designations for the superficial and bedrock aquifers is provided in Table 2.5.

Table 2.5: Aquifer Designations of Superficial and Bedrock Geology

Geological Formation	Aquifer Designation
Superficial	
Glacial Till	Secondary Undifferentiated
Bedrock	
Alston Formation	Secondary A

2.8.5 According to BGS 1:625,000 scale hydrogeological mapping[9], Carboniferous strata (Alston Formation) comprise part of the Yoredale Group, a moderately productive aquifer comprising limestone and sandstone aquifers, with variable yields of up to 40l/s separated by mudstones and shales.[9]

Aquifer Properties

2.8.6 WA undertook five falling head tests (FHT) within the boreholes installed in 2019. Three FHT were undertaken in borehole WW08 and a further two in borehole WW09 in May 2019 with testing undertaken both during drilling and on the completed well installation. Analysis of the results was carried out using Aqtesolv Pro, a software package used for the analysis of data from hydrogeological tests. Bouwer and Rice (1976) and Hvorslev (1951) solutions were used to analyse the data and calculate indicative hydraulic conductivity values during both the early and late stages of aquifer recovery.

[8] Environment Agency (2015). Aquifer Designation Map [online]. Accessed 05/09/2019. Available at: https://data.gov.uk/dataset/ef2399f1-acf4-45a7-abf3-c7369c0c8640/aquifer-designation-map-superficial-deposits

[9] British Geological Survey (2019). Geoindex-Onshore: Hydrogeology 1:625,000 scale [online]. Accessed: 05/09/2019. Available: http://mapapps2.bgs.ac.uk/geoindex/home.html

2.8.7 The results of the analysis can be found in Table 2.6. Hydraulic conductivity values produced from the FHTs range from $2.03x10^{-7}$m/second (m/s) recorded in the hard competent limestone in borehole WW08 to $4.95x10^{-5}$m/s recorded in the sandstone in borehole WW09, see Appendix 2.

2.8.8 The majority of results produced from hydraulic testing on-site fall within the limits outlined in Domenico and Schwartz (1997) of $3x10^{-10}$m/s to $6x10^{-6}$m/s for sandstone and $1x10^{-9}$ m/s to $6x10^{-6}$m/s for limestone.

Table 2.6: Summary of Analysis of Results from Falling Head Tests (m/s)

Borehole	Test Number	Bouwer and Rice	Hvorslev	Geology test undertaken in	Comments
WW08	Test 1	$2.03x10^{-7}$	$2.44x10^{-7}$	Hard limestone	Undertaken during drilling
	Test 2	$8.44x10^{-7}$	$8.44x10^{-7}$	Sandstone and Mudstone	Undertaken during drilling
	Test 3	$3.18x10^{-6}$	$3.51x10^{-6}$	Sandstone and Mudstone	Undertaken post installation
WW09	Test 1	$7.93x10^{-6}$	$8.95x10^{-6}$	Sandstone	Undertaken during drilling
	Test 2	$3.81x10^{-5}$	$4.95x10^{-5}$	Sandstone	Undertaken during drilling

2.8.9 Site-specific hydraulic testing undertaken at the Site indicates that the Site geology is of moderate to high permeability. Groundwater monitoring boreholes were screened against permeable and impermeable horizons.

Groundwater Elevations and Flow

2.8.10 During the 4-year excavation period on the Site, the quarry was dry worked.

2.8.11 Groundwater elevation monitoring results obtained from monthly monitoring rounds undertaken between January 2016 and January 2020 in boreholes WW01-WW06, WW08N, WW08S and WW09 have been reviewed. Groundwater elevation monitoring results are presented in Appendix 3 and summarised in Table 2.7.

2.8.12 Borehole logs and installation details are only available for boreholes WW04, WW05, WW06, WW08 (dual installation) and WW09. Boreholes WW04, WW05, WW06 and WW09 were screened within bedrock geology across various strata; including sandstones, limestones, mudstones and shales. Sandstone is present below the base of the quarry, underlying the Four Fathoms Limestone Member. This sandstone band was

dry during borehole drilling within boreholes WW04 and WW08. Borehole WW08 was installed as a dual installation; WW08N was installed across the (shallow) sandstone band and WW08S across deeper strata (although the nature of the deeper strata is unknown as there were no drill returns at depth).

Table 2.7: Groundwater Monitoring Boreholes

Groundwater Monitoring Point	Top of Casing (mAOD)	Easting	Northing	Borehole Depth (m)	Base Level (mAOD)	Installation Top (mbgl)	Installation Bottom (mbgl)	Installation Top (mAOD)	Installation Bottom (mAOD)	Strata	Groundwater Elevation (mAOD)		
											Minimum	Average	Maximum
WW01	206.01	358587.3	560396.2	39.8	166.21	No borehole log					194.36* 194.72**	194.96* 194.93**	195.87* 195.46**
WW02	204.95	358649.4	560177	41.0	163.95	No borehole log					196.75* 196.83**	197.10* 196.90**	197.80* 197.07**
WW03	222.74	359121.2	560230.2	43.6	179.14	No borehole log					194.89* 194.99**	195.22* 195.13**	196.09* 195.42**
WW04	232.00	358273.2	560710.0	42.5	189.50	3.0	42.5	229.00	189.50	Limestone / sandstone / mudstone	202.00* 202.59**	210.99* 209.70**	217.79* 213.25**
WW05	241.50	358683.9	560734.6	20.5	221.00	9.0	25.0	232.50	216.50	Limestone / mudstone	234.00* 234.65**	234.76* 235.00**	235.51* 236.67**
WW06	251.00	358963.9	560697.0	30.5	220.50	9.0	30.5	242.00	220.50	Limestone / mudstone	222.41* 222.41**	223.86* 222.53**	231.70* 222.66**
WW08N (Shallow)	219.42	358350	560509.0	43.0	174.00	16.5	26.5	200.50	190.50	Sandstone	196.55**	197.90**	198.97**
WW08S (Deep)	219.42	358350	560509.0	43.0	176.42	39.5	43.0	179.92	176.42	No returns	197.47**	200.87**	202.21**
WW09	210.50	358449	560509.0	22.3	191.90	18.0	22.3	196.20	191.90	Sandstone / mudstone	195.87*	196.64*	197.69*

Notes
* These values were taken from the whole of 2016 to January 2020 data
** These values are taken from January 2019 to January 2020 data

2.8.13 Groundwater elevations recorded within boreholes WW01 to WW06, WW08N, WW08S and WW09 varied between 235.51m AOD in borehole WW05 located to the north of the wider quarry area and 194.36m AOD in borehole WW01 located to the south of the Site. Groundwater elevations recorded within WW01 to WW06 and WW09 boreholes indicates a south/south-westerly groundwater flow direction.

2.8.14 Whilst groundwater was not encountered in shallow sandstone bands during drilling of boreholes WW04 and WW08, groundwater elevation monitoring of the sandstone band (borehole WW08N (shallow)) indicates groundwater elevations of 197.19-198.97m AOD. Comparing boreholes WW08S (deep) and WW08N (shallow) indicates that groundwater elevations in the deeper strata are higher than in the shallow sandstone band; the lower permeability mudstone acting as a confining layer for the deeper groundwater. Groundwater levels recorded in borehole WW04 display an unusual trend compared to the other boreholes. This could potentially be due to borehole WW04 being screened over numerous interbedded bands of sandstone, limestone and mudstone. The other boreholes are each screened over one or two geological strata, see Appendix 1.

Groundwater Quality

2.8.15 Groundwater quality samples have been obtained and analysed for two monitoring periods, July to October 2016 (WW01 to WW06) and November 2019 to January 2020 (WW01 to WW05, WW08N, WW08S and WW09).

Groundwater quality results are presented in Appendix 4, both monitoring periods have been plotted for each determinand on the same graph for ease of comparison.

2.8.16 Groundwater quality results have been screened against UK Drinking Water Standards (UKDWS). Borehole WW04, located at the northern extent of the Site, and boreholes WW05 and WW06, to the north of the wider quarry area, represents up-gradient conditions. WW01, WW08N, WW08S and WW09 located to the south of the Site and off-site to the south represent down-gradient conditions. Boreholes WW02 and WW03 are located to the south of wider quarry area, across-gradient from the Site.

2.8.17 Concentrations of ammonia and chloride (typical indicators of landfill leachate) in groundwater are below screening values.

2.8.18 Determinands that exceeded the screening values are described below.

2.8.19 Calcium concentrations in across-gradient borehole WW03 exceeded the UKDWS (250mg/l) in October 2016 (260mg/l) and in December 2019 (273mg/l).

2.8.20 Iron concentrations exceeded the UKDWS (200µg/l) in across-gradient borehole WW02 in August 2016 (270µg/l) and up-gradient borehole WW05 in October 2016 (401µg/l) and November 2019 (1,506µg/l).

2.8.21 Magnesium concentrations exceeded the UKDWS (50mg/l) in across-gradient borehole WW03 in September to October 2016 and November to January 2020, concentrations ranged from 58 to 89mg/l.

2.8.22 Manganese concentrations were found to exceeded the UKDWS (50µg/l) in all boreholes apart from WW02 and WW09. The greatest and most frequent exceedances were recorded in up-gradient borehole WW05.

2.8.23 Nickel concentrations were found to exceed the UKDWS (20µg/l) in September (24µg/l) and October 2016 (24µg/l) in WW05.

2.8.24 Sulphate concentrations were found to exceed the UKDWS (250mg/l) in across-gradient borehole WW03 in August to September 2016 and November 2019 to January 2020. Concentrations ranged from 380 to 671mg/l.

2.8.25 Overall, the water quality results from the 2019-2020 monitoring period are largely within the range of concentrations from the 2016 results, showing little change in water quality over the three years. A greater frequency of exceedances was found in boreholes WW03 (across-gradient borehole) and WW05 (up-gradient borehole). No exceedances were found within borehole WW09 (down-gradient borehole). Manganese was found to exceed UKDWS across the Side and wider quarry.

Groundwater Abstractions

2.8.26 The Envirocheck records three groundwater abstractions within 2km of the Site (Table 2.8). The nearest is 68m north of the Site. The licence was for groundwater taken from a shallow well for agricultural use. The status of this licence is shown as being revoked. The next nearest groundwater abstraction is located 484m to the north of the Site, where groundwater is abstracted at Low Row, Brampton for farming and domestic use. The third abstractions is located 998m to the north west of the Site. All three abstractions are located up-gradient of the Site.

2.8.27 The Site is not recorded to be with a groundwater Source Protection Zone (SPZ).

Table 2.8: Summary of Groundwater Abstractions within 2km of the Waste Recovery Operation					
Abstraction Licence Number	**National Grid Reference**	**Approximate Distance from Site (m)**	**Operator**	**Source**	**Use**
2776008005 (Revoked)	3585 5608	68 N	Mr Todd	Groundwater	Agriculture
2776008003	3586 5612	484 N	Messrs J & L Todd	Groundwater	General; Farming and Domestic
2776008021 (reported twice with two different operators in the Envirocheck report)	3574 5612	998 NW	Mr P Howard/Earl of Carlisle	Groundwater	General Farming and domestic

Discharge Consents

2.8.28 The Envirocheck records indicate that there are no groundwater discharge consents within 1km of the Site.

3 CONCEPTUAL HYDROGEOLOGICAL SITE MODEL

3.1.1 A schematic hydrogeological cross-section is included as Drawing NT12629-024 to illustrate the main hydrogeological pathways for the Site. Information on the Site condition presented above has been interpreted to form a CHSM, which is discussed in the form of "source, pathways and receptors" below.

3.2 Sources

3.2.1 Thompsons of Prudhoe propose to import inert waste to the Site as part of the restoration of Silvertop Quarry. It is anticipated that some 240,000m³ will be required over a 4 to 5 year period.

3.2.2 The waste types to be accepted are outlined in Table 3.1 below.

Table 3.1: Waste Types

Waste Code	Description
01 01 02	Wastes from mineral non metalliferous excavation
01 04 08	Waste gravel and crushed rocks other than those mentioned in 01 04 06
01 04 09	Waste sand and clays
17 01 07	Mixtures of concrete, bricks, tiles and ceramics, all rebar removed.
17 03 02	Bituminous mixtures other than those mentioned in 17 03 01 (Road planings only)
17 05 04	Soil and stones other than those mentioned in 17 05 03 (restricted to topsoil, peat, subsoil and stones only)
19 12 09	Minerals (for example sand, stones) only (From the treatment of waste aggregates that are otherwise naturally occurring minerals. Does not include fines from treatment of any non-hazardous waste or gypsum from recovered plasterboard)
19 12 12	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11 (restricted to crushed bricks, tiles, concrete, and ceramics only, Metal from reinforced concrete must have been removed. Does not include fines from treatment of any non-hazardous waste or gypsum from recovered plasterboard)
20 02 02	Soil and Stones (restricted to topsoil, peat, subsoil and stones only)

3.2.3 Other potential sources of contamination on-site and in the surrounding area include the wider quarry area adjacent to the east of Site (partially up-gradient), which has been restored using inert waste and overburden.

3.3 Pathways

3.3.1 Pathways for potential pollutants include any route from the inert waste (the source) to the groundwater and surface water receptors. The potential for this to occur via various pathways is discussed in the following sections.

3.3.2 There is a potential pathway via leakage to the underlying superficial (Glacial Till) and bedrock aquifers. Infiltration of precipitation through inert waste backfill, may mobilise potential contaminants which may migrate through the unsaturated zone into and through water-bearing permeable aquifer units.

3.3.3 There is also a potential pathway to surface water receptors via surface run-off.

3.4 Receptors

3.4.1 Potential groundwater and surface water receptors comprise groundwater within the Glacial Till (superficial Secondary Undifferentiated Aquifer) and Alston Formation (bedrock Secondary A Aquifer). There are three groundwater abstractions within 1km of the Site, however all are located up-gradient of the Site and the Site is not recorded to be with a groundwater SPZ.

3.4.2 The closest surface water feature is the Milton Beck located approximately 360m south of the Site. Milton Beck is located on low permeability Glacial Till and is likely to be fed entirely by surface water run-off associated with higher ground partly within the wider quarry.

3.5 Risk Screening

Groundwater

3.5.1 The EA classify the Glacial Till as a Secondary Undifferentiated Aquifer which typically have variable characteristics and in most cases were previously designated as both minor aquifers (now Secondary A or B aquifers) and non-aquifers (now Unproductive Strata). The Glacial Till is recorded to be clay with limestone boulders.

3.5.2 Impermeable superficial deposits will impede groundwater recharge and permit surface water run-off down topographic gradient toward the south/southwest and Milton Beck. Where superficial deposits are thin or absent and backfill material outcrops, precipitation may infiltrate through the waste mass and move toward the underlying

bedrock aquifer (Secondary A aquifer). The bedrock geology is comprised of mudstones, limestones, sandstones and shales. Groundwater flow will be focused in the more permeable horizons (sandstones and limestones). Where mudstones and shales are present infiltration and groundwater flow will be impeded.

3.5.3 The Site was worked dry and groundwater elevation monitoring indicates that the groundwater elevations will be below the base of the restored quarry.

3.5.4 Groundwater elevations at the Site indicate that groundwater is likely to flow in a south/south-westerly direction down bedrock dip.

Surface Water

3.5.5 The Milton Beck is considered to be the most sensitive surface water receptor. The Milton Beck is underlain by low permeability Glacial Till so unlikely to be in hydraulic continuity with groundwater. Therefore, there is unlikely to be a pathway from the inert materials to Milton Beck.

3.5.6 During restoration, all works are to be contained in the quarry void, and such there will be no surface water drainage to local water courses, again removing the pathway between activities on Site and the Beck.

4 HYDROGEOLOGICAL RISK ASSESSMENT

4.1 The Nature of the Hydrogeological Risk Assessment

4.1.1 The proposed scheme is a waste recovery operation. Therefore, once the fill materials are placed, the materials will cease to be a waste and the Site will not be a landfill. The Site will not be regulated under requirements of the Landfill Directive (99/31/EC).

4.1.2 The Site will accept only inert materials, which by definition will not give rise to environmental pollution and will not generate leachate that will endanger the quality of surface water or groundwater. There will no requirement for the collection and disposal of leachates at the Site.

4.1.3 The level of risk assessment for this HRA has been determined by the EAs 'Indicative risk assessment levels for a range of scenarios' to be 'Risk Screening'[10]. The following Site conditions support that a Risk Screening approach is appropriate for this Site:

- the Site will be accepting inert material;
- there are no surface water, springs or abstraction receptors. Please note there is no pathway between the Site and Milton Beck so is not considered a 'receptor' for the HRA see Section 3.5.5;
- the inert material will be above the water table; and
- the bedrock strata is a Secondary A Aquifer and outside of a SPZ.

4.2 The Proposed Assessment Scenarios

Lifecycle Phases

4.2.1 The proposed scheme is a waste recovery scheme. Therefore, once the soil substitute materials are placed, the materials will cease to be waste and the Site will not be landfill.

4.3 The Priority Contaminants to be Modelled

4.3.1 Numerical modelling is not considered necessary, see Section 4.1.

[10] Environment Agency. 2016. Guidance Landfill developments: groundwater risk assessment for leachate (online) available at: https://www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate#risk-assessment-level-guide [accessed March 2020]

4.4 Review of Technical Precautions

4.4.1 As described in the Waste Recovery Plan, all incoming waste will be subject to a system of procedures to ensure compliance with the waste types the site will accept.

4.4.2 Wastes will be subject to a basic characterisation to provide:

- information on waste source and origin;
- appearance of the waste (smell, colour and physical form);
- six figure code according to the European Waste Catalogue; and
- any additional precautions to be taken at the site, e.g. any additional acceptance and handling procedures that are required to ensure safe and proper deposit.

4.4.3 Where there is any reason to believe waste may not be fully inert, the waste producer will be required to provide representative chemical analysis, showing that the waste meets the waste acceptance criteria. Where the results of the basic characterisation show that a waste stream is not acceptable for deposit, the waste will not be accepted at the Site.

4.4.4 All vehicles delivering wastes for deposit at the Site will stop at the site office where a suitably trained and experienced operator will examine transport documentation details and compare the information against the pre-acceptance details on Basic Characterisation and the waste types specified in the Recovery Plan

4.4.5 Loads will be inspected visually by the operator to ensure that, as far as possible, the waste load matches the details given on the Basic Characterisation and the waste types permitted for acceptance at the site.

4.4.6 Wastes that do not conform to the conditions of the Recovery plan will be rejected from the site. All instances of rejected loads will be recorded in a site log, which will be made available for inspection by authorised officers of the Environment Agency.

4.5 Numerical Modelling

Justification for Modelling Approach and Software

4.5.1 Numerical modelling not considered necessary, see Section 4.1.

Model Parameterisation

4.5.2 Numerical modelling not considered necessary, see Section 4.1.

Sensitivity Analysis

4.5.3 Numerical modelling not considered necessary, see Section 4.1.

Model Validation

4.5.4 Numerical modelling not considered necessary, see Section 4.1.

Accidents and their consequences

4.5.5 Numerical modelling not considered necessary, see Section 4.1.

4.6 Emissions to Groundwater

Hazardous Substances

4.6.1 In general, for hazardous substances, the compliance point would be the point at which the substance would enter groundwater below the Site. However, the inert nature of the waste materials and strict adherence to waste acceptance procedures at the Site, will mean that there will be negligible risk of unacceptable inputs of hazardous substances to groundwater. Furthermore, risk screening has indicated that the restored quarry will be above groundwater elevations in the bedrock aquifer and that low permeability mudstones and shales will impede infiltration and groundwater flow.

Non-Hazardous Pollutants

4.6.2 In general, for non-hazardous pollutants, the compliance point is groundwater down-gradient of the Site boundary. However, risk screening has indicated that there is no groundwater present in the superficial deposits or the Limestone at the Site. The base of the void consists of low permeability mudstone which limits the potential for percolation of water through the base of the void. There is potential movement into the limestone strata on the southern side of the void. However, there is no evidence that this limestone strata contains groundwater at this location

Surface Water Management

4.6.3 During waste recovery operations, all works are to be contained in the quarry void, and such there will be no surface water drainage to local water courses. Only upon completion of infilling and post restoration, will surface flow to the south and towards the Milton Beck will be re-established.

4.7 Hydrogeological Completion Criteria

4.7.1 The proposed scheme is a waste recovery scheme. Therefore, once the soil substitute materials are placed the materials will cease to be a waste and the Site will not be a landfill.

4.7.2 Groundwater monitoring is not considered necessary (see Section 5.1) and groundwater compliance limits have not been proposed. Surface water monitoring is not considered necessary.

5 REQUISITE SURVEILLANCE

5.1 The Risk Based Monitoring Scheme

Leachate Monitoring

5.1.1 Given the CHSM and the nature of the waste recovery scheme, and the low risk to identified groundwater receptors, no leachate monitoring is considered necessary.

Groundwater Monitoring

5.1.2 Given the CHSM and the nature of the waste recovery scheme, and the low risk to identified groundwater receptors, no groundwater monitoring is considered necessary.

Surface Water Monitoring

5.1.3 Given the CHSM and the nature of the waste recovery scheme, and the low risk to identified surface water receptors as outlined in Section 3.5.5, no surface water monitoring is considered necessary.

5.1.4 At post restoration, surface runoff to the south will be re-established, however, the risk to surface water receptors (the Milton Beck) will remain low and no surface water monitoring is considered necessary.

6 CONCLUSIONS

6.1 Compliance with the Landfill Directive

6.1.1 The Landfill Directive does not apply to deposit for recovery operations and has not been considered for this report.

6.2 Compliance with the Groundwater Regulations, 2009

6.2.1 Prior investigation has been undertaken in the vicinity of the waste recovery operation area. This information has informed the CHSM for the waste recovery area.

6.2.2 Appropriate risk assessment has been undertaken which has identified that the presence of the low permeability mudstone limits the pathway to groundwater within the superficial and bedrock aquifers. The water level record indicates that the water levels underneath the Site are always below the base of the excavated void. The design will therefore prevent hazardous substances and non-hazardous pollutants from entering the groundwater as the CHSM concludes that there are no viable pathways to groundwater.

6.2.3 Only inert waste as agreed with the EA will be accepted for the waste recovery scheme. Quality verification checks of the material will be undertaken at the production site including visual and laboratory analysis.

6.2.4 The proposed deposit for recovery scheme is therefore considered to comply with the requirements of the Groundwater regulations 2009.

APPENDICES

Appendix 1

Borehole Logs

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/07/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358273.16 N560709.99
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW04	RO	232.00m AoD		1:50	Sheet 1 of 5

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Brown clay with limestone boulders (driller's description)
					1.70	230.30		Yellow/ brown limestone (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/07/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358273.16 N560709.99
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW04	RO	232.00m AoD		1:50	Sheet 2 of 5

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Yellow/ brown limestone (driller's description)
					10.50	221.50		Hard grey limeston (driller's description)
					13.20	218.80		Grey/ yellow sandstone (driller's description)
					14.60	217.40		Grey sandstone with mudstone bands (driller's description)
					16.20	215.80		Dark grey mudstone (driller's description)

11 12 13 14 15 16 17 18 19 20

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/07/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358273.16 N560709.99
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW04	RO	232.00m AoD		1:50	Sheet 3 of 5

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Dark grey mudstone (driller's description)
					22.10	209.90		Hard grey limestone (driller's description)
					27.20	204.80		Yellow/grey sandstone
					28.50	203.50		Mudstone (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/07/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358273.16 N560709.99
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW04	RO	232.00m AoD		1:50	Sheet 4 of 5

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Mudstone (driller's description)
					32.10	199.90		Coal (driller's description)
					32.30	199.70		Mudstone (driller's description)
					33.10	198.90		Grey sandstone(driller's description)
					34.80	197.20		Dark grey mudstone (driller's description)
					35.90	196.10		Dark grey mudstone with thin grey sandstone bands (driller's description)
					37.20	194.80		Grey mudstone (driller's description)
					37.80	194.20		Grey sandstone (driller's description)
					38.30	193.70		Mudstone (driller's description)

31 32 33 34 35 36 37 38 39 40

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/07/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358273.16 N560709.99
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW04	RO	232.00m AoD		1:50	Sheet 5 of 5

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Mudstone (driller's description)
					41.10	190.90		Grey sandstone (driller's description)
					42.50	189.50		End of Borehole at 42.500m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date:
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358683.94 N560734.64
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW05	RO	241.50m AoD		1:50	Sheet 1 of 3

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Top soil/over burden (driller's description)
					7.70	233.80		Mudstone (driller's description)
					8.20	233.30		Blue Shale (driller's description)
					9.10	232.40		Dark mudstone with blue shale (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date:
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358683.94 N560734.64
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW05	RO	241.50m AoD		1:50	Sheet 2 of 3

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Dark mudstone with blue shale (driller's description)
					10.80	230.70		Grey mudstone (driller's description)
					14.30	227.20		Blue shale (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date:
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358683.94 N560734.64
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW05	RO	241.50m AoD		1:50	Sheet 3 of 3

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					20.20	221.30		Blue shale (driller's description)
								Limestone (driller's description)
					25.00	216.50		End of Borehole at 25.000m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/06/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358963.94 N560696.98
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW06	RO	251.00m AoD		1:50	Sheet 1 of 4

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								TOPSOIL/brown CLAY. (driller's description)
					2.70	248.30		Red CLAY with occasional limestone boulders (driller's description)
					8.10	242.90		Blue SHALE/MUDSTONE (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/06/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358963.94 N560696.98
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW06	RO	251.00m AoD		1:50	Sheet 2 of 4

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Blue SHALE/MUDSTONE (driller's description)
					12.50	238.50		Blue SHALE (driller's description)
					14.60	236.40		MUDSTONE (driller's description)
					17.20	233.80		Blue SHALE (driller's description)
					19.90	231.10		

11 12 13 14 15 16 17 18 19 20

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/06/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358963.94 N560696.98
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW06	RO	251.00m AoD		1:50	Sheet 3 of 4

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
								MUDSTONE with band of blue shale (driller's description)
					27.70	223.30		MUDSTONE (driller's description)

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Percussion Drilling Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 12/06/2016
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358963.94 N560696.98
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW06	RO	251.00m AoD		1:50	Sheet 4 of 4

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
					30.50	220.50		MUDSTONE (driller's description) End of Borehole at 30.500m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 08/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358350.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW08	RO	217.00m AoD		1:50	Sheet 1 of 5

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											Turf/topsoil/boulder clay (driller's description)
								1.20	215.80		Boulder clay/ limestone (driller's description)
								2.60	214.40		LIMESTONE BOULDER (driller's description)
								4.80	212.20		Stiff brown CLAY (driller's description)
								9.00	208.00		Hard LIMESTONE (driller's description)
			Type/FI	TCR	SCR	RQD	D/R/(SPT)				

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 08/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358350.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW08	RO	217.00m AoD		1:50	Sheet 2 of 5

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											Hard LIMESTONE (driller's description)
								12.20	204.80		MUDSTONE (driller's description)
								13.00	204.00		SANDSTONE (driller's description)
								14.00	203.00		LIMESTONE (driller's description)
								15.00	202.00		SANDSTONE (driller's description)
			Type/FI	TCR	SCR	RQD	D/R/(SPT)	20.00	197.00		

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 08/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358350.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW08	RO	217.00m AoD		1:50	Sheet 3 of 5

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											SANDSTONES/MUDSTONE (driller's description)
								26.00	191.00		MUDSTONE (driller's description)
			Type/FI	TCR	SCR	RQD	D/R/(SPT)				

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 08/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358350.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW08	RO	217.00m AoD		1:50	Sheet 4 of 5

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											MUDSTONE (driller's description)
								38.00	179.00		COAL (driller's description)
								39.00	178.00		Hard strata-loss of flush nil returns

Type/FI | TCR | SCR | RQD | D/R/(SPT)

31 32 33 34 35 36 37 38 39 40

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 08/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358350.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW08	RO	217.00m AoD		1:50	Sheet 5 of 5

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											Hard strata-loss of flush nil returns
								43.00	174.00		End of Borehole at 43.000m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 14/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358449.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW09	RO	210.50m AoD		1:50	Sheet 1 of 3

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											Turf/topsoil/ CLAY (driller's description)
								1.20	209.30		Stiff brown CLAY with cobbles (driller's description)
								5.20	205.30		SANDSTONE (driller's description)
								6.00	204.50		LIMESTONE (driller's description)
								7.30	203.20		SANDSTONE (driller's description)
								8.30	202.20		LIMESTONE (driller's description)
								9.30	201.20		SANDSTONE with occasional bands of limestone (driller's description)
			Type/FI	TCR	SCR	RQD	D/R/(SPT)	10.00	200.50		

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 14/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358449.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW09	RO	210.50m AoD		1:50	Sheet 2 of 3

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											Brown SANDSTONE (driller's description)
								13.30	197.20		SANDSTONE with occasional bands of limestone (driller's description)
								18.90	191.60		SANDSTONE/MUDSTONE (driller's description)
			Type/FI	TCR	SCR	RQD	D/R/(SPT)				

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Rotary Core Log

Project Name: Silvertop Quarry Waste Application	Client: Thompson's of Prudhoe	Date: 14/05/2019
Location: Silvetop Quarry, Cumbria	Contractor: Rotadrill	Co-ords: E358449.00 N560509.00
Project No. : NT12629	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WW09	RO	210.50m AoD		1:50	Sheet 3 of 3

Well	Water	Depth (m)	Type /FI	Coring TCR	Coring SCR	Coring RQD	Diameter Recovery (SPT)	Depth (m)	Level (m)	Legend	Stratum Description
											SANDSTONE/MUDSTONE (driller's description)
								20.50	190.00		MUDSTONE (driller's description)
								22.30	188.20		End of Borehole at 22.300m

	Type/FI	TCR	SCR	RQD	D/R/(SPT)

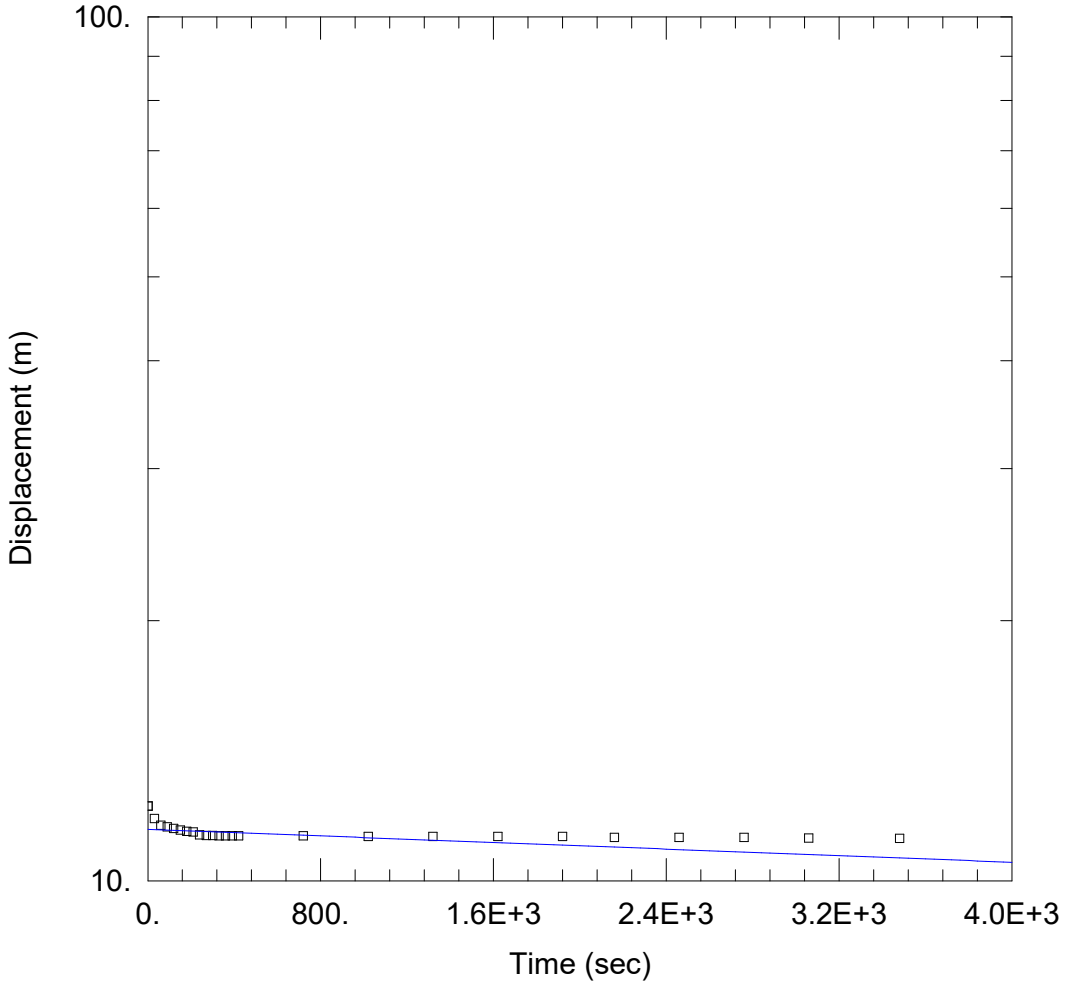
Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation				Drilling Flush					
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation	Depth Top	Depth Base	Type	Colour	Min (%)	Max (%)

Remarks

AGS

Appendix 2

Falling Head Tests



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T1.aqt
Date: 03/31/20 Time: 13:56:54

PROJECT INFORMATION

Company: Wardell Armstrong

AQUIFER DATA

Saturated Thickness: 13. m Anisotropy Ratio (Kz/Kr): 1.

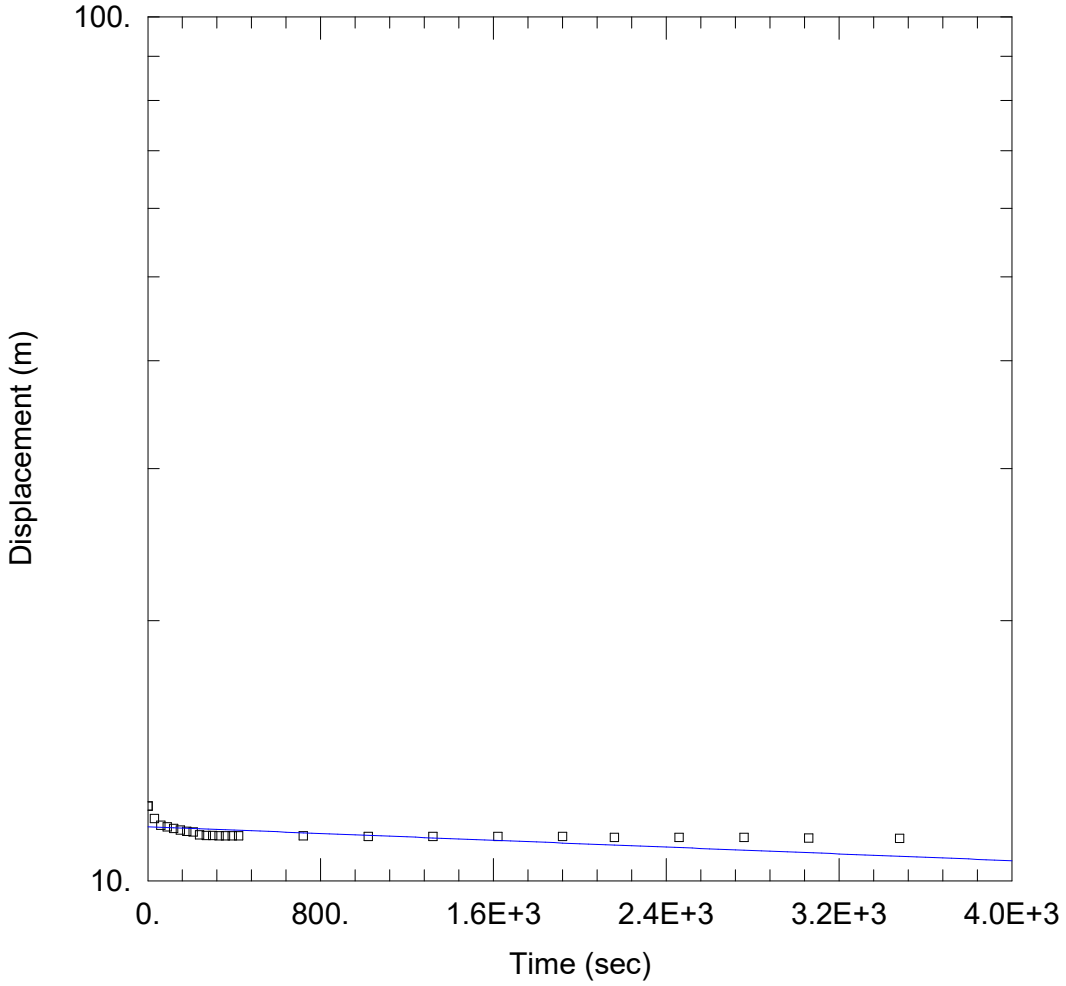
WELL DATA (New Well)

Initial Displacement: 12.2 m
Total Well Penetration Depth: 12.2 m
Casing Radius: 0.15 m
Static Water Column Height: 1. m
Screen Length: 3.2 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.031E-7 m/sec y0 = 11.47 m



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T1.aqt
Date: 03/31/20 Time: 13:57:57

PROJECT INFORMATION

Company: Wardell Armstrong

AQUIFER DATA

Saturated Thickness: 13. m Anisotropy Ratio (Kz/Kr): 1.

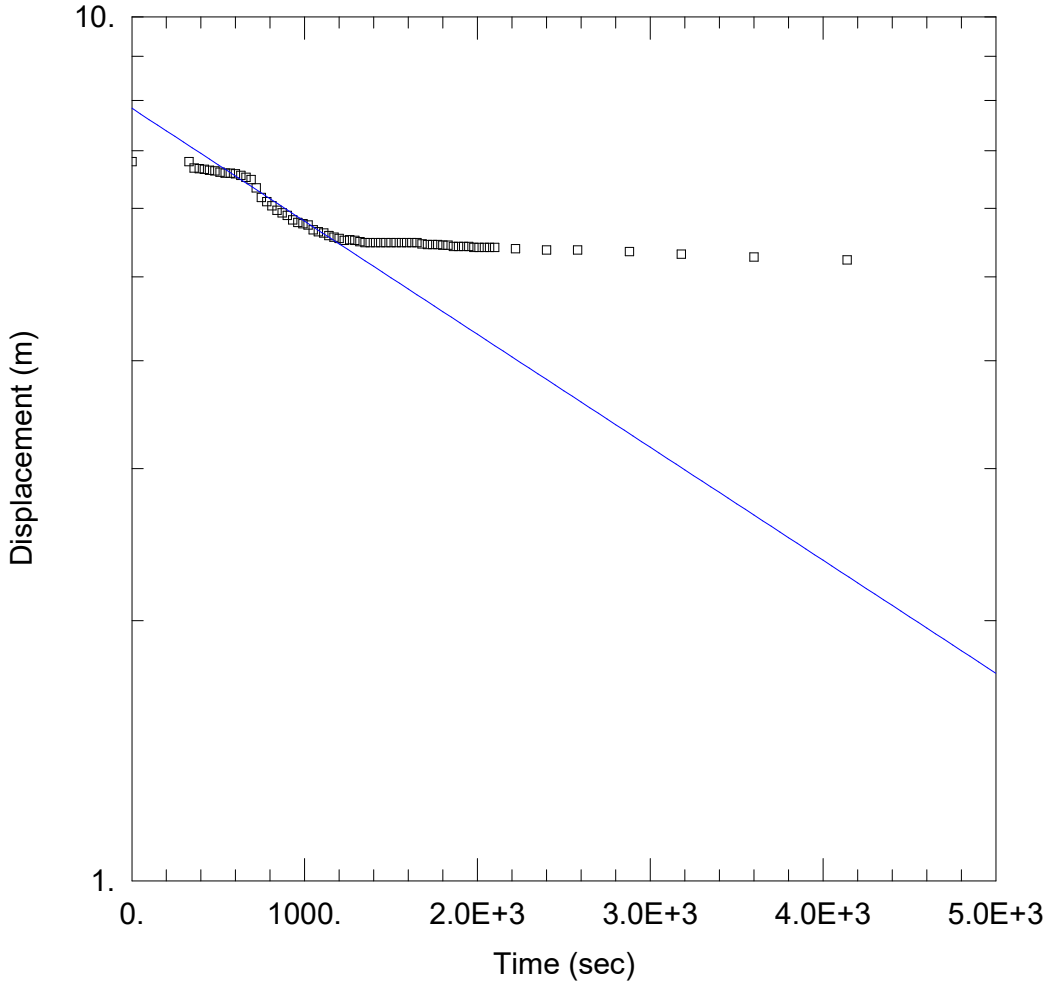
WELL DATA (New Well)

Initial Displacement: 12.2 m
Total Well Penetration Depth: 12.2 m
Casing Radius: 0.15 m
Static Water Column Height: 1. m
Screen Length: 3.2 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 2.44E-7 m/sec y0 = 11.55 m



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T2.aqt
Date: 03/31/20 Time: 14:00:04

PROJECT INFORMATION

Company: Wardell Armstrong

AQUIFER DATA

Saturated Thickness: 17. m Anisotropy Ratio (Kz/Kr): 1.

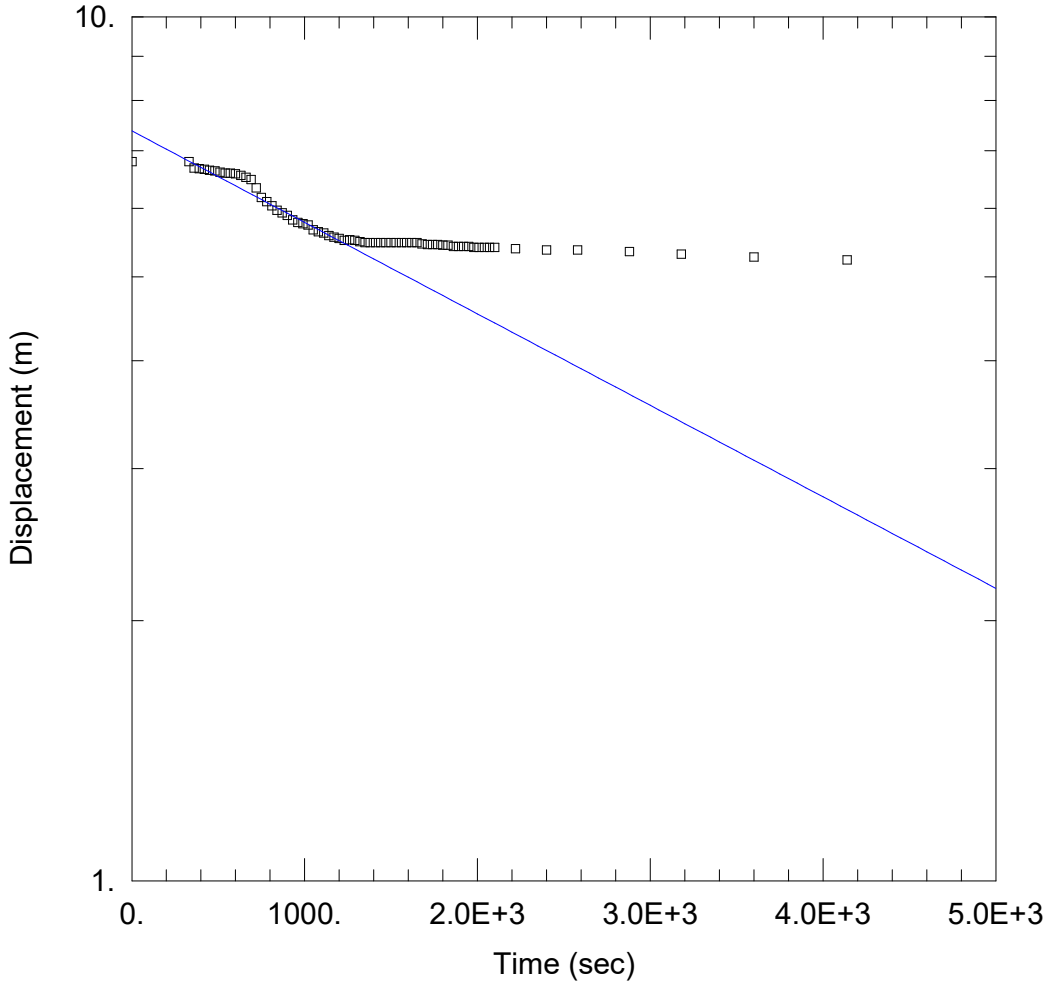
WELL DATA (New Well)

Initial Displacement: 6.8 m
Total Well Penetration Depth: 43. m
Casing Radius: 0.15 m
Static Water Column Height: 17. m
Screen Length: 34. m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 8.437E-7 m/sec y0 = 7.837 m



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T2.aqt
Date: 03/31/20 Time: 14:01:34

PROJECT INFORMATION

Company: Wardell Armstrong

AQUIFER DATA

Saturated Thickness: 17. m Anisotropy Ratio (Kz/Kr): 1.

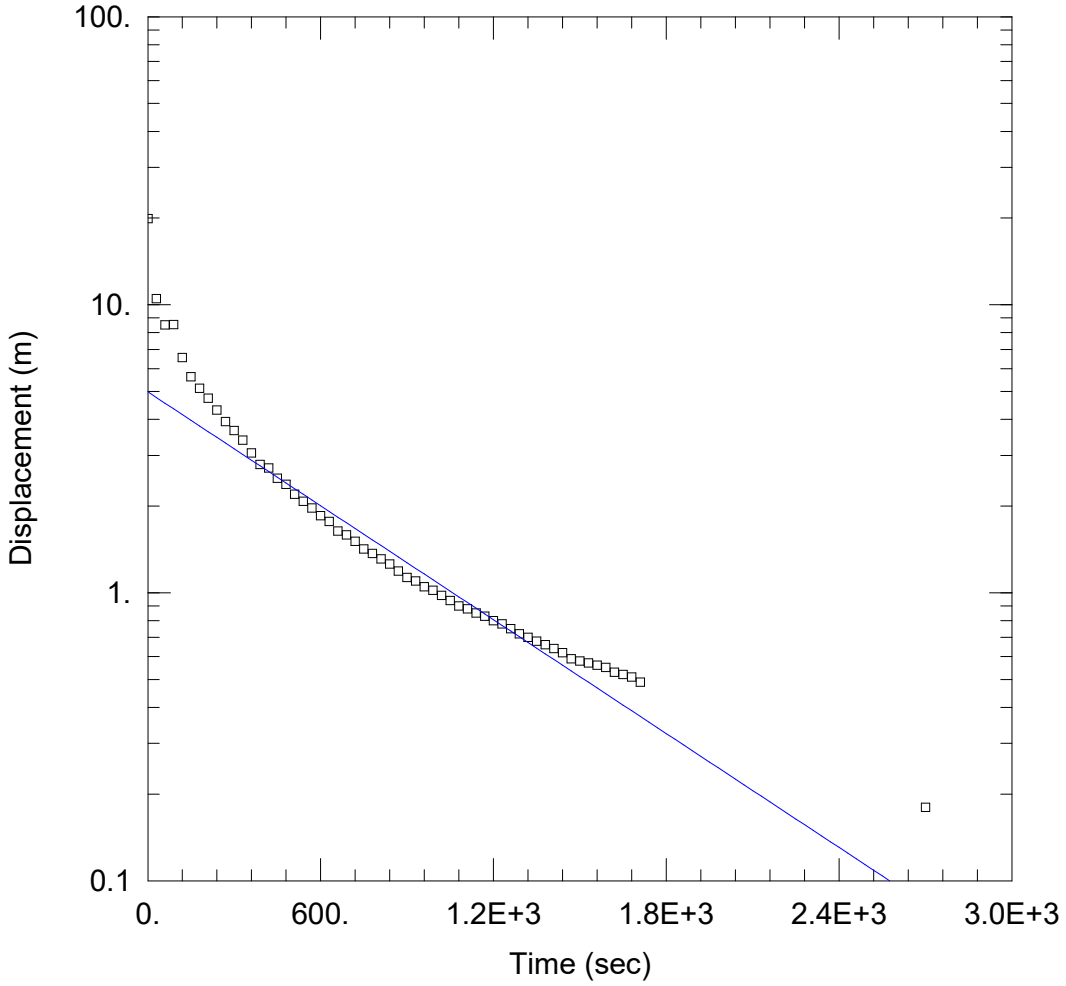
WELL DATA (New Well)

Initial Displacement: 6.8 m
Total Well Penetration Depth: 43. m
Casing Radius: 0.15 m
Static Water Column Height: 17. m
Screen Length: 34. m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 8.55E-7 m/sec y0 = 7.378 m



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T3.aqt
Date: 03/31/20 Time: 14:22:04

AQUIFER DATA

Saturated Thickness: 23.09 m Anisotropy Ratio (Kz/Kr): 1.

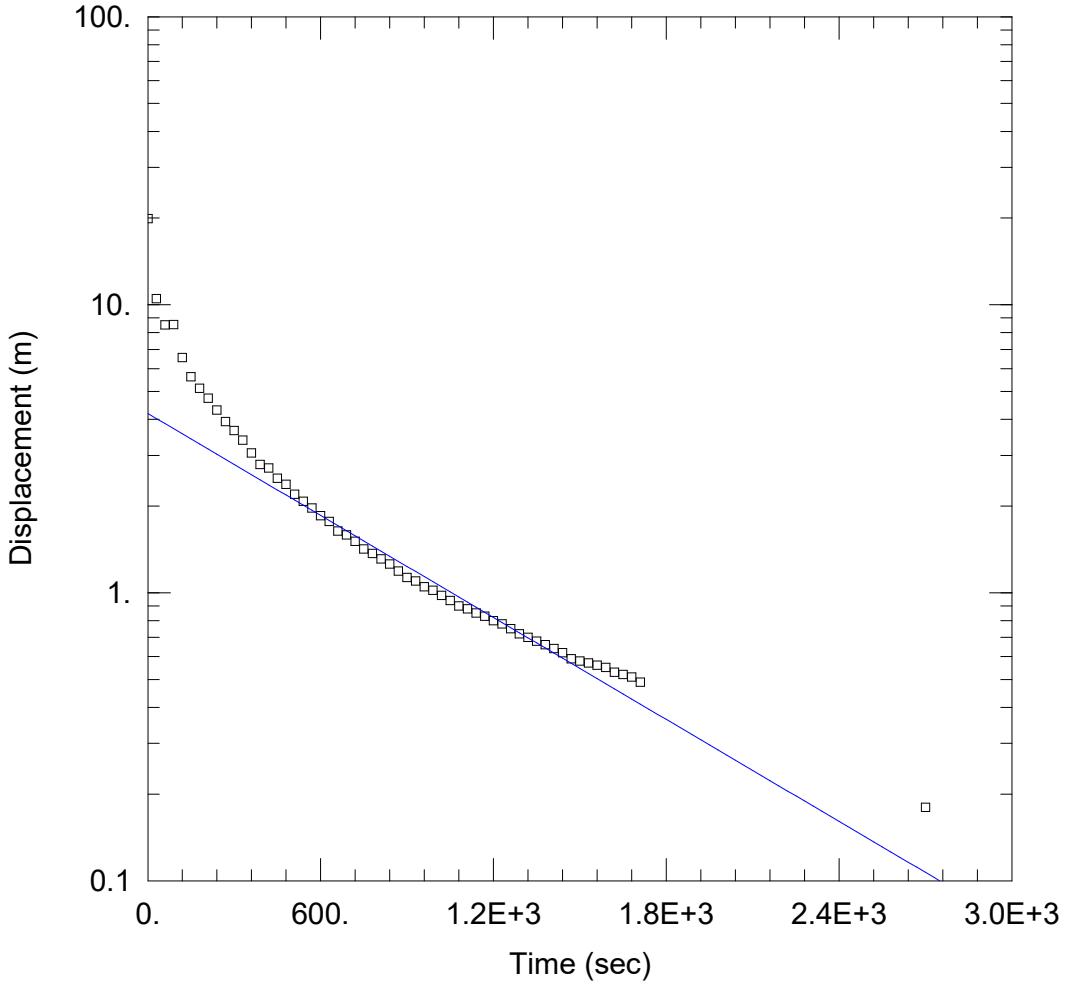
WELL DATA (WW08)

Initial Displacement: 19.91 m
Static Water Column Height: 23.09 m
Total Well Penetration Depth: 43. m
Screen Length: 34. m
Casing Radius: 0.15 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.182E-6 m/sec
y0 = 4.986 m



WELL TEST ANALYSIS

Data Set: N:\...\WW08 T3.aqt
Date: 03/31/20 Time: 14:21:14

AQUIFER DATA

Saturated Thickness: 23.09 m Anisotropy Ratio (Kz/Kr): 1.

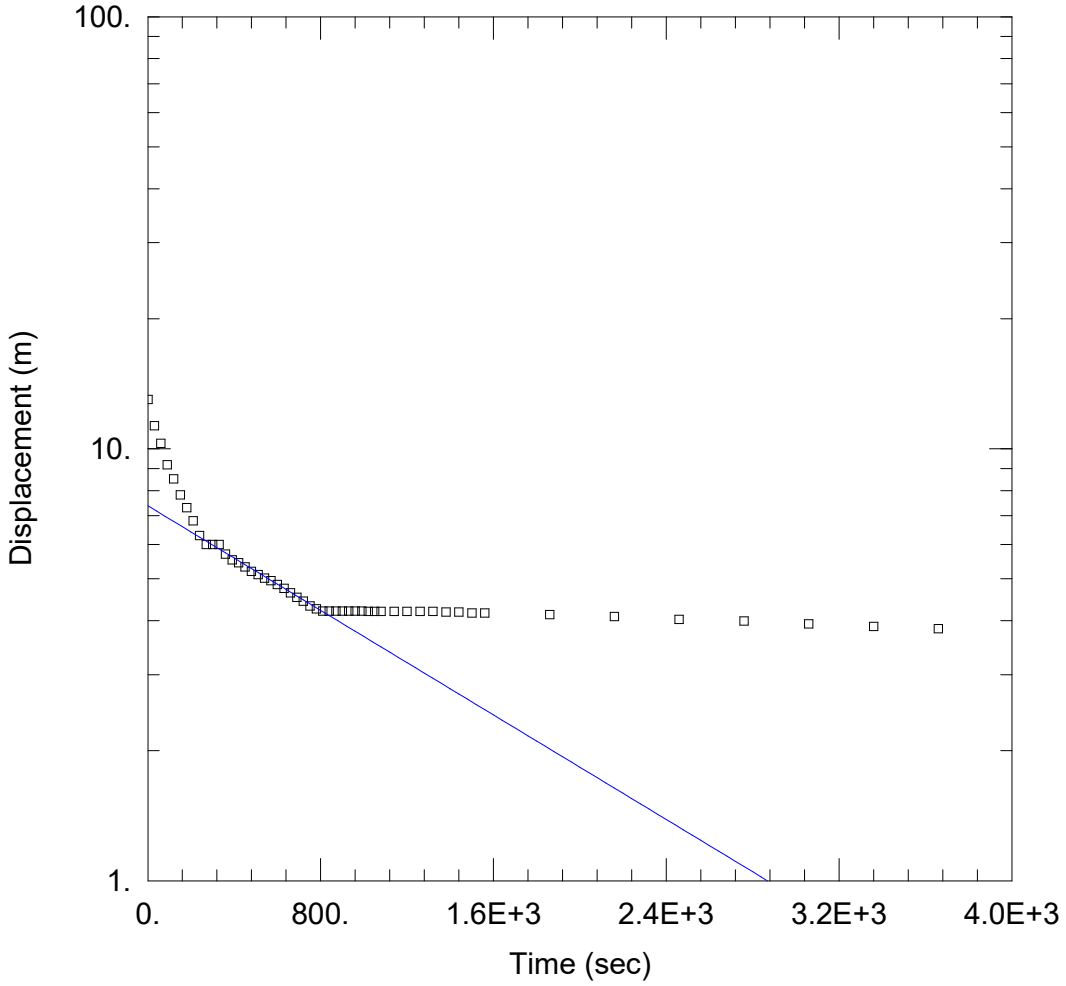
WELL DATA (WW08)

Initial Displacement: 19.91 m
Static Water Column Height: 23.09 m
Total Well Penetration Depth: 43. m
Screen Length: 34. m
Casing Radius: 0.15 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 3.509E-6 m/sec
y0 = 4.195 m



WELL TEST ANALYSIS

Data Set: N:\...\WW09 T1.aqt
Date: 03/31/20 Time: 13:49:28

AQUIFER DATA

Saturated Thickness: 13. m Anisotropy Ratio (Kz/Kr): 1.

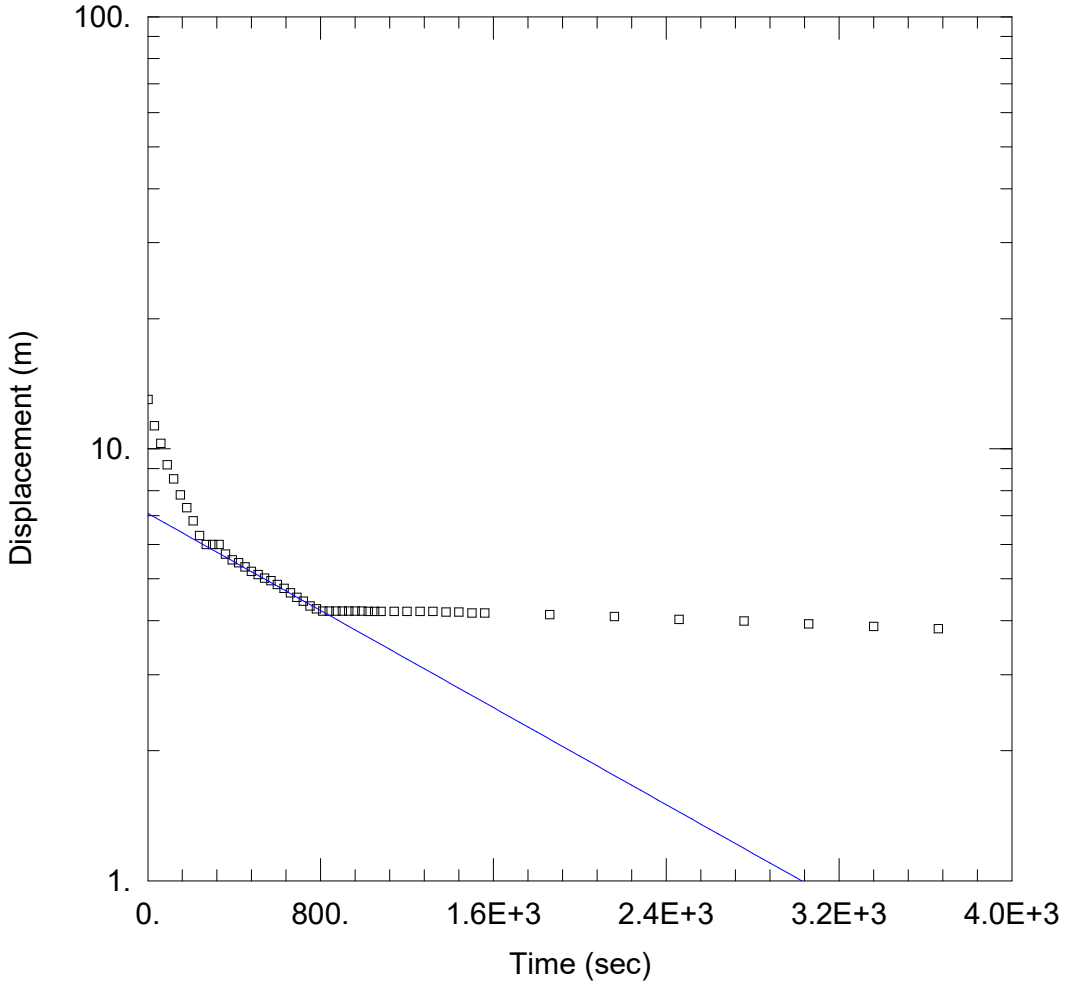
WELL DATA (WW09)

Initial Displacement: 13. m
Total Well Penetration Depth: 13. m
Casing Radius: 0.15 m
Static Water Column Height: 0. m
Screen Length: 3. m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 7.928E-6 m/sec y0 = 7.38 m



WELL TEST ANALYSIS

Data Set: N:\...\WW09 T1.aqt
Date: 03/31/20 Time: 13:48:16

AQUIFER DATA

Saturated Thickness: 13. m Anisotropy Ratio (Kz/Kr): 1.

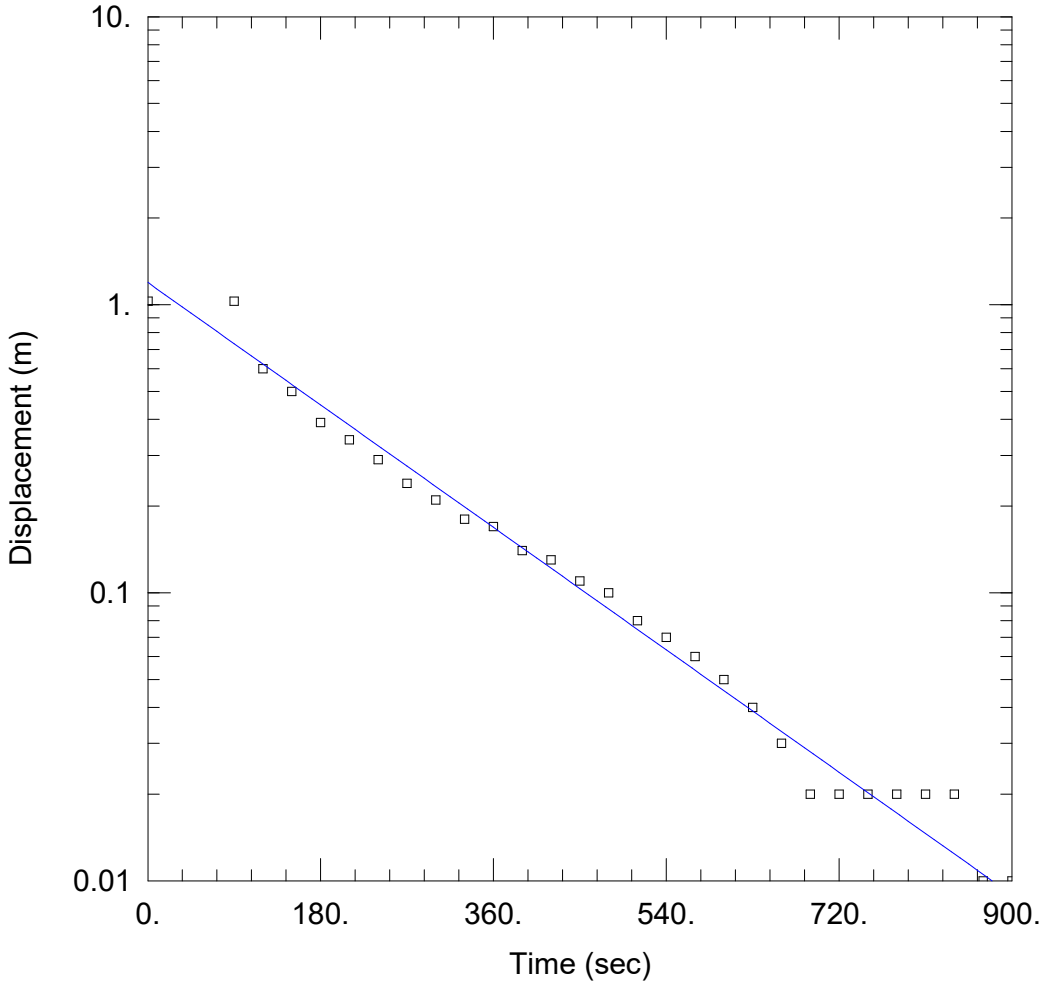
WELL DATA (WW09)

Initial Displacement: 13. m
Total Well Penetration Depth: 13. m
Casing Radius: 0.15 m
Static Water Column Height: 0. m
Screen Length: 3. m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 8.952E-6 m/sec y0 = 7.088 m



WELL TEST ANALYSIS

Data Set: N:\...\WW09 T2.aqt
Date: 03/31/20 Time: 13:45:10

AQUIFER DATA

Saturated Thickness: 5.61 m Anisotropy Ratio (Kz/Kr): 1.

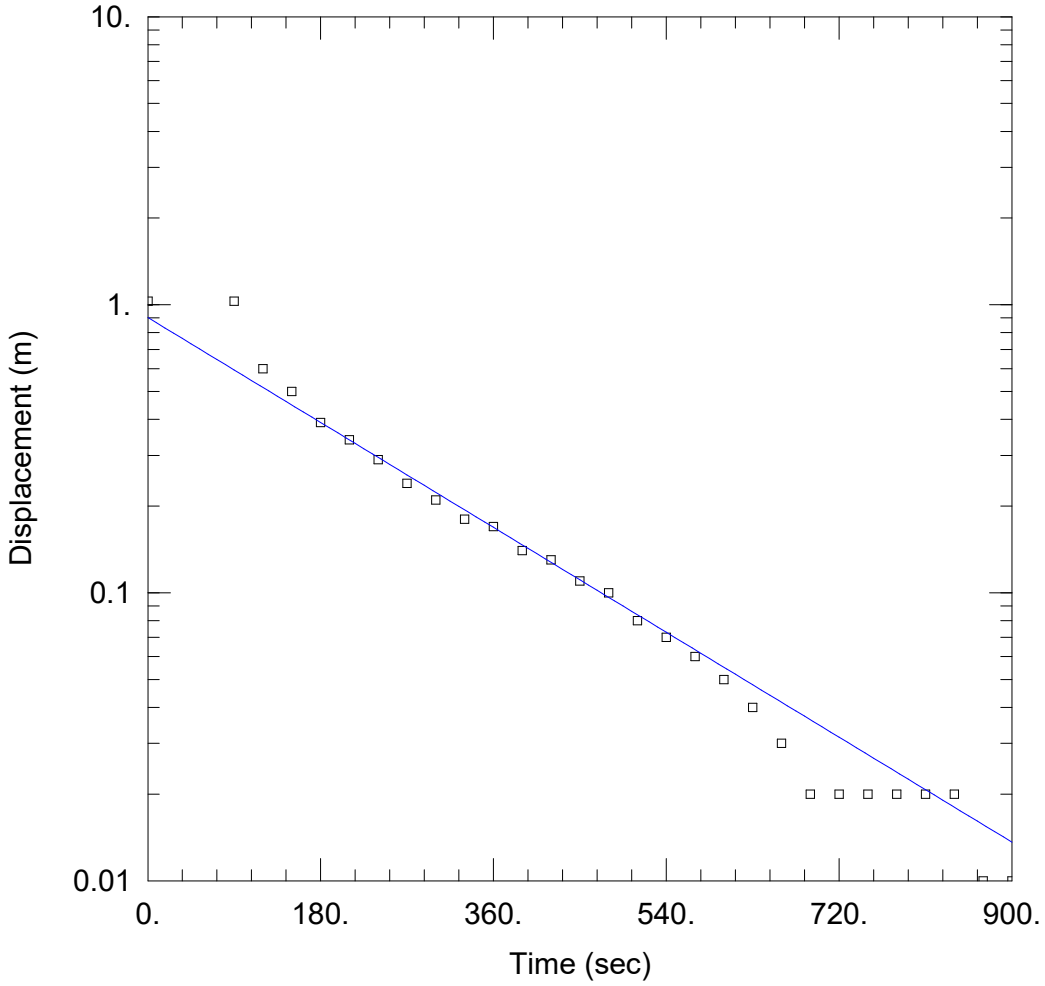
WELL DATA (WW09)

Initial Displacement: 1.03 m
Static Water Column Height: 1.61 m
Total Well Penetration Depth: 19. m
Screen Length: 9. m
Casing Radius: 0.15 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.81E-5 m/sec
y0 = 1.195 m



WELL TEST ANALYSIS

Data Set: N:\...\WW09 T2.aqt
Date: 03/31/20 Time: 13:42:03

AQUIFER DATA

Saturated Thickness: 5.61 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (WW09)

Initial Displacement: 1.03 m
Static Water Column Height: 1.61 m
Total Well Penetration Depth: 19. m
Screen Length: 9. m
Casing Radius: 0.15 m
Well Radius: 0.15 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 4.952E-5 m/sec
y0 = 0.9034 m

Appendix 3

Groundwater Elevations

Appendix 4

Groundwater Quality

Groundwater Quality Data July to October 2016 and November 2019 to January 2020

Concentrations have been screened against their respective UK DWS

UKDWS	Determinand	Units	WW01	WW01	WW01	WW01	WW01	WW01	WW01	WW02	WW02	WW02	WW02	WW02	WW02	WW02	WW03	WW03	WW03	WW03	WW03	WW03	WW04	WW04	WW04
			26/07/2016	23/08/2016	12/09/2016	10/10/2016	11/11/2019	06/12/2019	09/01/2020	26/07/2016	23/08/2016	12/09/2016	10/10/2016	11/11/2019	06/12/2019	09/01/2020	26/07/2016	23/08/2016	12/09/2016	10/10/2016	11/11/2019	06/12/2019	09/01/2020	26/07/2016	23/08/2016	12/09/2016
	Alkalinity (settled)	mg/l CaCO	294	318	348	346	74	212	84	136	74	148	156	82	262	154	400	414	342	290	308	310	310	284	296	278
	Ammonia	µg/l	10	<10	22	35	13	120	84	23	<40	45	39	15	44	15	1729	17835	14793	2346	25	37	56	103	48	36
5	Antimony (dissolved)	µg/l					<0.1							<0.1							<0.1					
10	Arsenic (dissolved)	µg/l					<0.06							0.08							<0.06					
	Barium (dissolved)	µg/l					187.7							8.1							20.9					
	Biological Oxygen Demand	mg/l	2	2	3	2	2	2	2	10	5	5	4	2	2	2	3	2	8	5	1	1	2	3	4	4
5	Cadmium (dissolved)	µg/l	<0.07	0.121233981	0.48931153	0.499544178	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	0.130956853
250	Calcium (dissolved)	mg/l	90.70188636	131.3039035	133.1	121.0625385	35.7	42.62	24.1295094	72.06868769	37.72957258	63.72102384	67.72534642	59.31	59.07	67.15960516	146.3245901	150.4693404	212.66	259.8493067	213.59	273.26	195.582565	43.53862917	78.12379342	86.93068156
	Chemical Oxygen Demand (total)	mg/l	36	28	65	41	35	27	84	640	191	297	175	41	88	270	93	30	65	37	12	14	41	77	114	77
250	Chloride	mg/l	9.7	11	12.5	14	5.2	17	2.848	6.1	3.7	8.2	8.3	8.4	8	9.697	15	15	13.2	18	22	21	22.012	26	26	27.6
50	Chromium (dissolved)	µg/l	<0.2	<0.2	0.274822051	0.27338265	<0.2	<0.2	<0.2	0.449485115	<0.2	<0.2	0.25507068	0.6	0.5	<0.2	<0.2	<0.2	<0.2	0.461934147	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
2000	Copper (dissolved)	µg/l	2.192319941	1.488248201	5.740796562	1.640322131	<0.4	1.7	1.401849975	0.68902916	2.981482086	0.873410414	1.378318956	0.5	<0.4	0.769261614	1.660891865	1.457543589	0.743597942	1.250532866	<0.4	<0.4	0.403388327	<0.4	<0.4	7.025969328
	Cresols	µg/l		<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5
	Dissolved Organic Carbon	mg/l					<5	<5	<5					<25	<5	<5					<5	<5	<5			
	Dissolved Oxygen	mg/l	8	8.1	8	8.1	8.2	8.1	7.9	7.8	8	7.9	8	8.2	7.8	7.9	8	8.1	7.7	7.8	8.2	8.2	8	7.9	7.9	7.9
	Electrical conductivity	µS/cm	536	734	737	810	1066	303	169	330	236	383	422	424	362	436	882	1086	1139	1352	1298	1400	1387	547	659	579
1.5	Fluoride	mg/l					0.6	0.1	<0.1					<0.1	<0.1	<0.1					<0.1	<0.1	<0.1			
200	Iron (dissolved)	µg/l	<3	<3	9.726066858	102.8860358	<3	<3	11.96564765	98.94935811	269.8022117	54.1870924	48.36874484	178	115	19.52147321	<3	<3	28.19617314	55.54888096	50	<3	<3	<3	<3	<3
10	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	0.229611011	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
50	Magnesium (dissolved)	mg/l	13.75661988	21.55675286	34.25182862	38.01394336	6.56	7.45	2.770551047	11.61437746	6.323983241	13.17618691	13.10786881	14.23	10.21	12.40287325	43.73903983	45.48051562	58.43305585	83.3937482	88.64	73.68	78.19397401	36.78018207	35.13148584	35.64390526
50	Manganese (dissolved)	µg/l	0.402211641	68.16585702	92.00449723	167.6471674	1.3	14.7	28.24080964	4.463867688	9.224593989	4.15333067	10.60910523	<0.4	12.1	6.77072429	1.800949979	1000.792491	2108.9	442.8102082	0.5	16	36.64279632	3.201254401	243.7287101	175.8590103
1	Mercury (dissolved)	µg/l					0.008							0.011							0.015					
	Molybdenum (dissolved)	µg/l					0.6							<0.3							<0.3					
	Naphthols	µg/l		<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5
20	Nickel (dissolved)	µg/l	0.815925203	1.7008399	3.610140309	2.385734526	<0.5	0.6	0.751049794	0.578821299	1.109233479	<0.5	1.11089258	<0.5	<0.5	0.524928018	2.166908713	3.317514071	3.112272334	3.580626775	<0.5	<0.5	1.313898671	12.35128911	14.21139427	12.44219023
50	Nitrate	mg/l					0.8	1.5	1.619					14	11	8.991					1.2	1.1	1.444			
0.5	Nitrite	mg/l					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3			
	pH	pH Units	7.5	7.3	7.4	7.4	9.4	8.1	8.4	7.6	7.4	7.4	7.3	8.8	7.9	8.2	7.3	7.5	7.1	7.1	8	7.8	7.9	7.8	7.7	7.4
	Phenols (total)	µg/l	<0.5	<0.5	<0.5	<0.5	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<10	<10	<10	<0.5	<0.5	<0.5
	Phosphate	mg/l					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3			
12	Potassium (dissolved)	mg/l	4.653795248	3.730285011	3.391732223	3.810821243	1.84	2.63	1.297557615	1.619061311	1.291936719	1.390745895	2.296795516	2.25	1.58	1.533724341	11.82457948	10.54900614	7.456188823	5.094269536	5.17	4.38	4.88763529	6.313064876	4.167431174	4.573075482
	Selenium (dissolved)	µg/l					0.17							0.17							1.06					
200	Sodium (dissolved)	mg/l	9.066239481	8.226473808	10.2299585	9.009819153	2	11.1	2.616660863	5.393778732	4.025759094	5.903745596	6.64266821	8.7	7.5	7.308285517	8.909938402	8.599179092	8.362422533	11.50782548	13.6	11.3	12.08501244	5.123097885	6.115521636	8.289374925
250	Sulphate	mg/l	36	53	78	92	35	37	6.684	5	23	40	33	49	43	41.34	121	161	380	559	647	671	607.947	30	33	30
	Suspended solids	mg/l	74	86	284	143	58	1862	458	3543	398	1031	823	141	742	404	367	62	173	171	22	42	108	459	1110	696
	Total dissolved solids	mg/l	410	560	560	615	810	230	125	255	180	290	320	322	275	330	675	825	865	1030	986	1064	1050	420	500	440
	Total Organic Carbon	mg/l	8.5	4.1	6.8	13	<5	<5	<5	11	67	49.6	22	8.7	<5	7.4	178	5.3	16	8.7	<5	<5	<5	7.5	30	19.7
	Total Oxidised Nitrogen (as N)	mg/l	2	<1	<1	3	<0.2	0.3	0.4	3.4	<1	3.2	2.2	3.2	2.4	2	5.1	<1	<1	<1	0.3	0.2	0.3	<1	<1	<1
	Trimethylphenols	µg/l		<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5
	Xylenols	µg/l		<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5
5000	Zinc (dissolved)	µg/l	<1	50.20635194	1522	73.16737077	5	<1	<1	<1	<1	31.2717316	<1	<1	<1	<1	<1	<1	21.37641891	8.963197913	52	4	35.90758473	<1	<1	15.77614537

UKDWS exceedance

Where there is only one value for a determinand a graph has not been produced, namely: Antimony, Arsenic, Barium, Mercury, Molybdenum and Seleniun

Where there has been no detection above method detection limits for a determinand a graph has not been produced, namely: Cresols, Naphthols, Nitrite, Phenols, Trimethylphenols and Xylenol

Groundwater Quality Data July to October 2016 ar

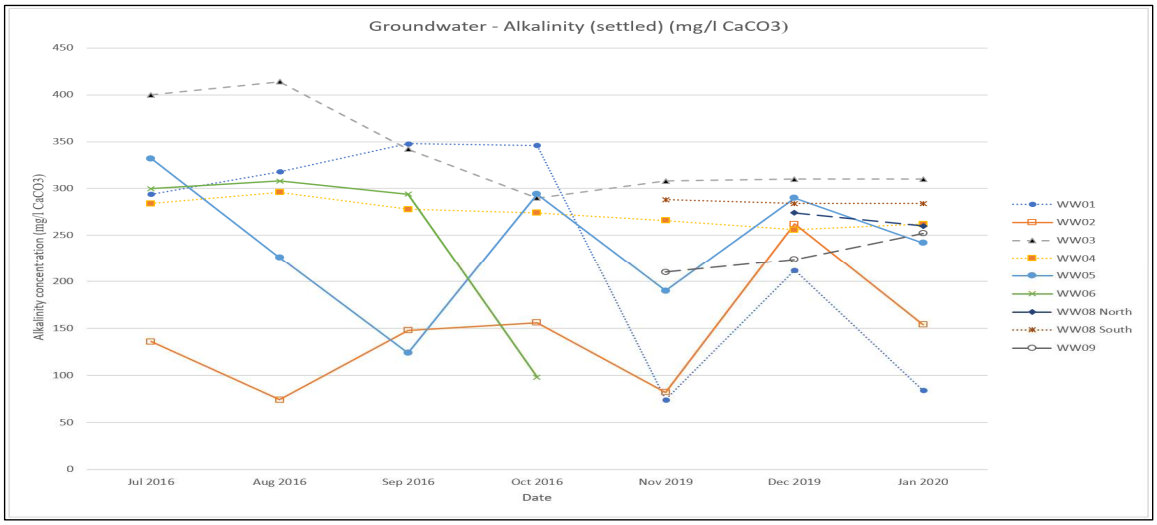
Concentrations have been screened against their respec

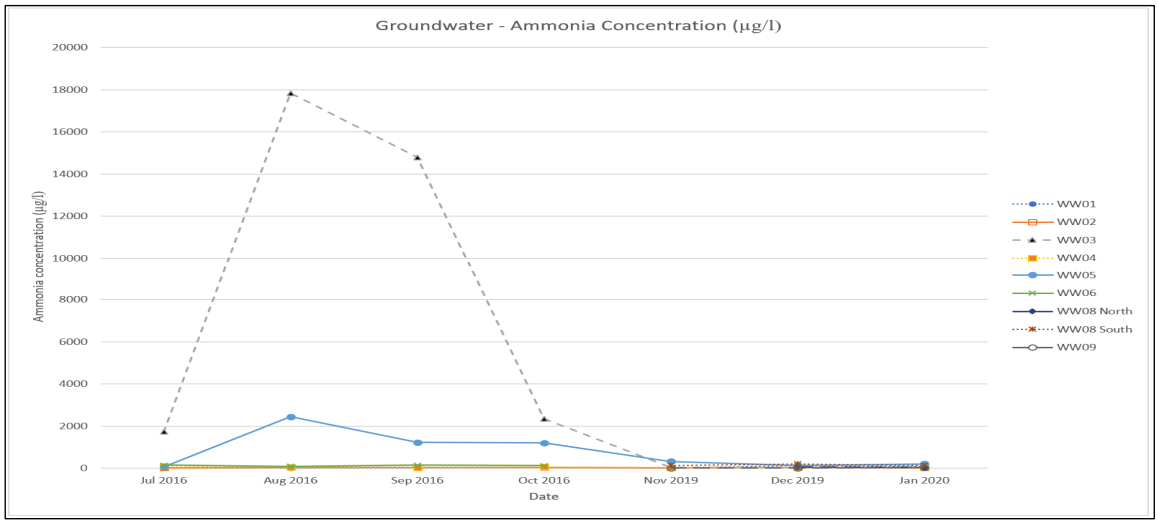
UKDWS	Determinand	Units	WW04	WW04	WW04	WW04	WW05	WW05	WW05	WW05	WW05	WW05	WW05	WW06	WW06	WW06	WW06	WW08 North	WW08 North	WW08 South	WW08 South	WW08 South	WW09	WW09	WW09
			10/10/2016	11/11/2019	06/12/2019	09/01/2020	26/07/2016	23/08/2016	12/09/2016	10/10/2016	11/11/2019	06/12/2019	09/01/2020	26/07/2016	23/08/2016	12/09/2016	10/10/2016	06/12/2019	09/01/2020	11/11/2019	06/12/2019	09/01/2020	11/11/2019	06/12/2019	09/01/2020
	Alkalinity (settled)	mg/l CaCO	274	266	256	262	332	226	124	294	190	290	242	300	308	294	98	274	260	288	284	284	210	224	252
	Ammonia	µg/l	69	27	17	39	67	2440	1219	1195	320	134	205	150	94	141	130	54	35	138	206	134	11	12	29
5	Antimony (dissolved)	µg/l		<0.1							<0.1									<0.1			<0.1		
10	Arsenic (dissolved)	µg/l		0.31							0.36									0.08			<0.06		
	Barium (dissolved)	µg/l		66.4							248.9									4296.1			49.1		
	Biological Oxygen Demand	mg/l	4	2	1	1	<1	3	6	6	5	3	2	3	3	4	2	3	2	2	2	3	1	<1	1
5	Cadmium (dissolved)	µg/l	<0.07	<0.07	0.09	<0.07	<0.07	<0.07	0.095124157	0.070120078	0.14	0.1	<0.07	<0.07	<0.07	0.118950347	<0.07	0.09	0.083416182	<0.07	0.1	<0.07	0.65	0.59	0.375087922
250	Calcium (dissolved)	mg/l	75.46598957	82.52	78.67	81.98457255	55.08444288	38.74460772	39.11926604	33.04077346	67.19	103.46	98.3644013	54.54328373	93.29887439	102.3511224	87.60580925	81.13	79.91888763	80.97	79.31	80.13788774	98.86	96.93	100.8726149
	Chemical Oxygen Demand (total)	mg/l	116	94	15	19	<10	117	358	352	390	70	75	80	123	168	52	67	48	19	10	69	16	13	12
250	Chloride	mg/l	24	23	22	21.465	5.3	6.2	5	4.5	5.7	6.7	7.895	8	8.2	7.9	7.6	12	12.568	7.5	7.5	9.509	6.8	7.5	11.078
50	Chromium (dissolved)	µg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.242657389	<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
2000	Copper (dissolved)	µg/l	<0.4	<0.4	<0.4	<0.4	<0.4	2.303832152	1.047149628	2.515021812	<0.4	1.9	1.425441301	<0.4	<0.4	0.804493777	<0.4	2.4	2.215097436	<0.4	<0.4	<0.4	<0.4	<0.4	0.505509464
	Cresols	µg/l	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5								
	Dissolved Organic Carbon	mg/l		<5	<5	<5					<25	<5	5					<5	<5	<5	<5	<5	<5	<5	<5
	Dissolved Oxygen	mg/l	7.8	8.2	8.1	8	8.2	7.9	7.8	7.7	7.7	7.9	7.9	8	7.9	7.9	8	7.9	7.9	8	8	7.8	8.2	8.2	8
	Electrical conductivity	µS/cm	607	679	382	598	516	551	317	303	475	596	545	485	586	511	561	643	636	511	306	537	645	625	664
1.5	Fluoride	mg/l		0.1	0.1	0.113					<0.1	<0.1	<0.1					0.1	0.121	0.2	0.2	0.122	<0.1	<0.1	<0.1
200	Iron (dissolved)	µg/l	22.48742395	<3	<3	<3	<3	96.3810877	13.07982947	401.8394446	1506	31	45.39113816	<3	<3	3.302165144	20.65221769	<3	<3	<3	<3	7.8363916	<3	<3	<3
10	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
50	Magnesium (dissolved)	mg/l	36.89678725	38.25	35.14	35.35340953	17.42703597	8.930244399	10.21917792	9.071560905	14.84	19.05	16.05632197	19.4135172	17.90012568	17.88506162	18.21113649	26.99	28.86469994	31.53	35.19	32.52372815	36.87	34.62	38.14587391
50	Manganese (dissolved)	µg/l	53.2580453	55.9	9.2	1.389688965	24.44651002	28968.49682	14355.74897	11591.83948	9584	3846.1	1456.404585	1.738750652	166.255457	139.5254934	32.60745025	163.2	171.781543	107.9	9.1	189.3590448	10.1	22.5	28.10853698
1	Mercury (dissolved)	µg/l		0.008							<0.008									<0.008			<0.008		
	Molybdenum (dissolved)	µg/l		0.3							<0.3									<0.3			<0.3		
	Naphthols	µg/l	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5								
20	Nickel (dissolved)	µg/l	10.97068307	4.8	8.7	6.196229428	1.053230308	16.7055537	24.1711514	24.25025664	12.2	4	4.99233056	<0.5	<0.5	0.788245352	<0.5	2.5	2.405669463	<0.5	8.6	4.060955205	<0.5	5.1	6.744146774
50	Nitrate	mg/l		3.3	3	7.659					<0.2	0.2	0.867					0.7	0.804	<0.2	0.2	<0.2	44	38	17.948
0.5	Nitrite	mg/l		<0.3	<0.3	<0.3					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
	pH	pH Units	7.5	7.9	8	8.1	7.4	6.6	6.1	6.1	7.8	7.2	8.1	7.5	7.5	7.1	7.3	8	8.1	7.4	8.1	8	7.7	7.7	8
	Phenols (total)	µg/l	<0.5	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<10	<10	<10	<10	<10	<10	<10	<10
	Phosphate	mg/l		<0.3	<0.3	<0.3					<0.3	<0.3	<0.3					<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
12	Potassium (dissolved)	mg/l	4.029157367	4.4	3.97	4.599101427	1.763886438	1.231230652	1.261996677	0.819915589	4.28	1.85	1.367198673	3.529642125	3.024353865	3.087943227	2.952793165	5.31	5.745775792	7.47	3.91	6.725515101	0.85	1.09	1.98539192
	Selenium (dissolved)	µg/l		0.42							0.27									<0.07			1.65	4.7	
200	Sodium (dissolved)	mg/l	5.596006632	5.7	5	5.521576937	8.289997113	48.68178634	13.58720716	7.712635281	11.3	5.8	4.427120337	6.867439	6.484948062	6.705059872	6.92906868	32.7	36.50191396	5.8	4.9	5.572435525	5	4.7	5.161985209
250	Sulphate	mg/l	28	55	53	51.644	<10	45	40	38	50	45	47.048	<10	<10	<10	<10	90	95.83	7	9.1	25.533	128	113	120.77
	Suspended solids	mg/l	657	462	133	104	55	333	1381	2028	1030	409	253	560	1372	1638	443	846	127	68	18	473	78	46	136
	Total dissolved solids	mg/l	460	516	290	450	395	420	240	230	361	453	410	370	445	390	425	489	480	388	233	405	490	475	500
	Total Organic Carbon	mg/l	14	<5	<5	<5	5.8	32	150.1	122	31	7.3	10.6	20	38	25.8	9.9	<5	<5	<5	<5	<5	<5	<5	<5
	Total Oxidised Nitrogen (as N)	mg/l	<1	0.8	0.7	1.7	<1	<1	<1	<1	<0.2	<0.2	<0.2	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.2	<0.2	9.9	8.6	4.1
	Trimethylphenols	µg/l	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5								
	Xylenols	µg/l	<0.5					<0.5	<0.5	<0.5					<0.5	<0.5	<0.5								
5000	Zinc (dissolved)	µg/l	2.681234312	34	8	8.336563854	<1	2.193085241	20.38690514	14.70726331	16	8	17.09732161	<1	<1	8.654231313	<1	11	15.16089001	12	9	16.70356773	55	45	38.44053867

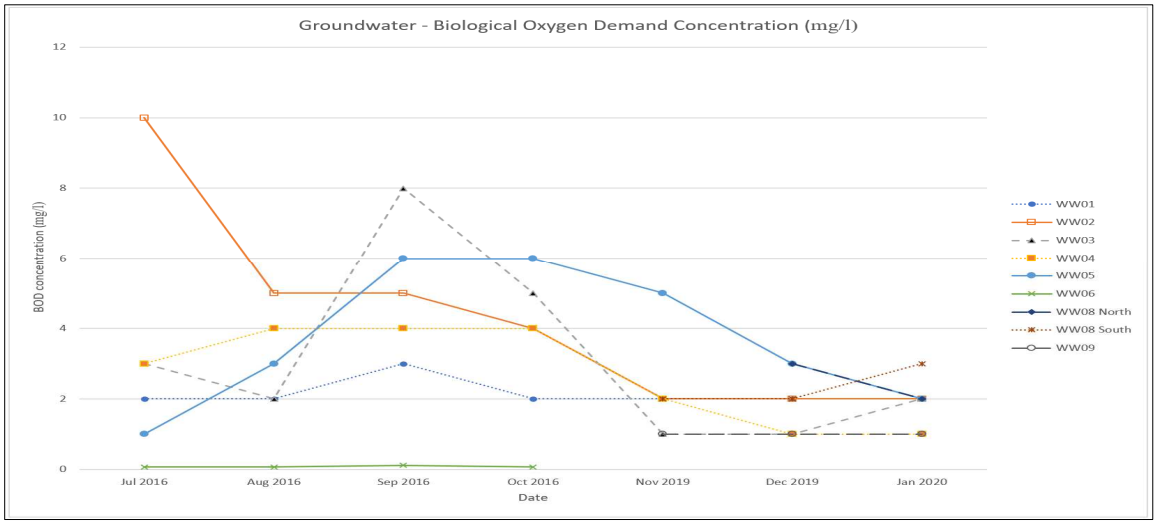
UKDWS exceedance

Where there is only one value for a determinand a graph

Where there has been no detection above method dete



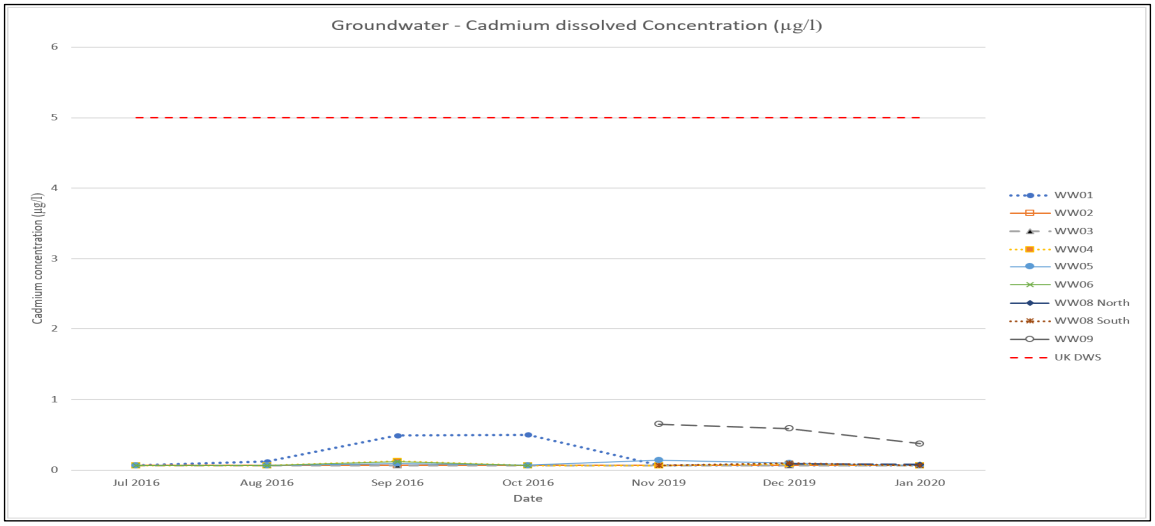


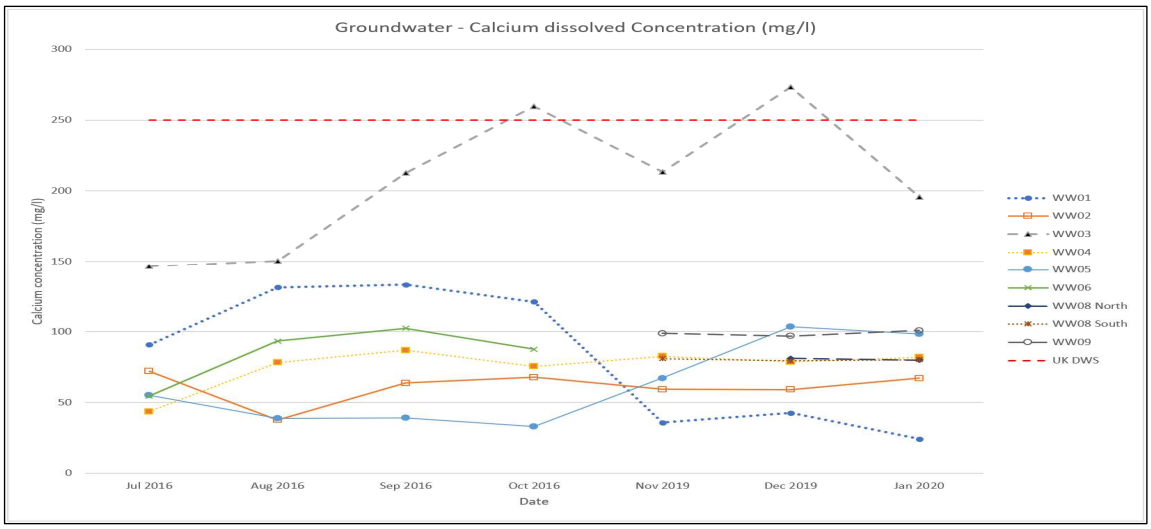


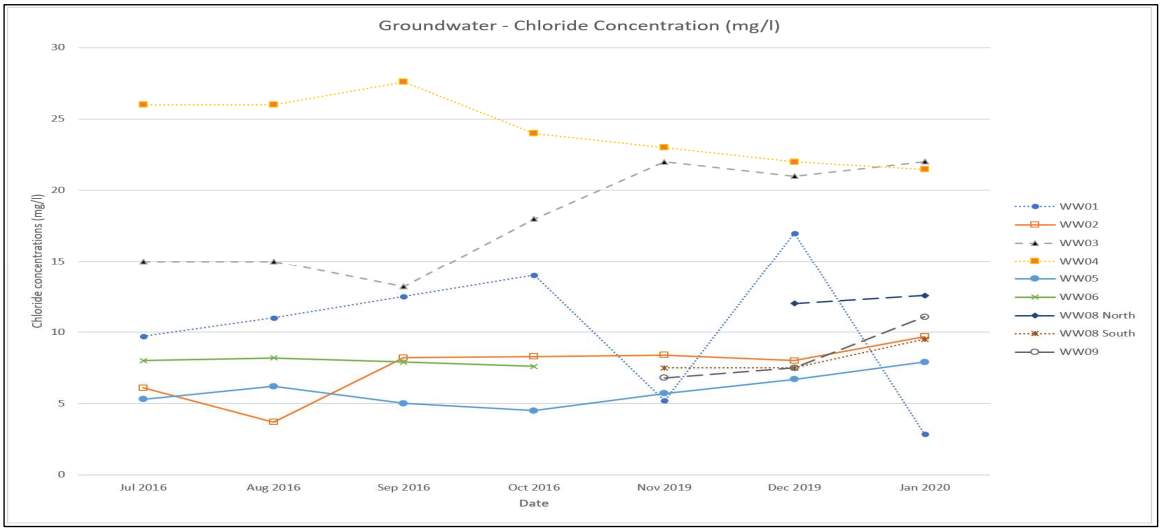
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Alkalinity, ammonia and BOD - no DWS available

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Alkalinity, Ammonia and Biological Oxygen Demand Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.2	AA	TM	Apr-20



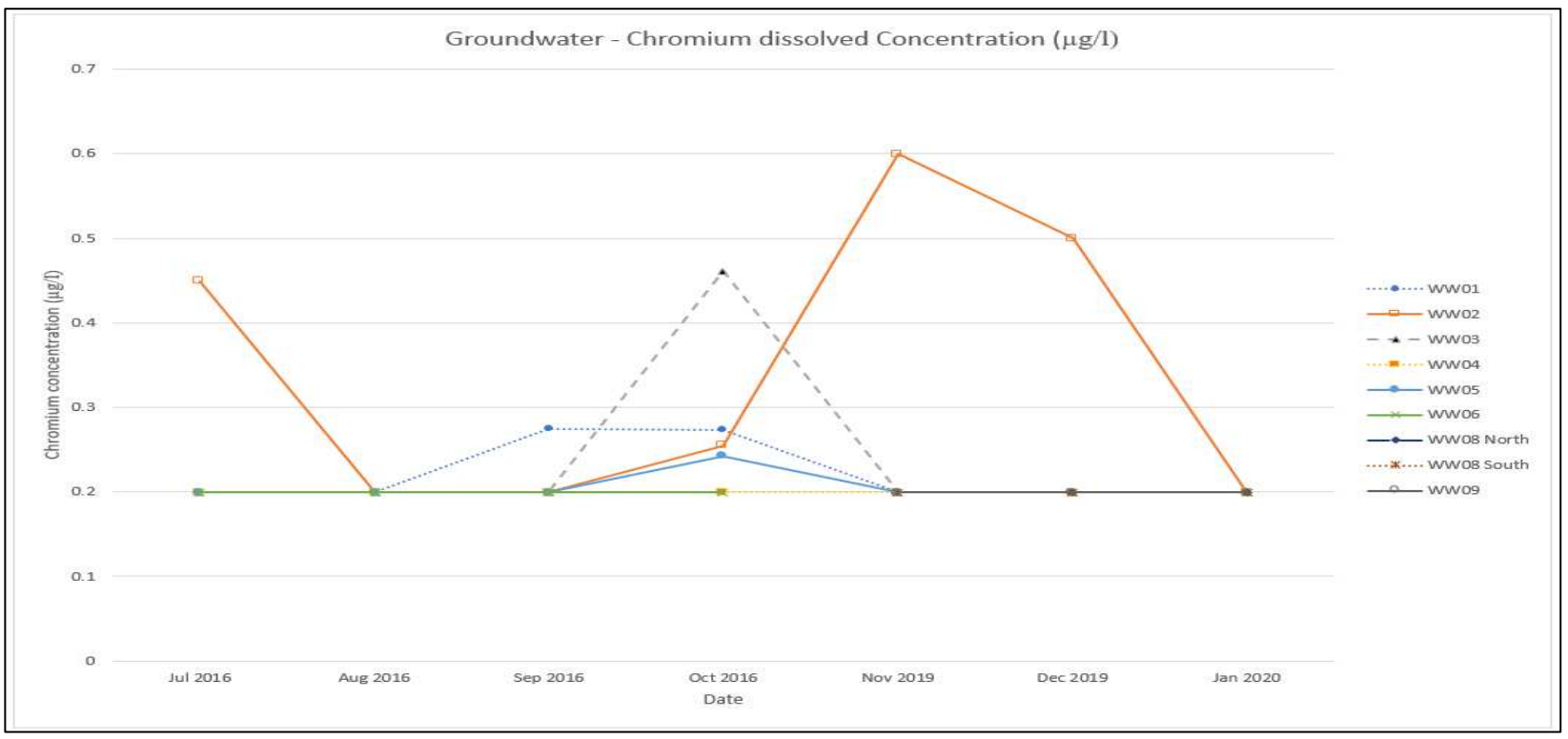


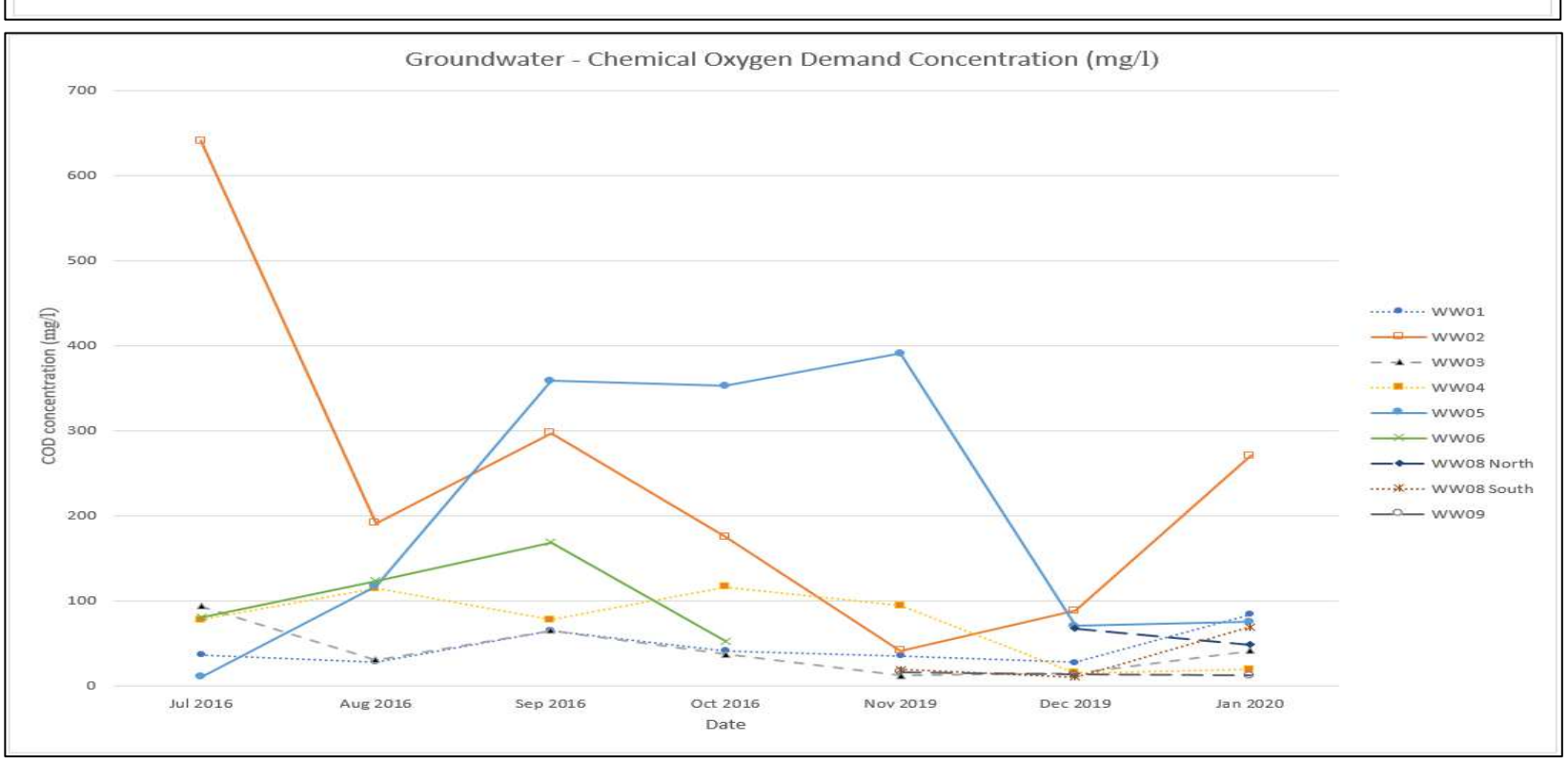


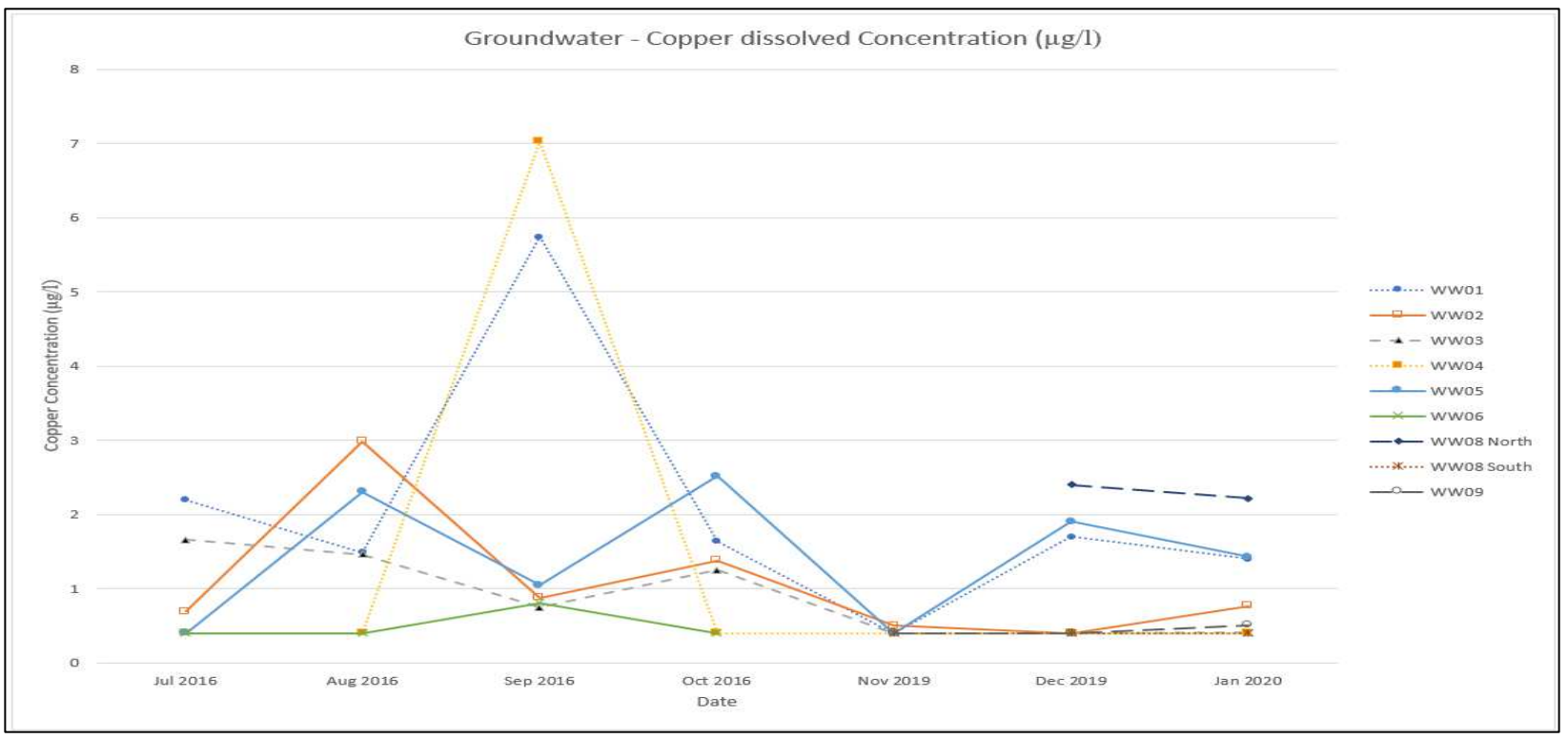
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Cadmium - 5µg/l
Calcium - 250mg/l
Chloride - 250mg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Cadmium, Calcium and Chloride Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.3	AA	TM	Apr-20



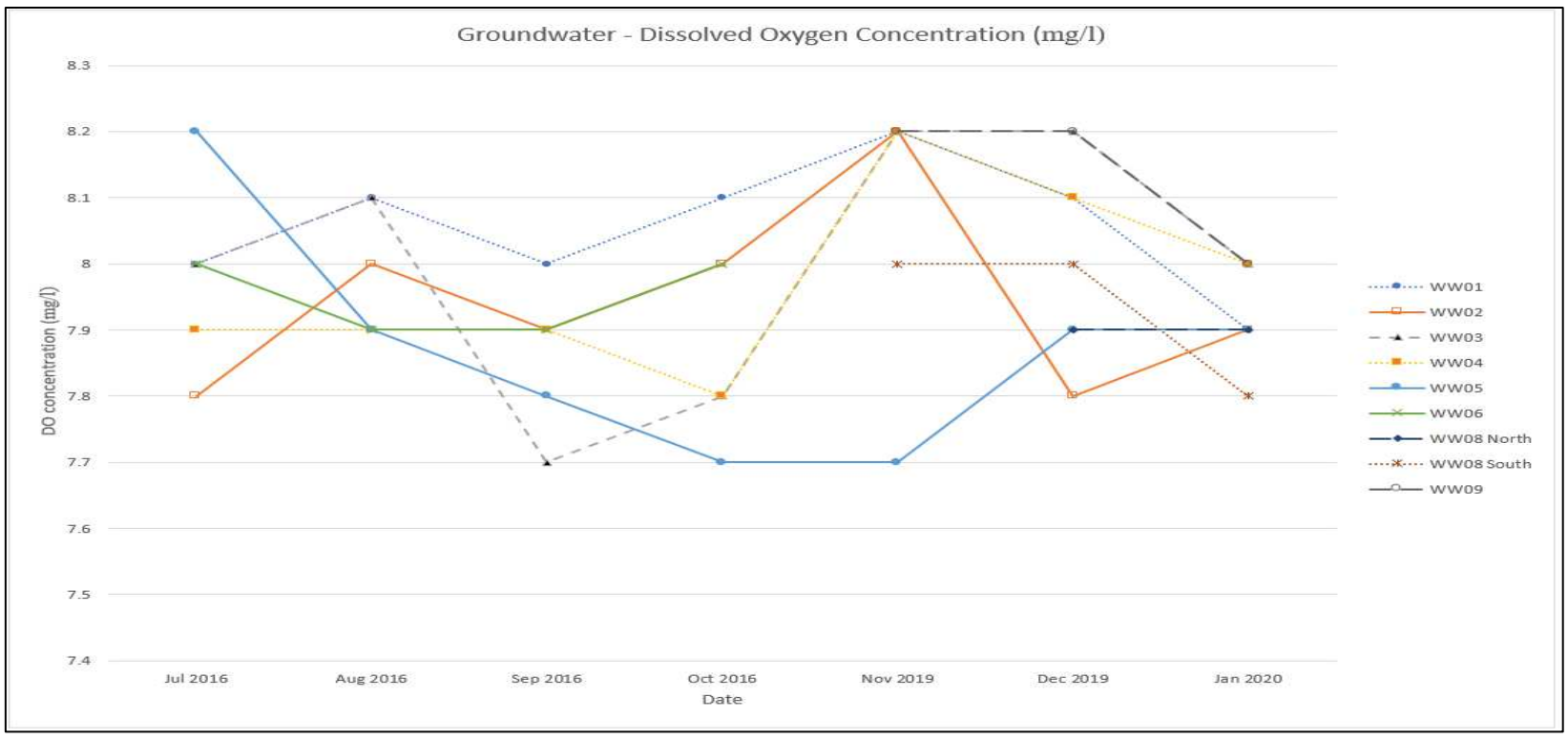


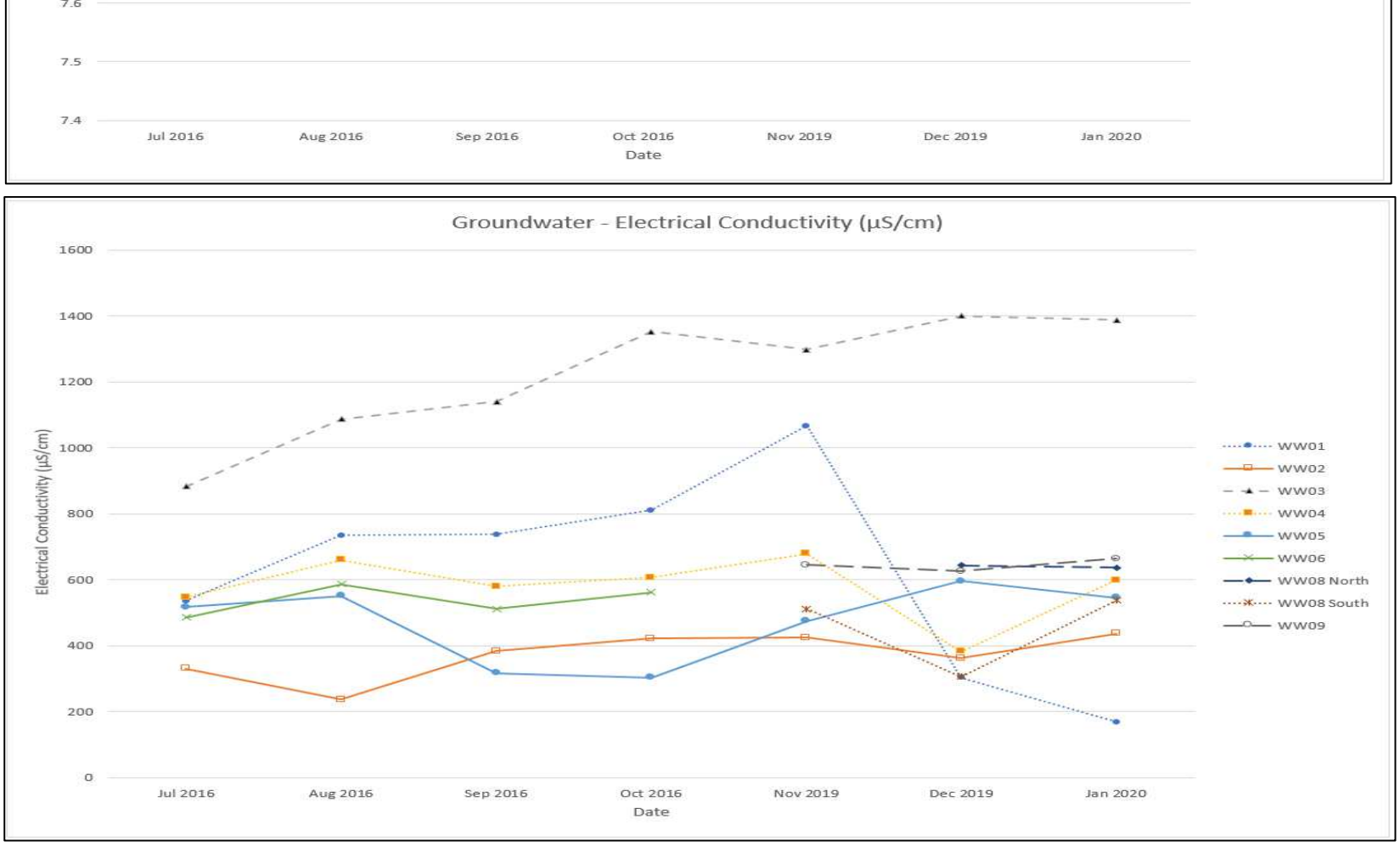


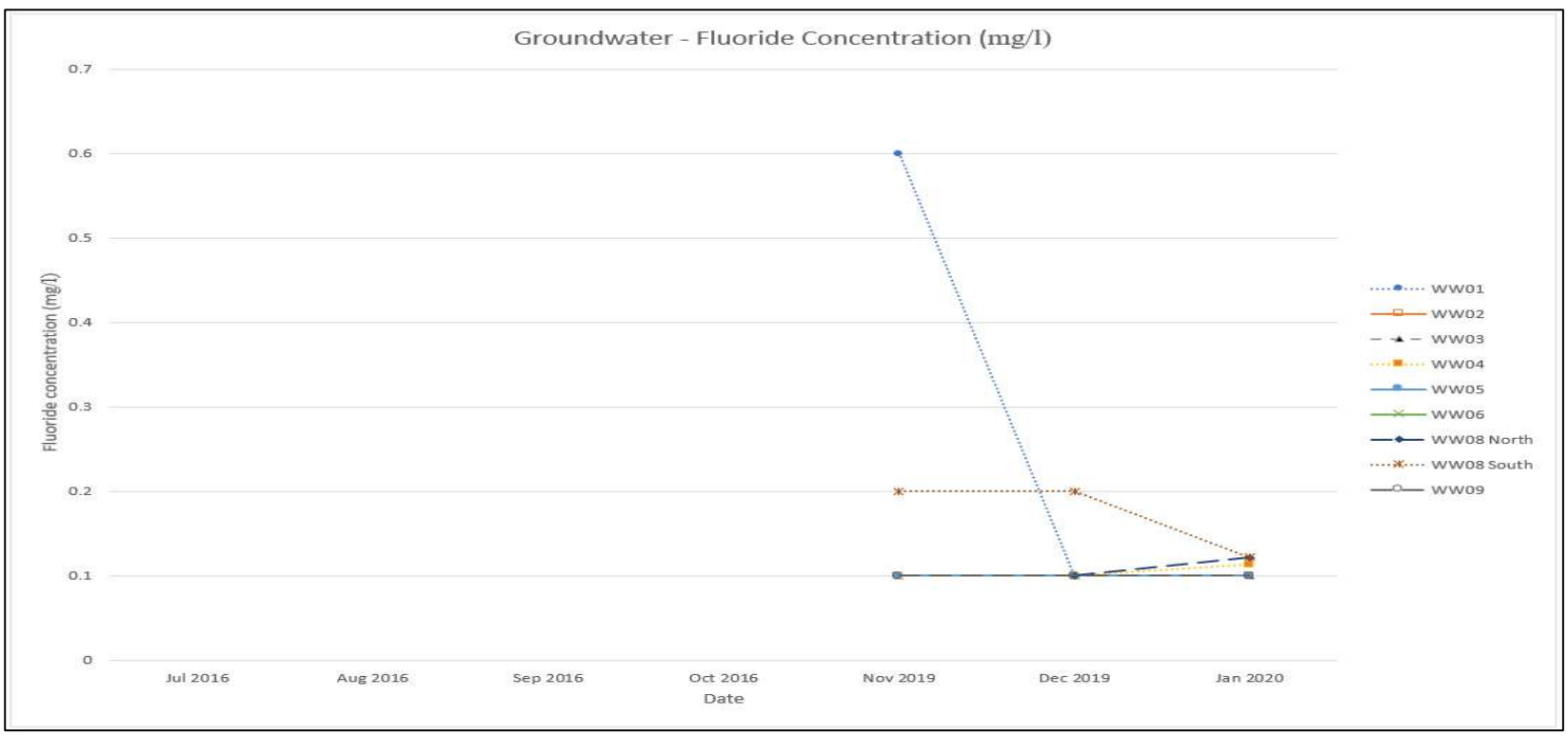
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Chromium - 50µg/l
COD - no DWS
Copper - 2000µg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Chromium, Chemical Oxygen Demand, Copper Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.4	AA	TM	Apr-20



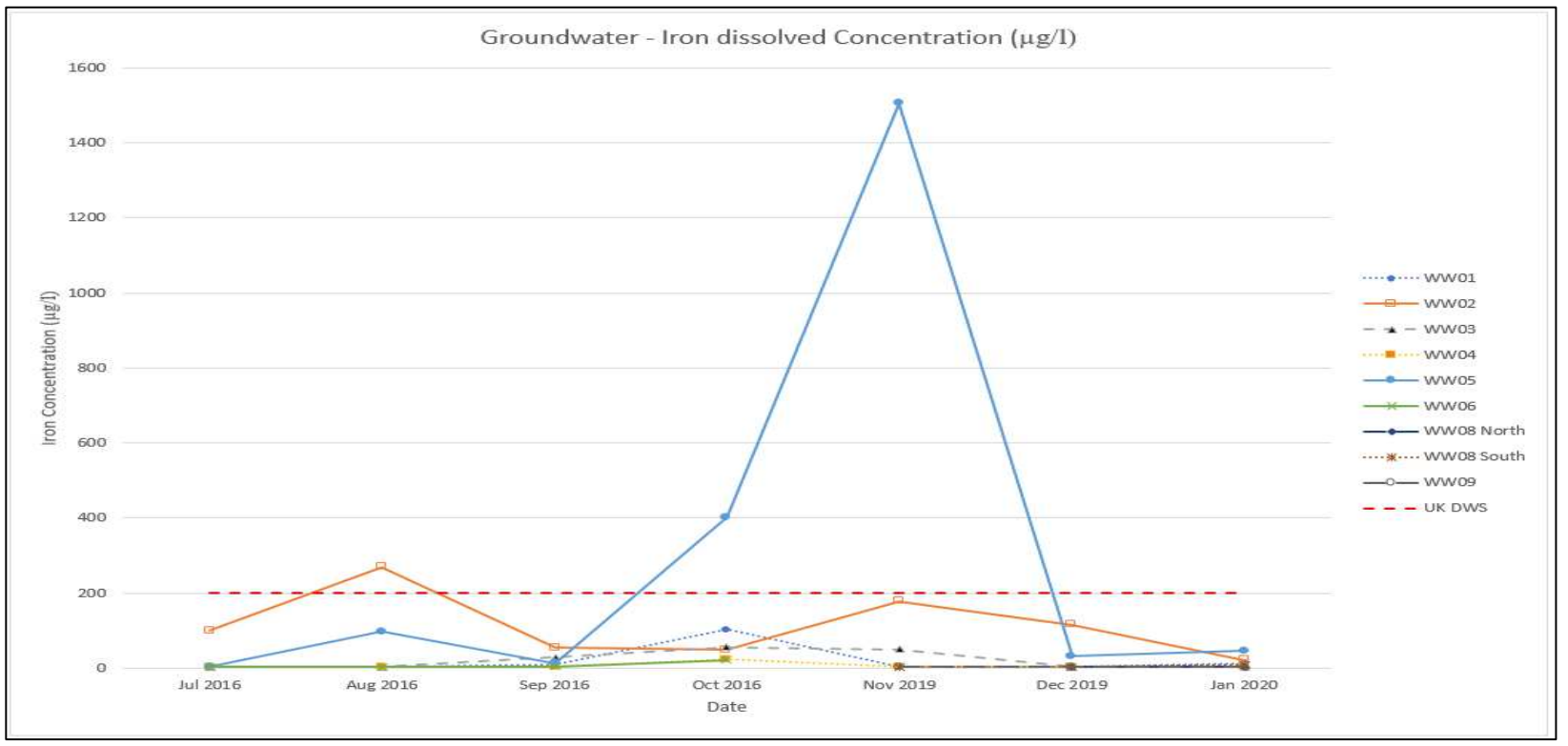


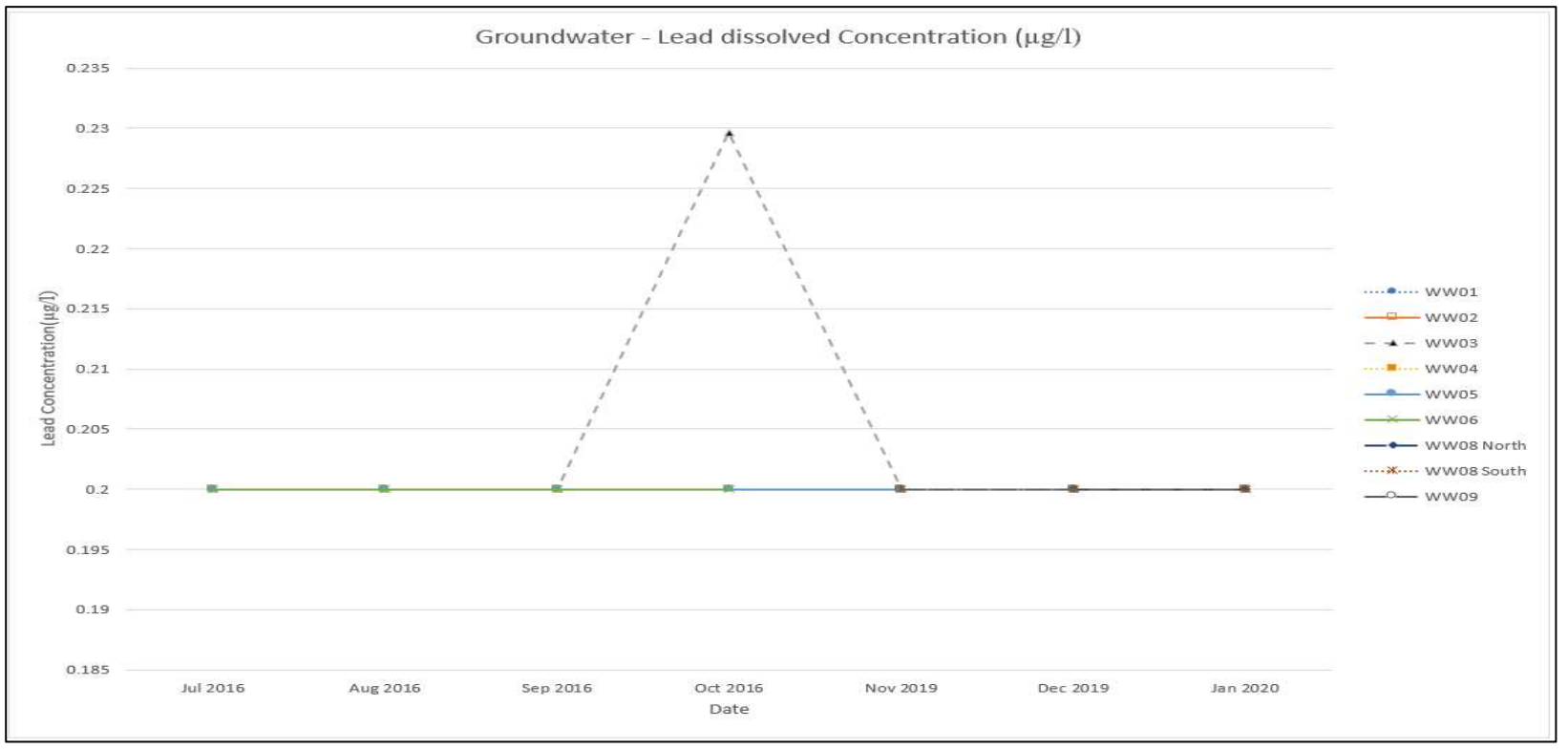


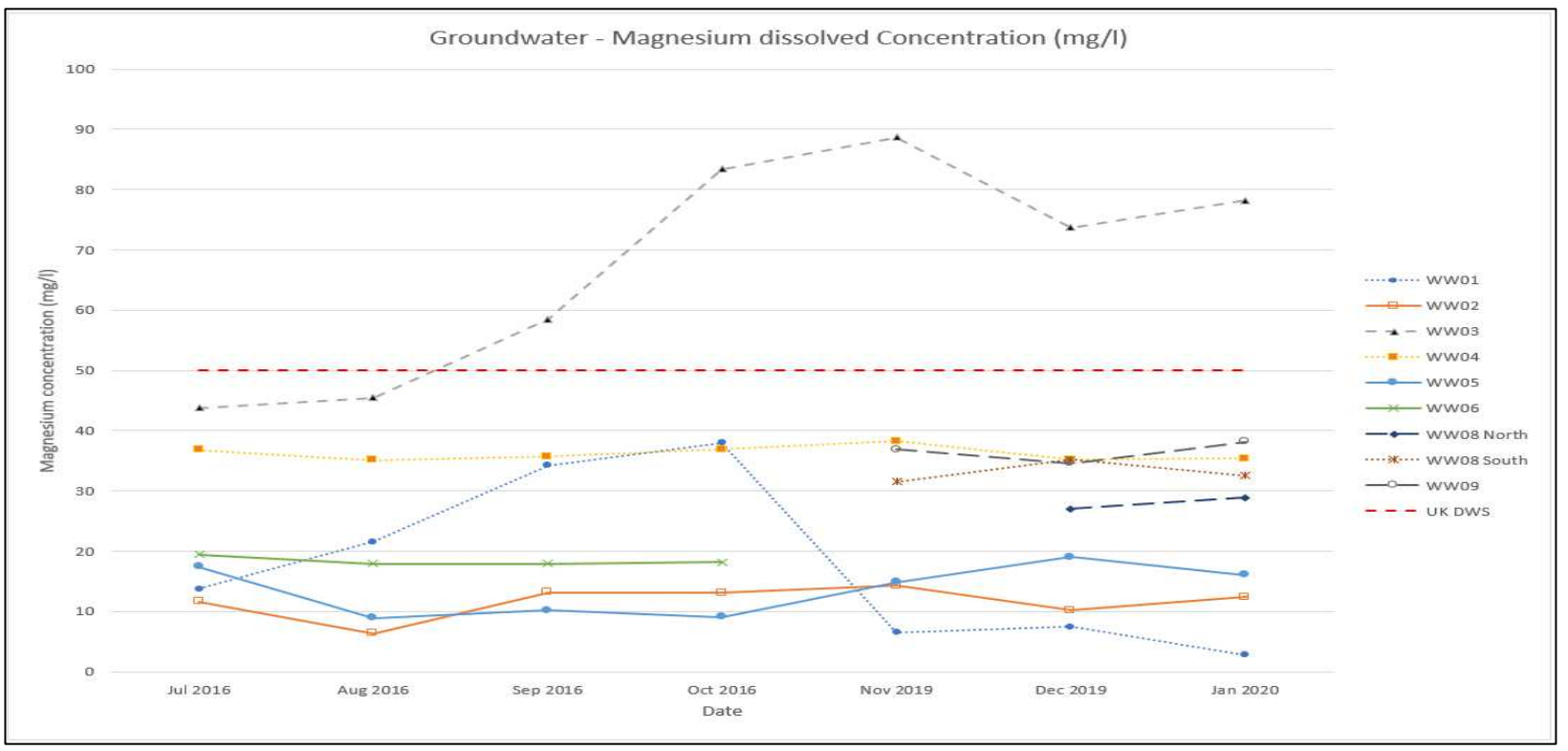
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
DO and EC - no DWS
Fluoride - 1.5mg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Dissolved Oxygen, Electrical Conductivity and Fluoride**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.5	AA	TM	Apr-20



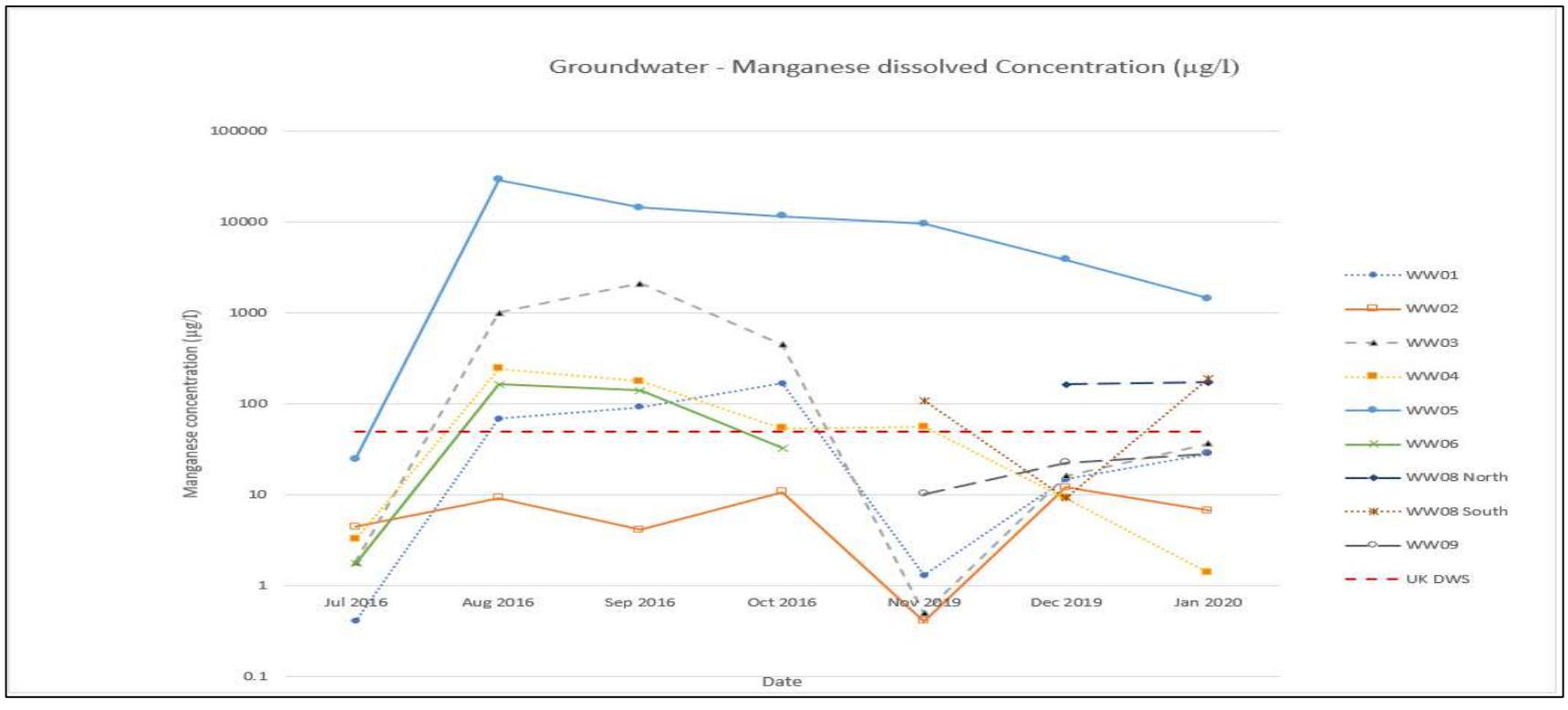


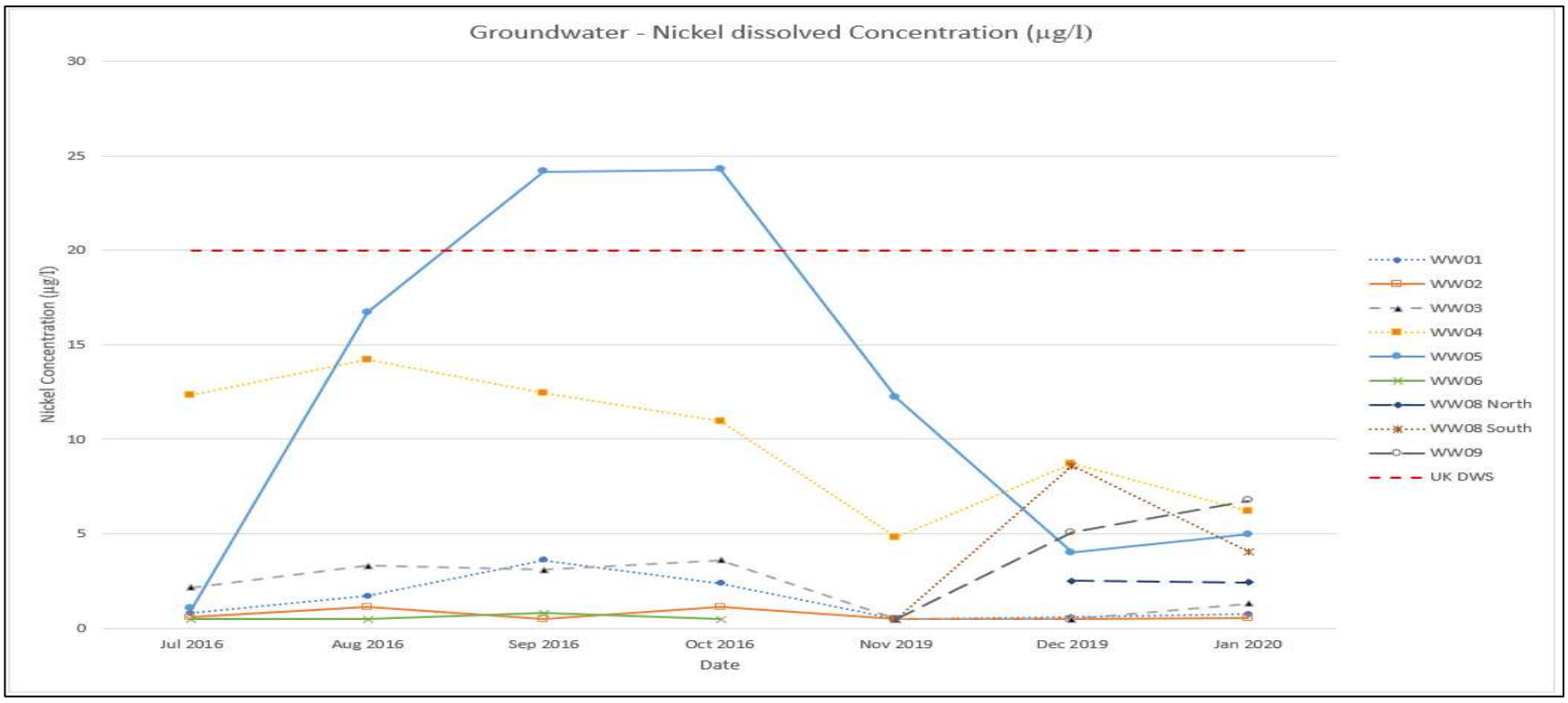


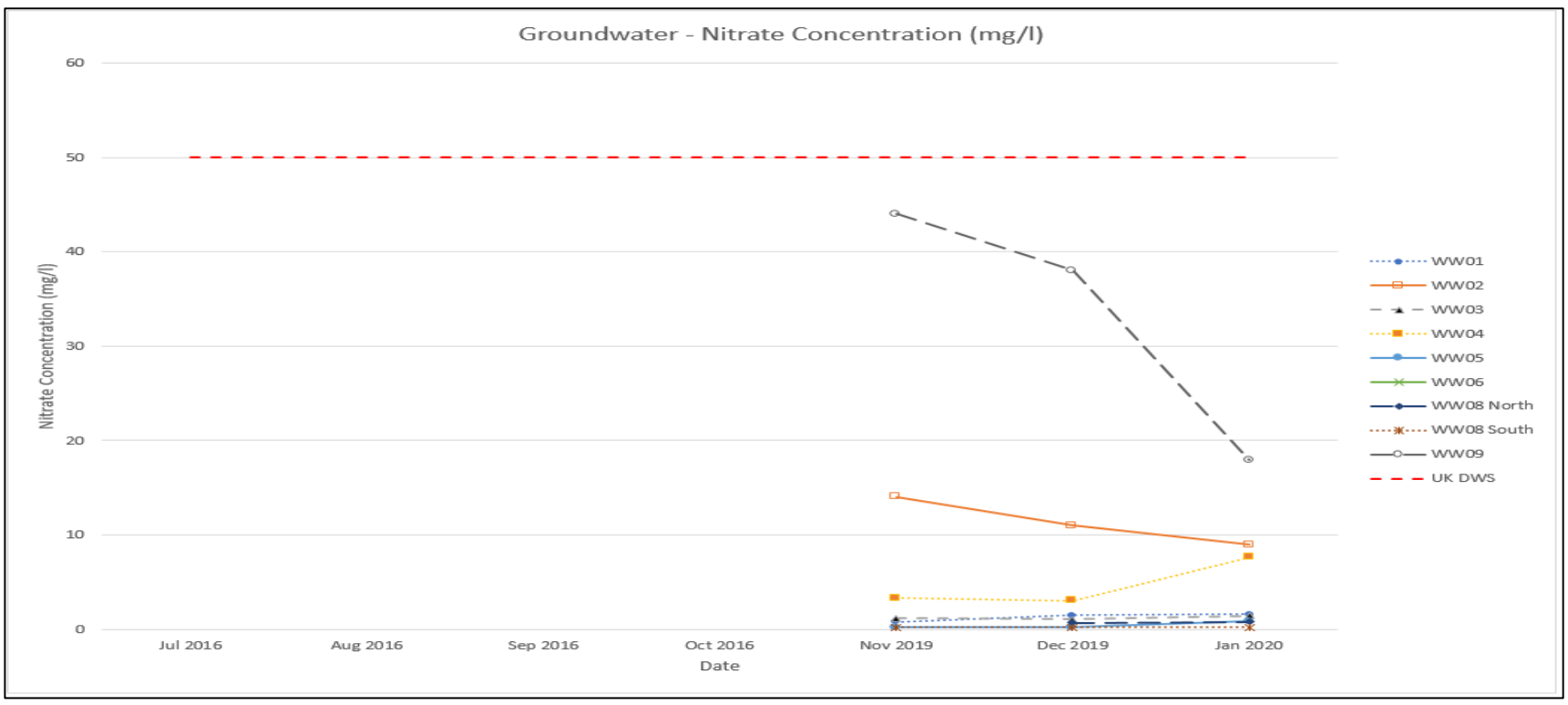
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Iron - 200µg/l
Lead - 10µg/l
Magnesium - 50mg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Iron, Lead and Magnesium Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.6	AA	TM	Apr-20



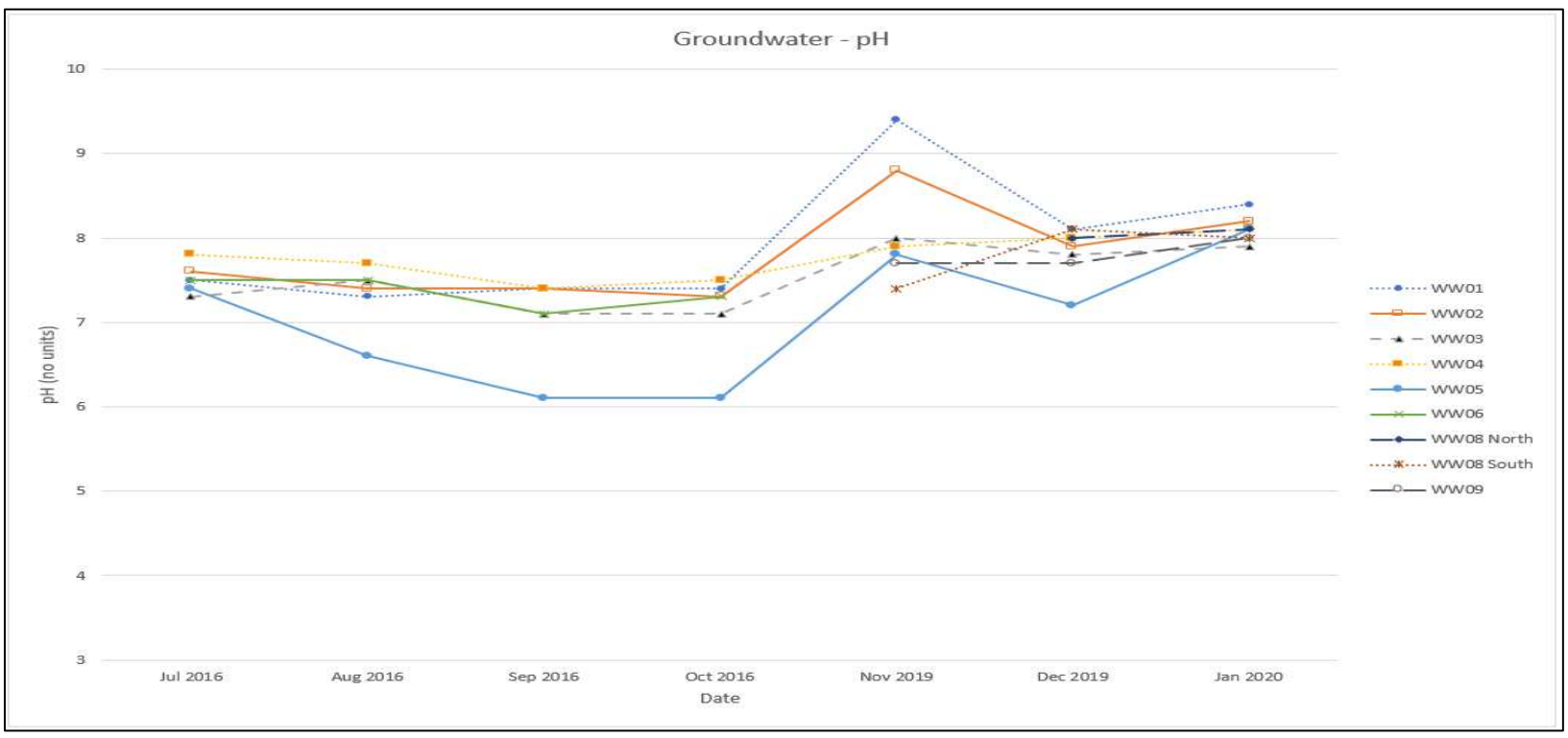


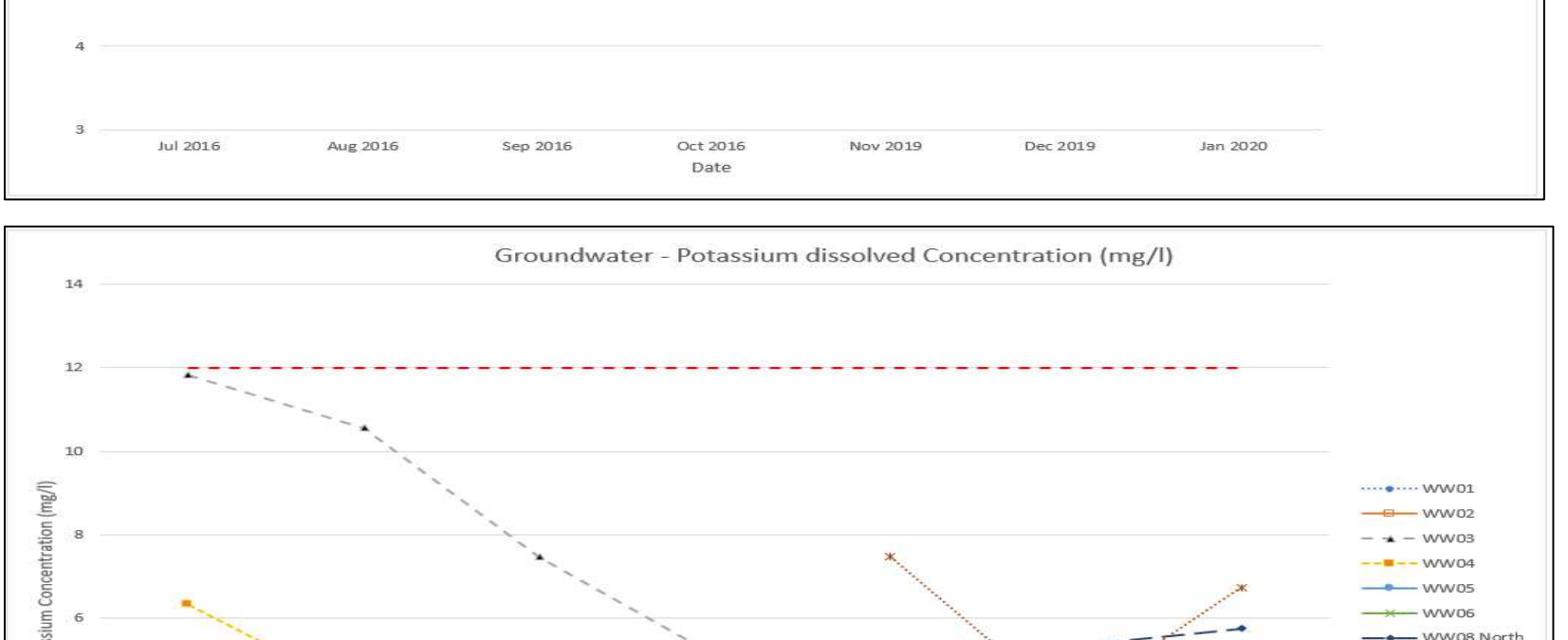


Notes:
Manganese graph is on a logarithmic scale as concentrations varied over several orders of magnitude.
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Manganese - 50µg/l
Nickel - 20µg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Manganese, Nickel and Nitrate Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.7	AA	TM	Apr-20

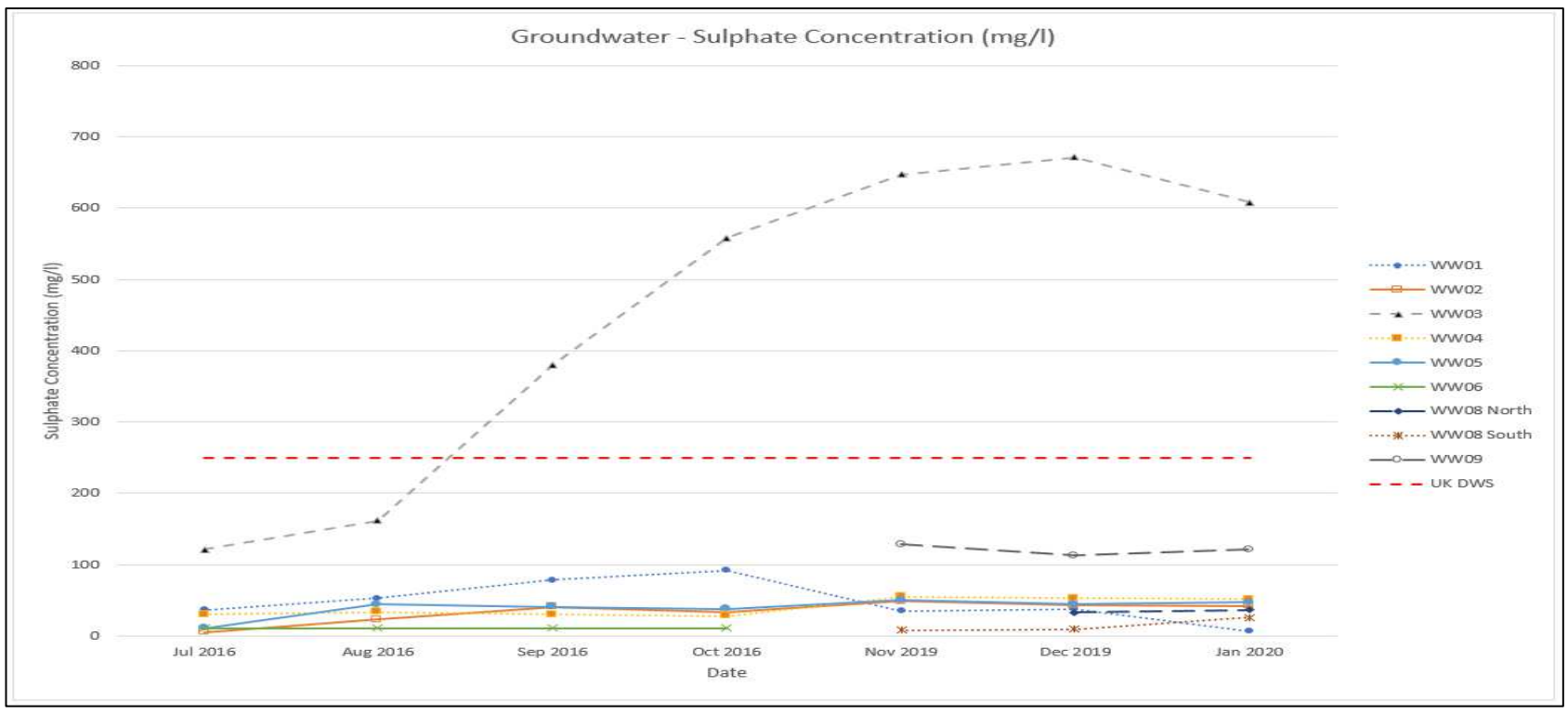


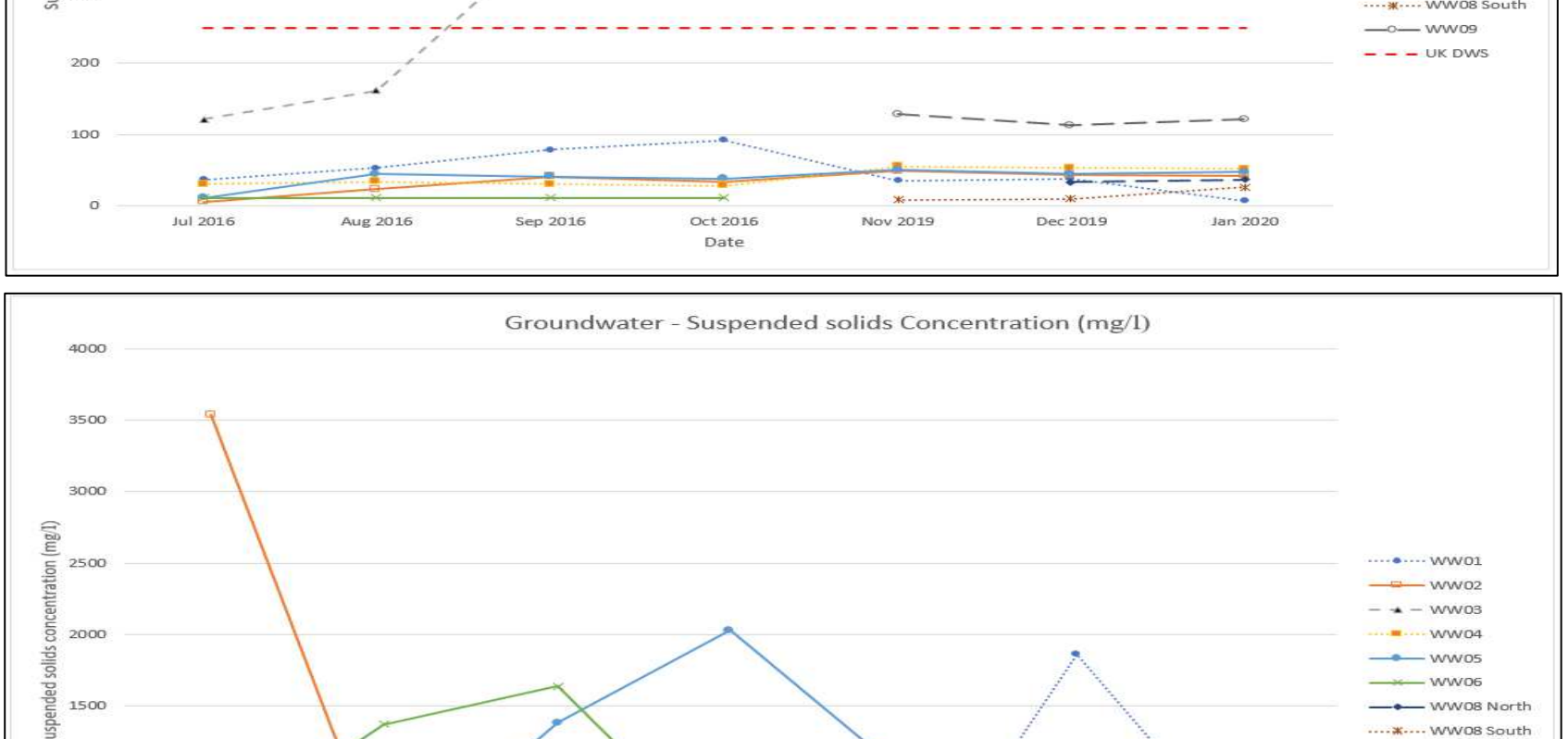


Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
pH - no DWS
Potassium - 12mg/l
Sodium - 200mg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater pH, Potassium and Sodium Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.8	AA	TM	Apr-20

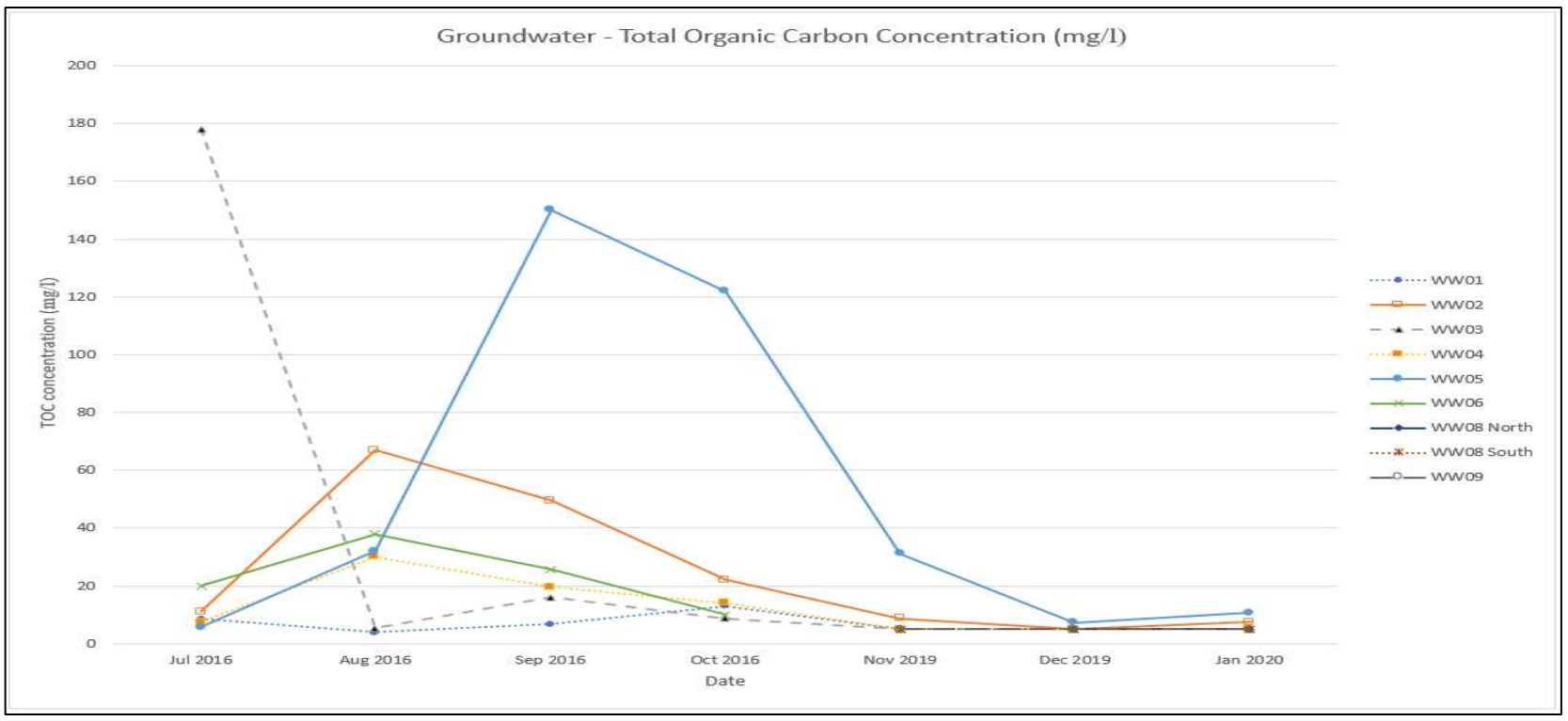


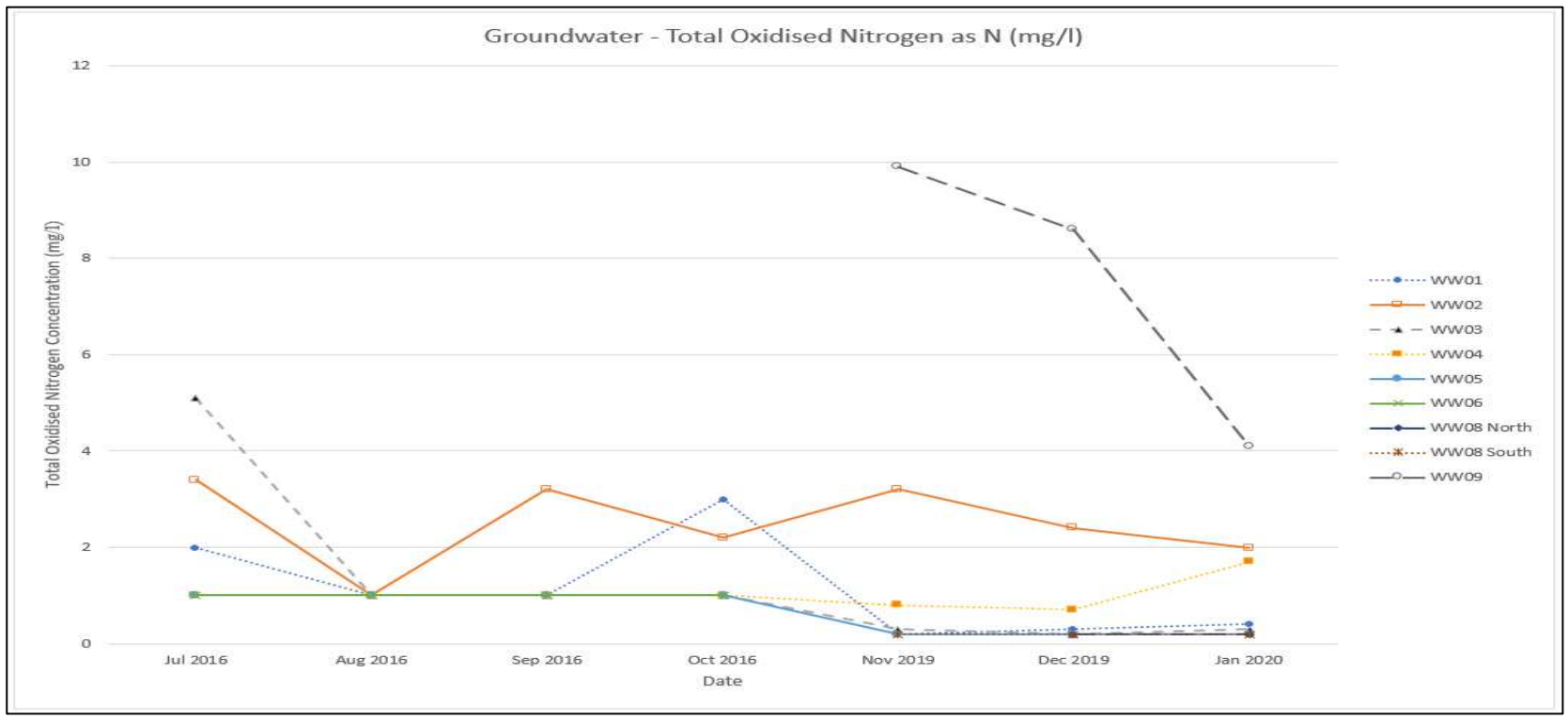


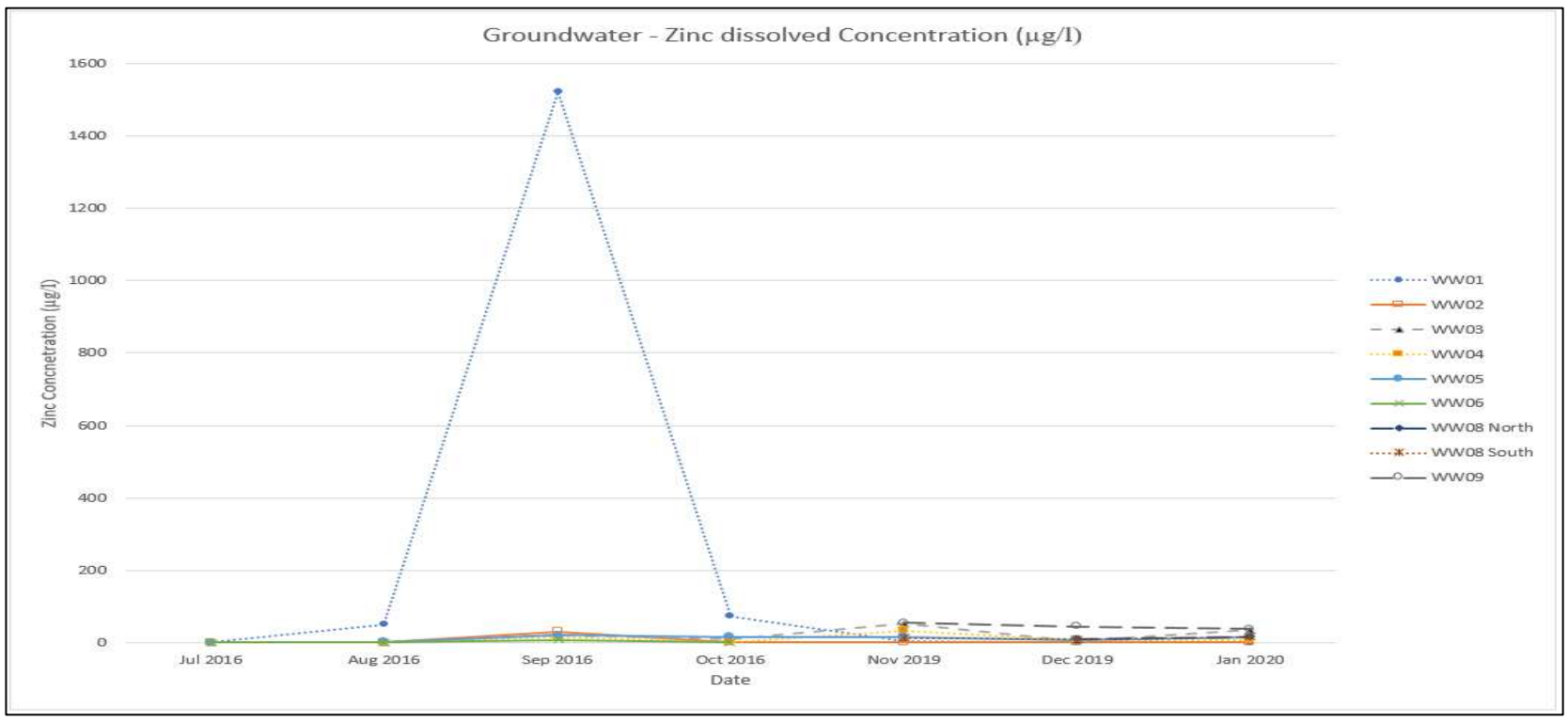
Notes:
2016, 2019 and 2020 data shown on the same graph.

UKDWS:
Sulphate - 250mg/l
SS and TDS - no DWS

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Sulphate, Suspended Solids and Total Dissolved Solids Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.9	AA	TM	Apr-20



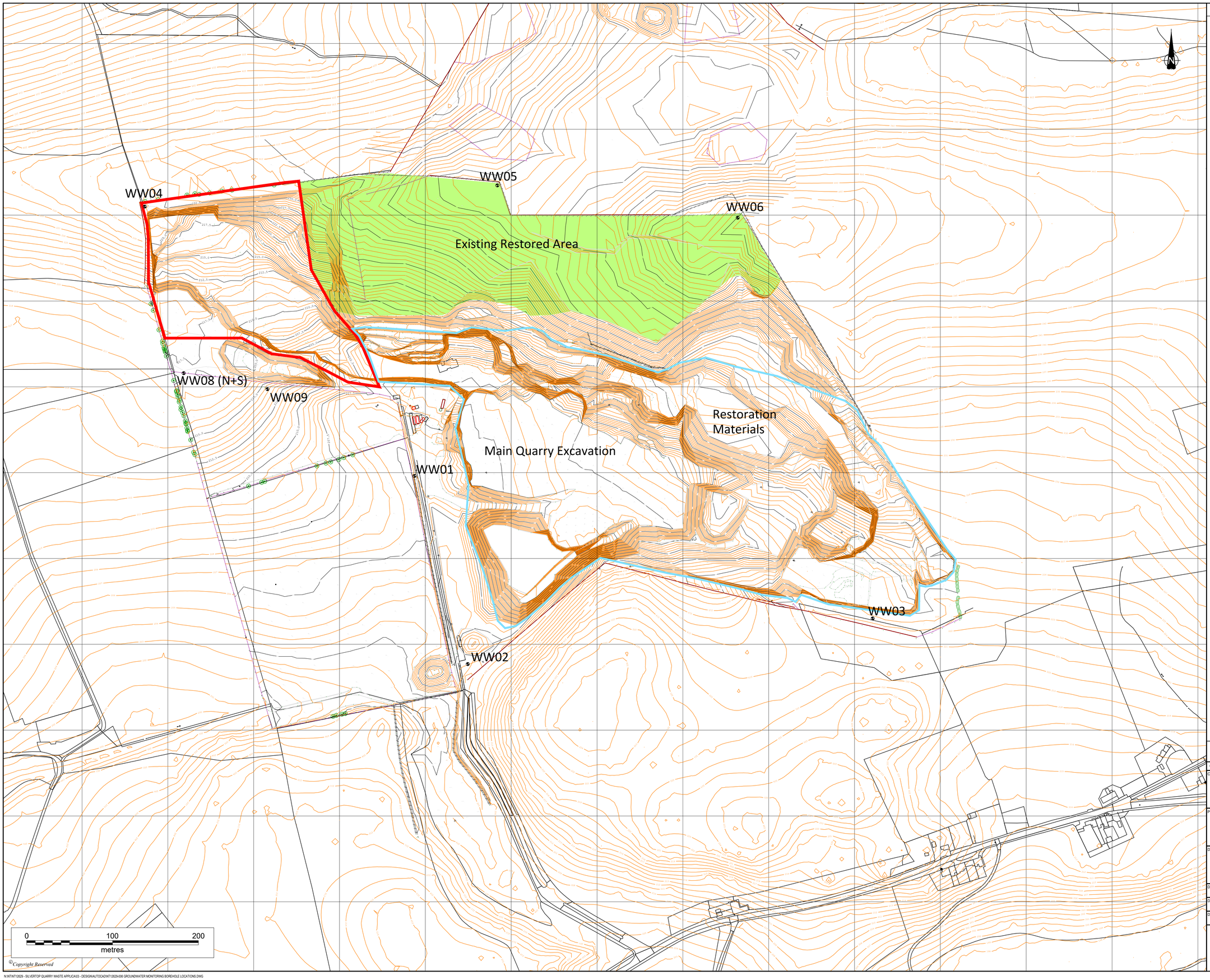




Notes:
2016, 2019 and 2020 data shown on the same graph.
UKDWS:
TOC and TON - no DWS
Zinc - 5000µg/l

CLIENT	Thompsons of Prudhoe		
PROJECT	Silvertop Quarry, Hallbankgate Application for an Environmental Permit		
FIGURE TITLE	**Groundwater Total Organic Carbon, Total Oxidised Nitrogen and Zinc Concentrations**		
FIGURE NO.	DRAWN BY	APPROVED BY	DATE
4.10	AA	TM	Apr-20

DRAWINGS



DO NOT SCALE FROM THIS DRAWING

KEY

- Waste Recovery Application Boundary
- Main Quarry Excavation
- WW01 Groundwater monitoring borehole

REVISION	DETAILS	DATE	DRAWN	CHKD	APPD

CLIENT

Thompsons of Prudhoe

PROJECT

Silvertop Quarry
West Excavation Area

DRAWING TITLE

Groundwater Monitoring Borehole Locations

ORG No.		REV
NT12629-006		-
ORG SIZE	SCALE	DATE
A1	1:2000@A1	March 2020
DRAWN BY	CHECKED BY	APPROVED BY
PAG	MG	MG

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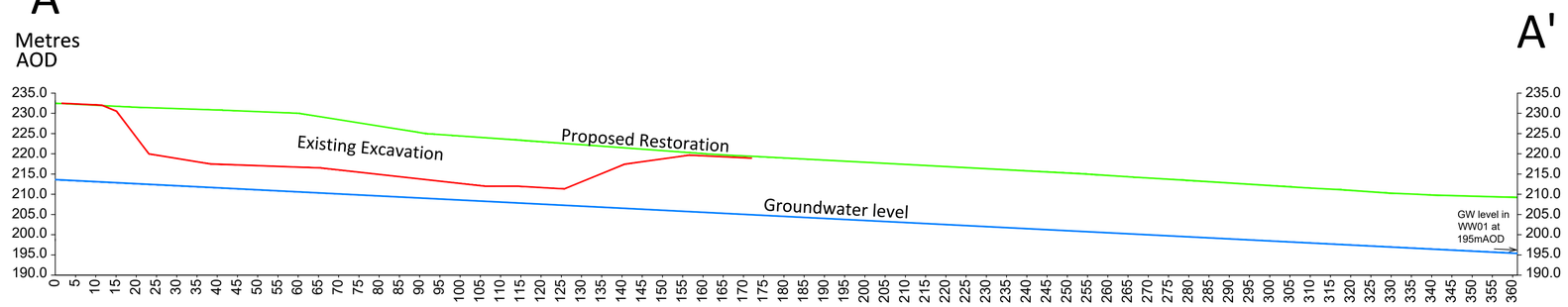
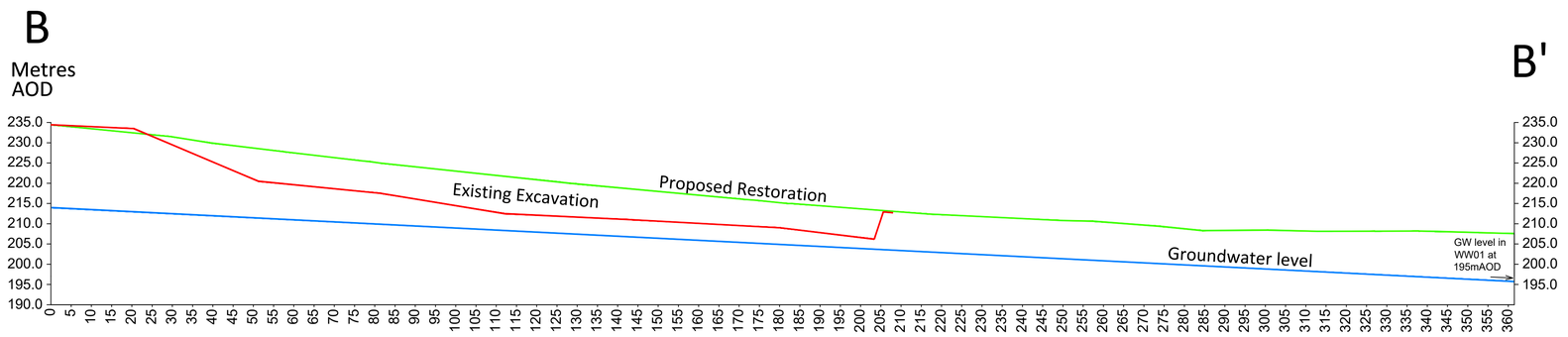
N:\NT\NT12629 - SILVERTOP QUARRY WASTE APPLICA\03 - DESIGN\AUTOCAD\NT12629-006 GROUNDWATER MONITORING BOREHOLE LOCATIONS.DWG

Cross Sections A and B
Scale @ 1:750

A



B



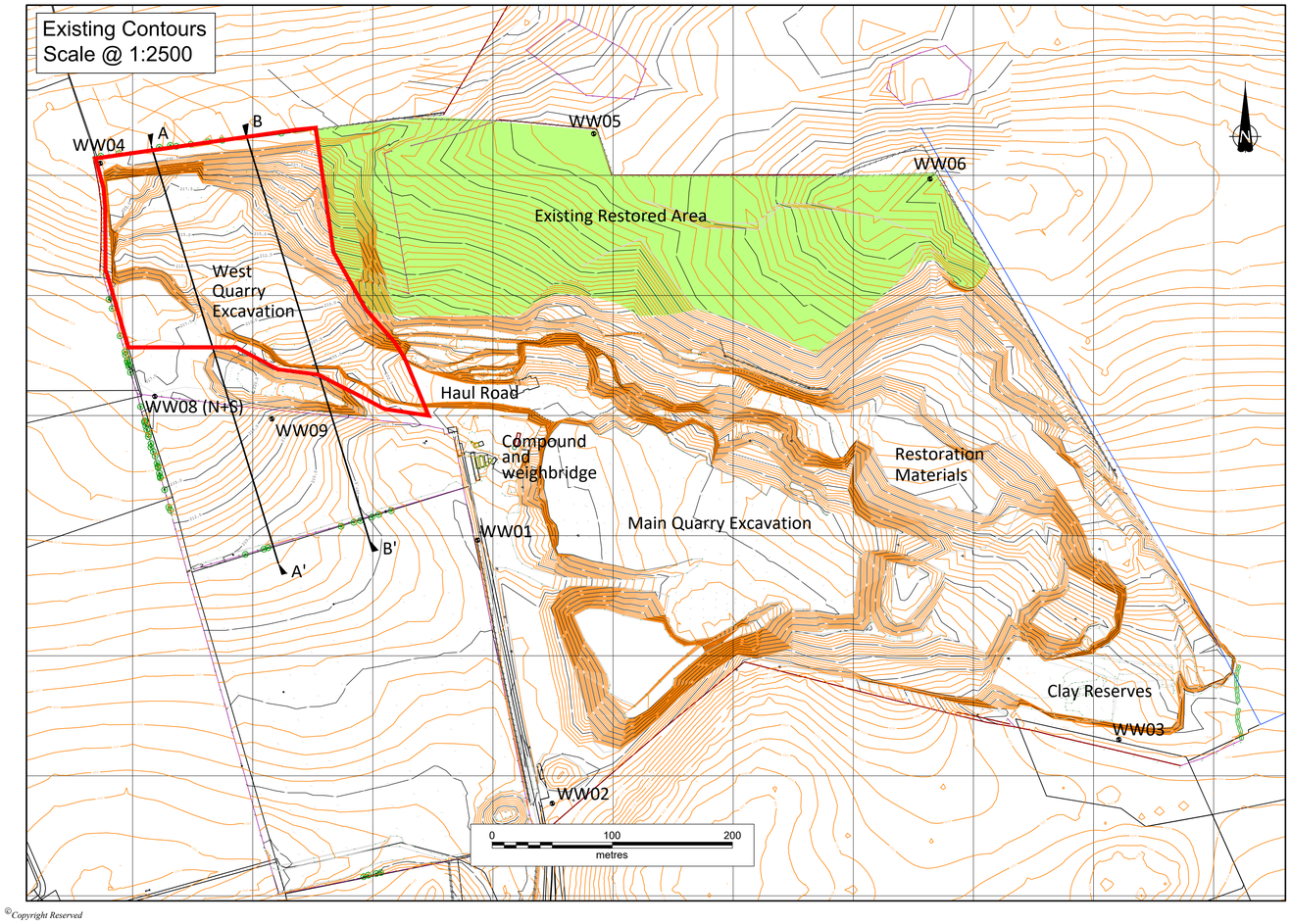
DO NOT SCALE FROM THIS DRAWING

KEY

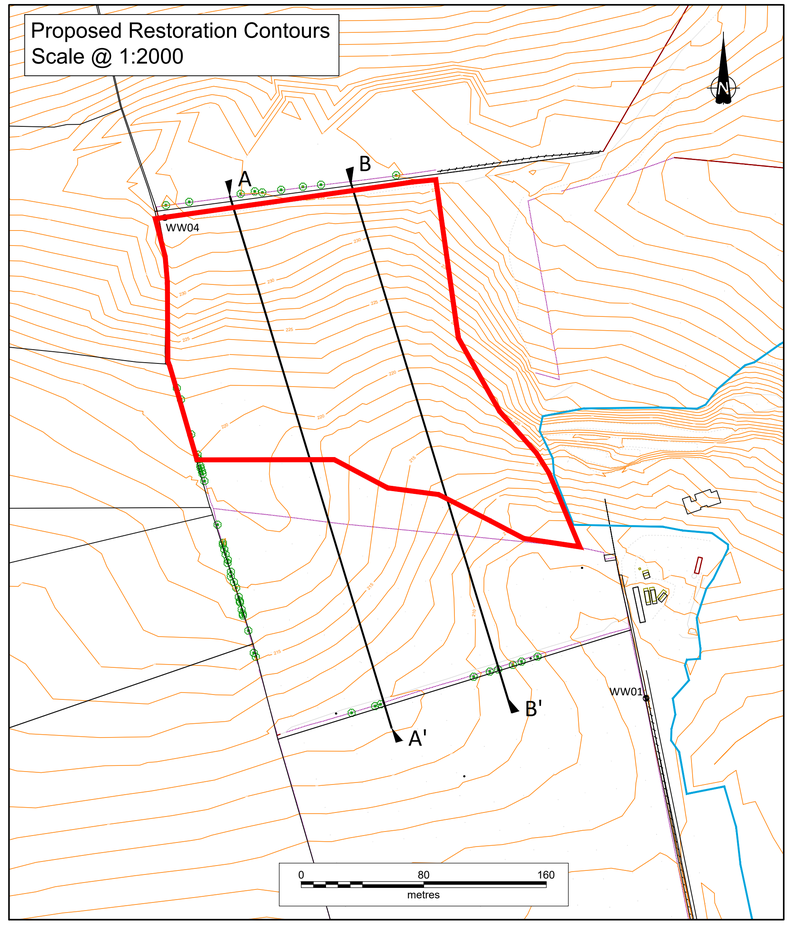
West Excavation Site Boundary (Application Boundary)

WW01 Groundwater monitoring borehole

Existing Contours
Scale @ 1:2500



Proposed Restoration Contours
Scale @ 1:2000



REVISION	DETAILS	DATE	DRAWN	CHKD	APPD

CLIENT: Thompsons of Prudhoe

PROJECT: Silvertop Quarry
West Excavation Area

DRAWING TITLE: Waste Recovery Permit
Application Area

DRG No.		REV
NT12629-012		-
DRG SIZE: A1	SCALE: As Shown	DATE: Jan 2019
DRAWN BY: PAG	CHECKED BY: MG	APPROVED BY: MG

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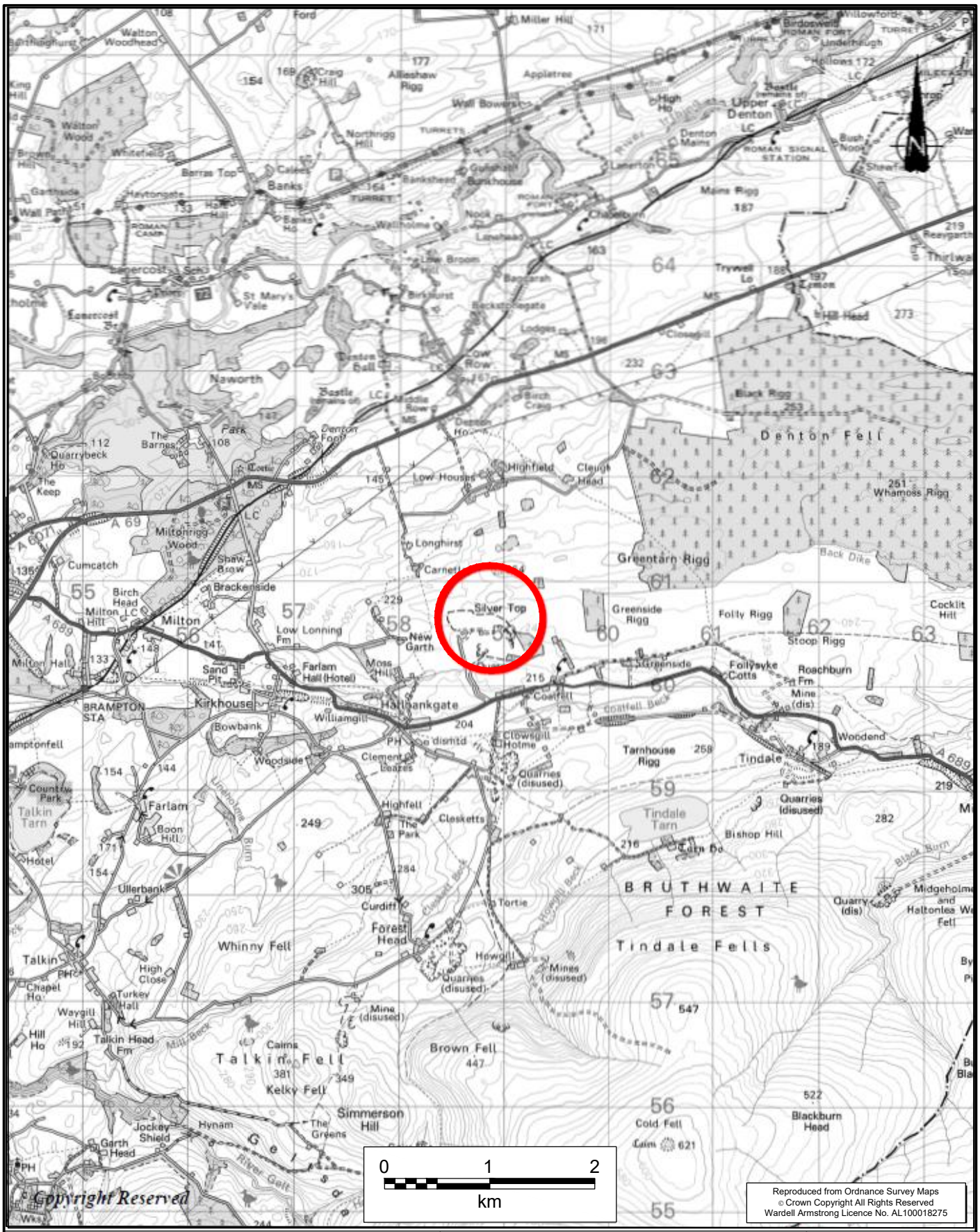
N:\NT\NT12629 - SILVERTOP QUARRY WASTE APPLICA\03 - DESIGN\AUTOCAD\NT12629-012 WEST EXCAVATION WASTE RECOVERY PERMIT APPLICATION AREA.DWG



CLIENT: Thompsons of Prudhoe	DRG No.: NT12629-013		REV: -
PROJECT: Silvertop Quarry	SIZE: A4	SCALE: 1:50,000	DATE: Jan 2019
	DRAWN BY: PAG	CHECKED BY: MG	APPROVED BY: MG
DRAWING TITLE: Site Location Plan			

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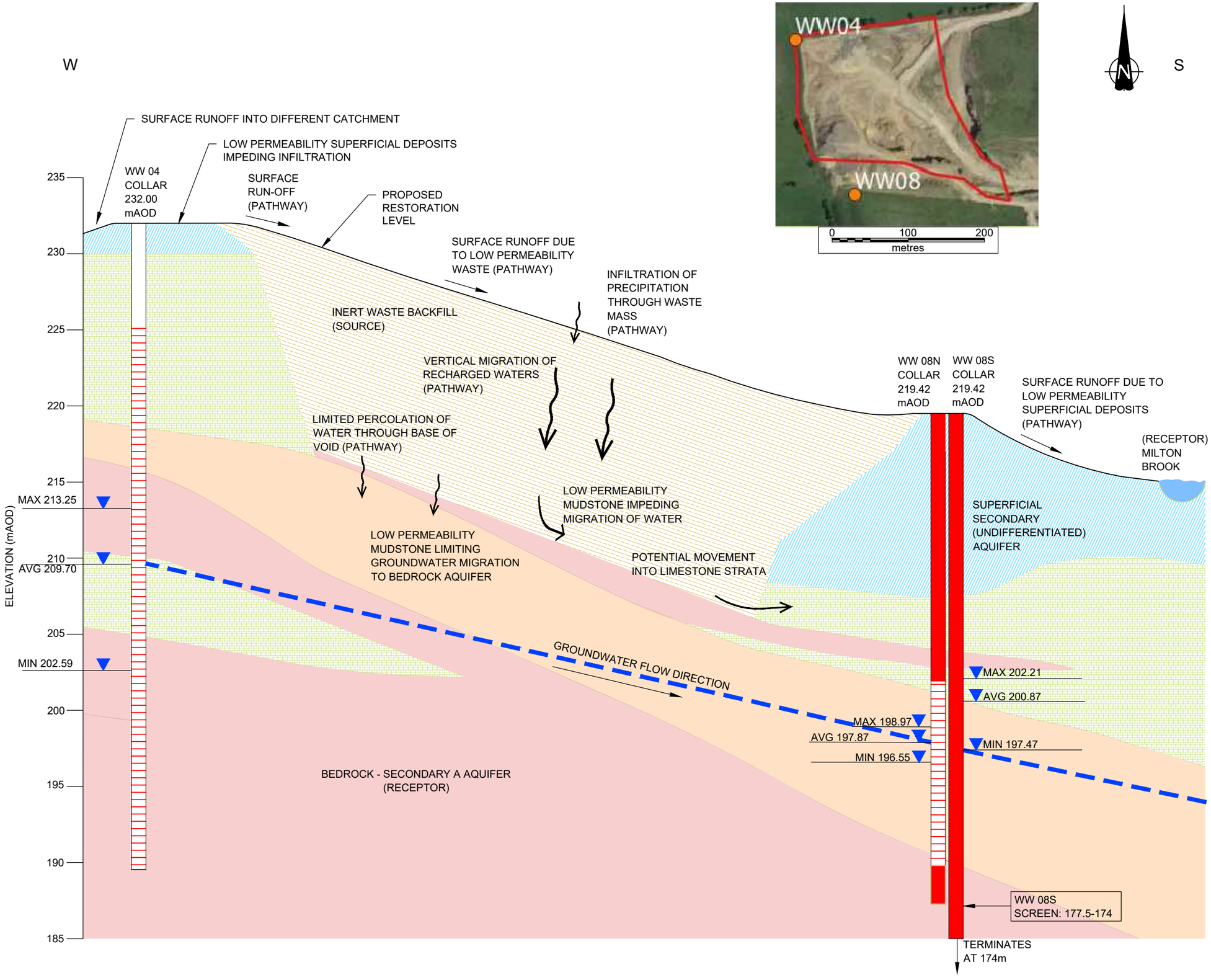
N:\NT\NT12629 - SILVERTOP QUARRY WASTE APPLICA\03 - DESIGN\AUTOCAD\NT12629-013 SITE LOCATION PLAN.DWG



DO NOT SCALE FROM THIS DRAWING

KEY

- GROUND WATER ELEVATION
- GLACIAL TILL
- LIMESTONE
- MUDSTONE WITH BANDS OF SANDSTONE
- SANDSTONE WITH BANDS OF MUDSTONE
- BACKFILL (OVERBURDEN AND INERT WASTE)

BOREHOLES AND TRIAL PITS

- BENTONITE PLUG
- SCREENED SECTION

NOTE

MAX, AVG, MIN WATER ELEVATIONS BASED ON DIP DATA FROM 29/05/2019 TO 09/01/2020

REVISION	DETAILS	DATE	DR'N	CHK'D	APP'D
A	FIRST ISSUE	24-03-20	DR	AA	LB

CLIENT

Thompsons of Prudhoe

PROJECT

Silver Top Quarry,
Hallbankgate
Hydrogeological Risk Assessment

DRAWING TITLE

Conceptual Site Model
for Waste Recovery Permit

DRG No.	REV
NT12629-024	A

DRG SIZE	SCALE	DATE
A3	NTS	24-09-19

DRAWN BY	CHECKED BY	APPROVED BY
DR	AA	LB

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