8.0 WATER ENVIRONMENT AND FLOOD RISK

The following Technical Appendices referred to in this chapter can be found at Appendix 2 to this document:

Appendices

Appendix 2.1 - Borehole Logs

Appendix 2.2 - Flood risk assessment

Appendix 2.3 - Estimation of hydraulic conductivity from particle size data

Appendix 2.4 – Saturated Thickness Chart

Appendix 2.5 – Ground Contamination Report

List of Figures, Tables and Drawings in the Chapter

Figures

Tables

Drawings (accompanying application)

8.1 Introduction

8.1.1 This chapter of the Environmental Statement has been prepared by Stantec UK Ltd. (Stantec) and considers the potential hydrological and hydrogeological impacts associated with the proposed excavation of sand and gravel, together with progressive restoration of the site using existing overburden and imported inert restoration materials.

8.1.2 Where relevant, mitigation measures are proposed to minimise the impacts of the proposed development during both the preparation, operational and restoration phases of the scheme. Any anticipated residual effects of the proposals are then stated.

8.1.3 In accordance with the requirements of the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021) a flood risk assessment (FRA) (Stantec, 2021) is also presented as Appendix 2.2 to this chapter.

8.1.4 This study follows the guidelines set out in the Environmental Impact Assessment Handbook (Carroll & Turpin, 2009) and the requirements of the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 (as amended).

8.1.5 The study draws on site specific data and information that is either readily available or has been provided by the operator, CEMEX UK Materials Ltd (CEMEX).

8.2 Study Area

8.2.1 The Site is located at the northern end of Hamble le Rice, Hampshire. It covers an area of approximately 60 ha, and it is situated east of Hamble Lane, west of Satchell Lane and to the south of the Portsmouth to Southampton railway. The Site consists of relatively flat lowland scrub and grassland and is in private ownership with no formal public access or rights of way. The Site is a former grassland airfield.

8.2.2 The Site location can be seen on Drawing Number P2/1717/1 and the proposed Site layout is shown on the plans submitted with the application.

8.3 Methodology

Previous Assessment Stages

8.3.1 This is the first known hydrogeological impact assessment (HIA) produced for this area.

Legislation and Planning Policy

National Planning Policy Framework, 2021

8.3.2 The NPPF sets out the Government's national planning policies including those on meeting the challenge of climate change, flooding and coastal change and the conservation and enhancement of the natural environment.

8.3.3 The NPPF states that local planning authorities should adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk.

8.3.4 The NPPF requires that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. Local Plans should be supported by Strategic Flood Risk Assessment and develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as lead local flood authorities and internal drainage boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change.

8.3.5 When determining planning applications, local planning authorities should ensure flood risk is not increased elsewhere.

8.3.6 The NPPF states that the planning system should contribute to, and enhance, the natural and local environment by;

- protecting and enhancing valued landscapes, geological conservation interests and soils;
- preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability; and
- remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

8.3.7 It is also noted that when determining planning applications, local planning authorities should aim to conserve and enhance biodiversity by applying adequate mitigation and as a last resort, compensation. Developments should not be permitted which may have an adverse effect on Sites of Special Scientific Interest, unless there are overriding benefits to the development.

8.3.8 This chapter has also been written with reference to Hampshire Minerals & Waste Plan (HMWP) adopted on 15 October 2013.

8.3.9 The relevant policies with regard to hydrogeology and hydrology are Policy 2 (Climate change – mitigation and adaptation) which states that minerals and waste development should minimise their impact on the causes of climate change and should be resilient to climate change impacts, including by avoiding areas of vulnerability to climate change and flood risk or otherwise incorporate adaptation measures.

8.3.10 Policy 11 (Flood risk and prevention) states that minerals and waste development in areas at risk of flooding should not result in an increased flood risk elsewhere and where possible should reduce flood risk overall; should incorporate flood protection, flood resilience and resistance measures; include suitable site drainage systems and SuDS if appropriate and not increase net surface water run-off.

Assessment Methodology

8.3.11 Assessment of effects has been carried out through the consideration of baseline conditions in relation to the elements of the scheme that could cause hydrological, hydrogeological and / or flood risk effects.

8.3.12 The assessment of effects is carried out in accordance with the methodology detailed below.

Receptor Sensitivity

8.3.13 The sensitivity of a receptor refers to its importance, i.e. its environmental value/attributes. This may include a feature's level of statutory designation, such as whether an aquifer is designated as a principal or secondary aquifer.

8.3.14 The sensitivity of receptors is based on the relative importance of the receptor using the scale in Table 8.1.

Table 8.1 Sensitivity of Receptors

Sensitivity	Example
Very High	SSSI or Aquatic Natura 2000 site; Wetland watercourse habitat of particular ecological importance; Highly vulnerable groundwater such as a principal aquifer;
High	Wetland watercourse habitat of lesser ecological importance; Highly vulnerable groundwater such as a secondary aquifer; Significant peat deposits.
Medium	Wetland watercourse habitat; Moderately vulnerable groundwater.
Low	Low vulnerability groundwater; Superficial peat deposits.
Not Sensitive	No aquatic habitats or watercourses present; No significant groundwater present.

Impact Magnitude

8.3.15 Impact magnitude is determined by predicting the scale of any potential change in the baseline conditions. Where possible, magnitude is quantified; however, where this is not possible a fully defined qualitative assessment has been undertaken. The assessment of magnitude is carried out considering any ‘design/embedded mitigation’, i.e. relevant design features, in the proposal forming part of the development description. This may result in the need for ‘additional mitigation’ i.e. that which results from the EIA process, to reduce impacts further. Therefore, the magnitude of impacts both before and after ‘additional mitigation’ are considered.

8.3.16 Magnitude is assigned to the identified receptors as detailed in Table 8.2.

Table 8.2 Magnitude of Impacts

Sensitivity	Example
Substantial	Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be fundamentally and irreversibly changed, e.g. watercourse realignment
Moderate	Total loss of, or alteration to, key features of the baseline resource such that post-development characteristics or quality would be partially changed, e.g. in-stream permanent bridge works
Slight	Small changes to the baseline resource which are detectable but the underlying characteristics or quality of the baseline situation would be similar to pre-development conditions, e.g. culverting of very small watercourses
Negligible	A very slight change from baseline conditions, which is barely distinguishable and approximates to the ‘no change’ situation, e.g. short-term compaction from plant movements

Determining Significance and Nature of Effects

8.3.17 The significance of effect is determined by combining the magnitude of impact with the sensitivity of the receptor.

8.3.18 Each effect has a source originating from the development, a pathway and a receptor. Effects which operate this direct way are regarded as direct effects. Effects on other receptors via subsequent pathways are regarded as indirect effects.

8.3.19 Table 8.3 shows how the interaction of magnitude and sensitivity determine the significance of an environmental effect.

Table 8.3 Example Significance of Effects Matrix

		Magnitude of Impact			
		Substantial	**Moderate**	**Slight**	**Negligible**
Sensitivity	**Very High**	Major	Major	Major/Moderate	Neutral
	High	Major	Major/Moderate	Moderate/Minor	Neutral
	Medium	Major/Moderate	Moderate	Minor	Neutral
	Low	Moderate/Minor	Minor	Minor/Neutral	Neutral

EIA Assumption Limitations

8.3.20 The following key assumptions have been made in preparing the ES:

- All legislative requirements will be met;
- The pre-additional mitigation effects assessment reported within this Environmental Statement assumes the project will be undertaken in accordance with industry standard techniques and currently enforced mandatory minimum standards. CEMEX is an experienced and competent operator with a good track record of working such sites.
- The base assessment is reported on the design, construction, and operation of the development as provided within the description given in Chapter 2;

- The potential environmental effects of the development will continue to be controlled through adherence to the Site Environmental Management System.

8.4 Baseline Environment

Physiographic setting

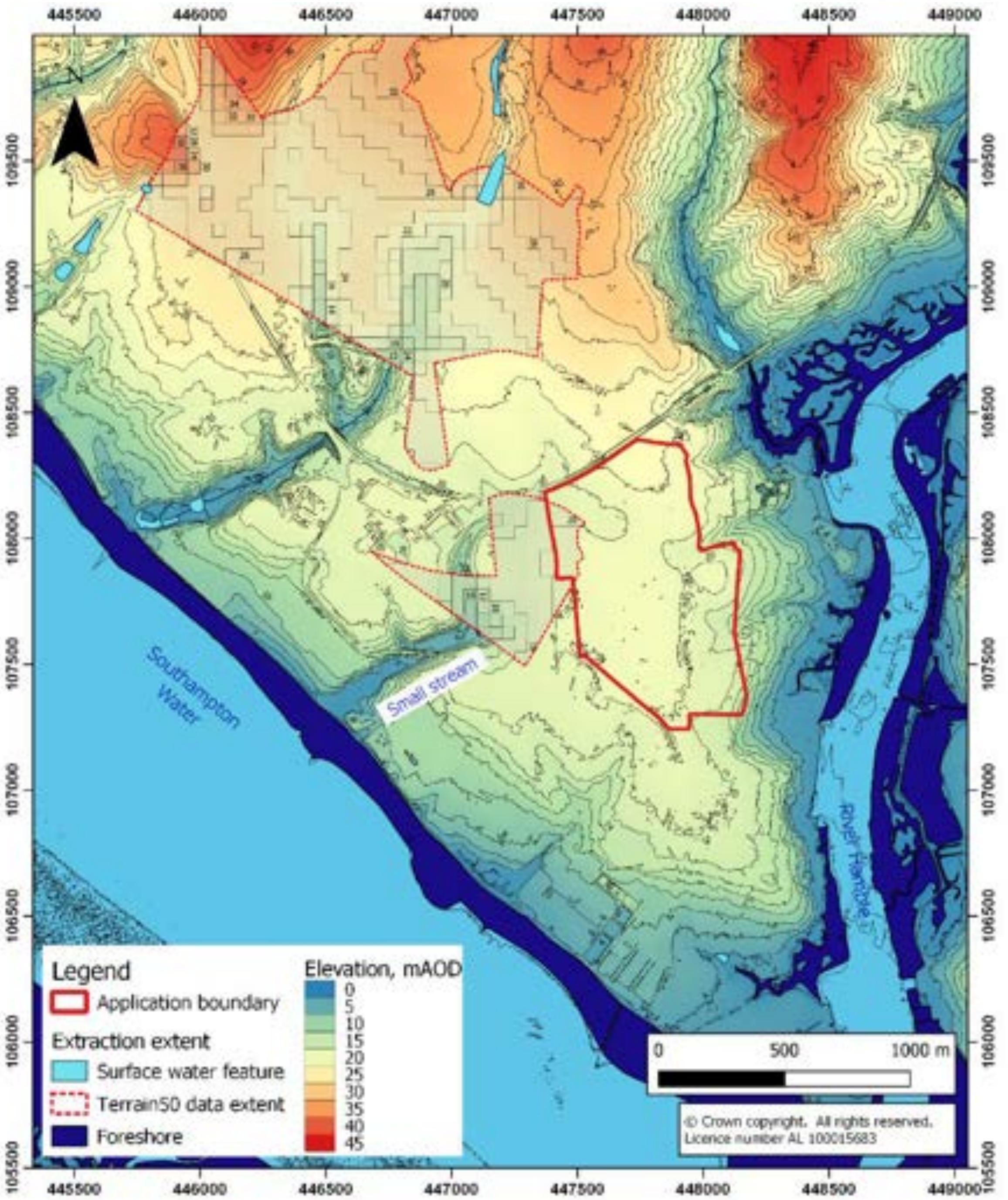
8.4.1 The Site is located to the north of the village of Hamble-le-Rice approximately 6 km southeast of Southampton on a peninsula between the River Hamble and Southampton Water, with the River Hamble lying some 300 m to the east. The villages of Butlocks Heath and Netley lie to the north-west of the Site and Hound, to the north. Hamble Station is located 20 m from the Site's northwest corner. The centre of the Site lies at approximate NGR: 447750, 107775.

8.4.2 The Site is predominately flat with a gradual fall towards the east and south. Beyond the Site boundaries the land falls more steeply towards the River Hamble in the southeast and Southampton Water and a small stream in the west and southwest. Figure 8.1 shows the topography of the Site as interpolated by LiDAR (Open data, 2018). Also shown are the surveyed ground levels for groundwater monitoring locations.

8.4.3 To the north-east of the site on the northern side of the railway lies the former Mallards Moor Sandpit, which was backfilled with inert material and is now closed. To the immediate north of the site on the northern side of the railway lies Hamble Community Sports College. There are residential properties adjoining the site to the east, south and west. These properties lie along either, on or off, the three main roads bordering the Site – Satchell Lane, Hamble Lane and the High Street.

8.4.4 The nearest residential properties to the boundary of the Site are those at the end of The Close, to the east of the side, Tutor Close and Astral Gardens to the southwest. A clubhouse and pitches immediately abut the Site to the south. On the western side of Hamble Lane, opposite the Site lies sports pitches and facilities used by the police and local community. Hamble Primary School also lies on the western side of Hamble Lane to the southwest of the Site. Along the River Hamble lie a series of boat yards and associated activities. Hamble Oil Refinery lies c700 m south of the Site, on the edge of Southampton Water. An Esso pipeline runs along the eastern boundary and southern boundary of the Site.

Figure 8.1 Site topography



Regional Geology

8.4.5 The geology of the Site and its surrounding area is shown in the 1:50,000 scale geological map 315 (BGS, 1987a) as presented on Figure 8.2 (solid geology) and Figure 8.3 (superficial geology). A summary of the geology as taken from this and on-Site sources, is summarised in Table 8.4. The following description of the formations is taken from the Geological Memoir (BGS, 1987b).

8.4.6 The superficial geology comprises River Terrace Deposits (RTD) (3rd Terrace) which are around 4.7 m thick on average. The memoir describes it as comprising ‘dominantly of gravels made up of subangular to subrounded flints’ and a ‘considerable amount of sand-grade components’ with an ‘appreciable amount of clay content’. It also describes the RTD as being overlain by ‘poorly sorted clayey, sandy silts and silty clays’ with the deposits violently disrupted by cryoturbidation.

8.4.7 Tidal flat deposits are present along Southampton Water and the River Hamble and alluvial deposits are present along surface water channels, particularly to the west and north-west of the Site.

8.4.8 The solid geology at the Site comprises the Selsey Sand Formation (SSF), Marsh Farm Formation (MFF) and Earnley Sand Formation (ESF). These are underlain by clays from the Wittering Formation. These formations are within the Bracklesham Group. To the southwest, clays from the Barton Clay Formation are present.

8.4.9 According to Jones et al. (2000), the Bracklesham Group contains four major sedimentary cycles, named in ascending order the Wittering Formation (laminated and glauconitic sandy clays), ESF (bioturbated sandy marine clays), MFF (laminated clays) and SSF (fine-grained sand).

8.4.10 The ESF is described as mainly green bioturbated clayey, fine grained sand and sandy silt. Most of the sands are clayey, silty, fine grained to very fine-grained quartz sand. They are moderately to poorly sorted, particularly near the top of the sequence.

8.4.11 The MFF is described in the memoir as containing two main lithologies;

- variably carbonaceous laminated clays with laminae and thin beds of fine-grained to very fine-grained sand and silt; and
- fine-grained to locally coarse-grained glauconitic sand with a variable number of clay beds and laminae.

8.4.12 Different sections show considerable variation in the proportions of the sand-dominant and clay-dominant facies. The base of the formation is usually well defined; laminated clay or fine-grained, sparsely glauconitic sand rests with marked lithological contrast on the highly glauconitic ESF.

8.4.13 The MFF is estimated to be between 18 to 25 m thick in the Southampton district. It is said to contain rapid lateral and vertical variations in sand and clay proportions, varying within tens of metres. Changes can be gradual as well as sharp. At sharp changes the sand can be channelled into the clay. In the Southampton Dock area, the lithology tends to be more clay dominant.

8.4.14 Laminations in the clays are typically 1 to 3 mm thick with the silt or sand partings commonly only one or two grains thick. The lamination is commonly lenticular; the lenticles vary from <1 cm to several centimetres on length and from <1 mm to several millimetres in thickness. Where a lenticle pinches out a silt or sand parting usually continues.

Table 8.4 Regional geology

Period	Group	Formation	Description	Thickness (m)
Quaternary and recent		Topsoil	Topsoil and clayey topsoil	0.2-1.6
		Alluvium	Clay, silt, sand and gravel found in river channels	~2-5
		Thames River Terrace Deposits	Orange brown gravelly sand	0.8-8.3
	Barton	Barton Clay	Olive grey and greenish grey shelly clays of varying sand content.	38 - 83
	Bracklesham	SSF	Silty sand, silty clay and sandy clayey silt, glauconitic, bioturbated, locally calcareous.	30-50
		MFF	Glauconitic silty sands and sandy silts.	18-25
Palaeogene		ESF		0-24
		Wittering Formation	Lignite and brown organic rich clays overlying seatearth clays with rootlets.	23-57
	London Clay	London Clay	Predominately silty sandy clay, clayey and sandy silt, and silty sand	53-114
		Reading Formation	Red mottled clays, sands and pebble beds.	15-32
Cretaceous		Upper Chalk	White to greyish white microcrystalline limestone with layers of nodular flints	258

8.4.15 The SSF consists dominantly of glauconitic, bioturbated, commonly shelly, sandy silt to silty fine-grained sand with a variable clay content. Greenish grey and olive-grey clays with a high silt and sand content also occur. Carbonate concretions are common at certain levels.

Figure 8.2: Superficial geology

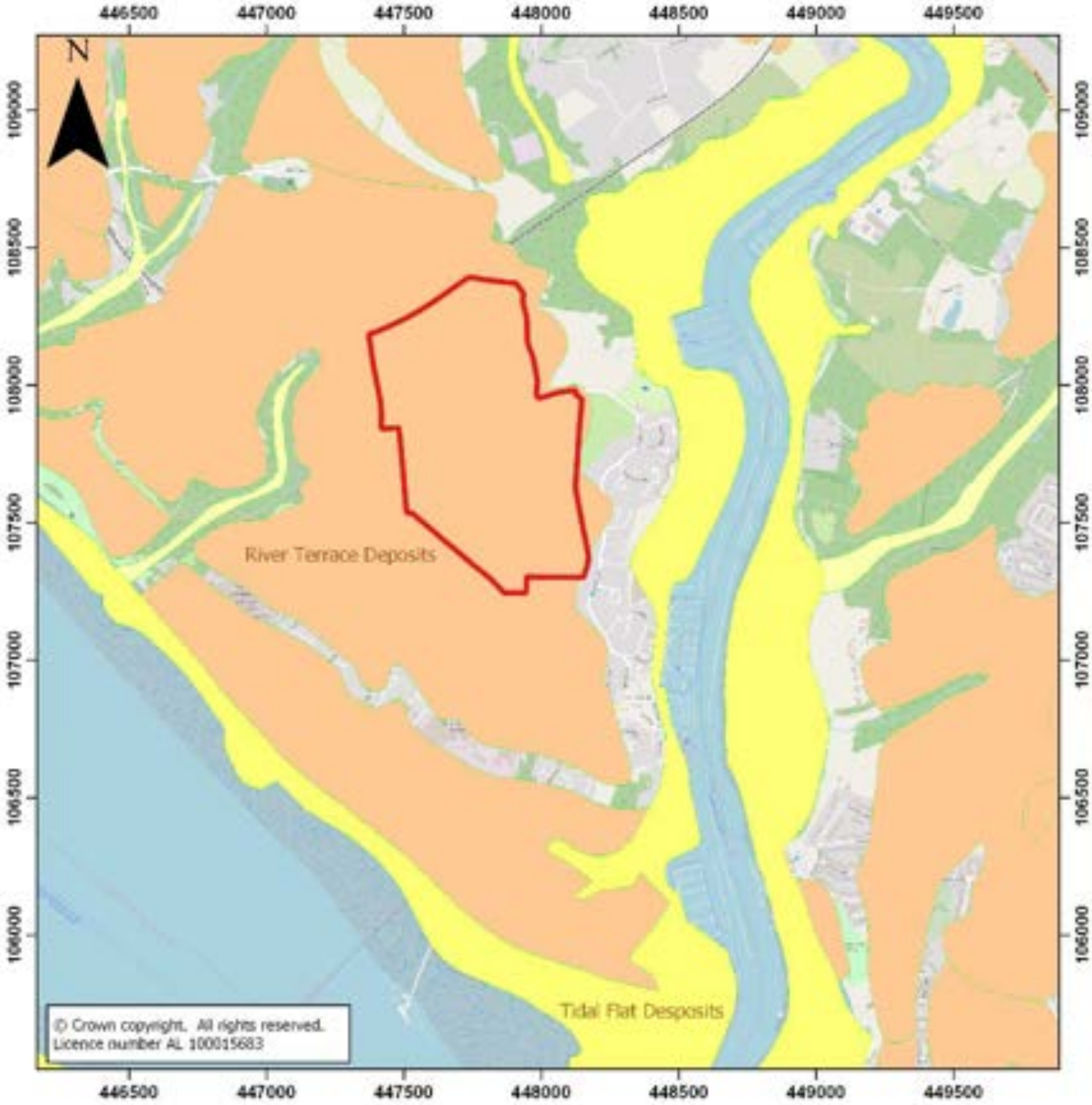
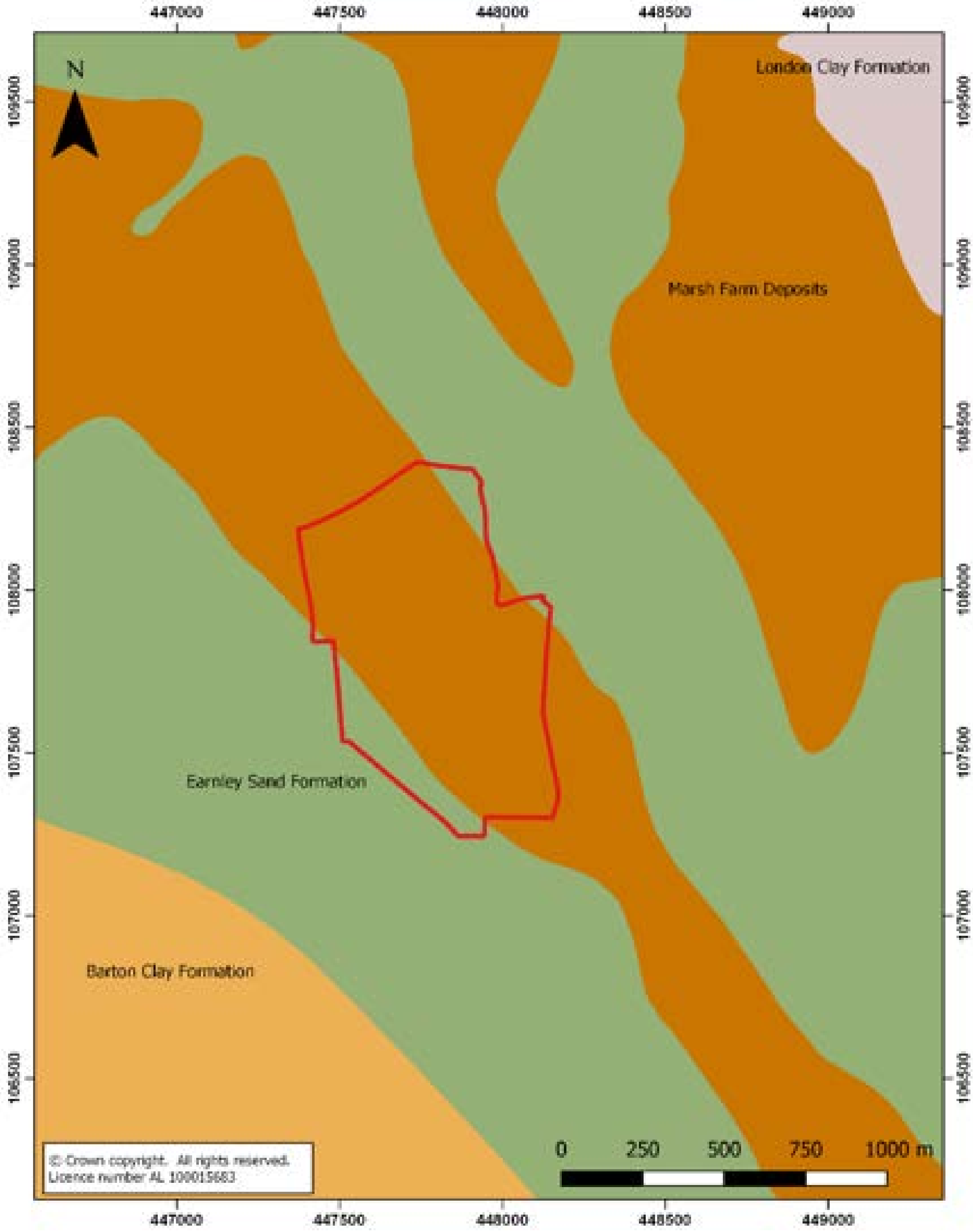


Figure 8.3 Bedrock geology



Local geology

Site investigations

8.4.16 Local geological information is available from a mineral reserve estimate carried out for the Site in 1995 when a total of 28 investigation boreholes were drilled. A further 12 and then 7 groundwater monitoring boreholes were installed around the Site perimeter in 2008 and 2011 respectively. The latter wells were installed to replace wells drilled in 2008 which had been lost. In 2018, the groundwater monitoring wells were remediated as many had been vandalised and 3 were replaced. At the same time 9 groundwater monitoring wells were installed into the underlying solid strata to monitor groundwater levels beneath the Site. A summary of all boreholes is provided in Table 8.5. In addition, 7 trial pits have been excavated. Lithological data for the trial pits are available, but not in digital format and have not been used for this study as none of the trial pits penetrated the base of the RTD.

8.4.17 The borehole locations are shown on Figure 8.4 and borehole logs are included in Appendix 2.1. Cross sections are presented on Figure 8.5 to Figure 8.7.

Table 8.5 Borehole summary

Date Drilled	Location	Easting (m)	Northing (m)	Surface Elevation (mAOD)	Base of borehole (mBGL)	Overburden Thickness (m)	RTD Thickness (m)	Top of Solid (mAOD)	Top of response zone (mAOD)[1]	Base of response zone (mAOD)[1]
1995	01/95	447816.87	108287.93	22.30	6.0	0.3	2.7	19.30	21.3	18.3
	02/95	447819.67	108097.48	21.10	5.0	0.6	1.6	18.90		
	03/95	447811.27	107900.02	20.90	7.5	0.6	6.4	13.90		
	04/95	447807.07	107694.15	21.20	7.0	0.6	5.9	14.70		
	05/95	447804.27	107503.70	20.90	7.5	0.6	5.9	14.40		
	06/95	447811.27	107324.44	20.00	7.5	0.6	6.4	13.00		
	07/95	447979.32	107324.44	18.50	5.0	0.6	3.9	14.00		
	08/95	448036.74	107394.46	18.90	6.0	0.6	4.4	13.90		
	09/95	447900.90	107404.27	19.90	6.0	0.6	4.4	14.90		
	10/95	447888.29	107614.33	20.20	6.0	0.6	3.9	15.70		
	11/95	447994.72	107503.70	18.80	6.0	0.6	3.9	14.30		
	12/95	448003.13	107702.56	18.10	6.0	0.6	2.9	14.60		
	13/95	447909.30	107793.58	20.00	4.0	0.6	2.9	16.50		
	14/95	447914.90	107984.04	19.60	6.0	0.3	2.7	16.60		
	15/95	447707.64	108181.50	21.20	5.0	0.6	3.3	17.30		
	16/95	447641.82	108250.12	21.70	5.0	0.6	0.9	20.20		
	17/95	447633.41	108131.09	19.90	6.0	0.6	3.9	15.40		
	18/95	447510.18	108129.69	19.30	6.0	0.6	3.4	15.30		

Date Drilled	Location	Easting (m)	Northing (m)	Surface Elevation (mAOD)	Base of borehole (mBGL)	Overburden Thickness (m)	RTD Thickness (m)	Top of Solid (mAOD)	Top of response zone (mAOD)[1]	Base of response zone (mAOD)[1]
	19/95	447528.38	108021.85	20.10	6.0	0.6	4.9	14.60		
	20/95	447629.21	107933.63	20.70	6.0	0.3	5.2	15.20		
	21/95	447699.23	107985.44	20.50	6.0	0.3	5.2	15.00		
	22/95	447618.01	107830.00	21.00	6.0	0.3	5.2	15.50		
	23/95	447619.41	107740.37	20.80	7.5	0.6	5.9	14.30		
	24/95	447511.58	107824.39	20.20	6.0	0.3	4.7	15.20		
	25/95	447519.98	107598.93	20.10	6.0	0.3	5.2	14.60		
	26/95	447692.23	107608.73	20.70	6.0	0.3	5.2	15.20		
	27/95	447618.01	107548.51	20.10	5.0	0.3	3.7	16.10		
	28/95	447688.03	107397.26	20.00	6.0	0.3	5.2	14.50		
2011	BH01	447425.00	108168.00	18.88	7.5	0.2	6.8	11.88	15.88	11.38
2011	BH01A	No survey data available			3.0	0.6	2.4			
2011	BH02	No survey data available			1.6					
2011	BH03	447879.00	108352.00	21.90	7.0	0.2	3.6	18.10	18.68	14.68
2011	BH04	447642.00	108300.00	22.40	6.0	1.0	4.5	16.90	18.58	16.08
2011	BH05	447504.00	107848.00	20.58	4.5	0.5	4.0	16.08	18.58	16.08
2011	BH06	447970.00	107921.00	19.40	3.0	1.3	1.7	16.40	17.79	16.29
2008	BH09	447843.00	107537.00	20.70	9.0	0.5	6.2	14.00	16.10	13.10
2008	BH10	448101.00	107650.00	16.60	5.6	0.5	5.0	11.10	13.44	10.44

Date Drilled	Location	Easting (m)	Northing (m)	Surface Elevation (mAOD)	Base of borehole (mBGL)	Overburden Thickness (m)	RTD Thickness (m)	Top of Solid (mAOD)	Top of response zone (mAOD)[1]	Base of response zone (mAOD)[1]
2011	BH11	No survey data available			5.0	1.6	2.9			
2008	BH12	447878.00	107309.00	20.60	8.0	0.9	5.4	14.30	17.20	14.20
2008	BHA/08	447420.42	108156.24	18.70	6.2	0.7	5.3	12.70		
	BHB/08	447639.22	108301.06	22.52	6.4	0.4	5.0	17.12		
	BHC/08	447873.19	108353.22	21.72	3.8	0.6	2.3	18.82		
	BHD/08	447673.80	108047.44	19.63	6.0	0.8	4.1	14.73		
	BHE/08	447511.00	107821.00	20.54	6.0	0.6	4.7	15.24		
	BHF/08	447967.79	107921.56	19.34	8.3	0.5	7.7	11.14		
	BHG/08	447730.70	107781.38	21.40	7.3	0.7	5.8	14.90		
	BHH/08	447582.12	107539.80	20.02	7.5	0.6	5.1	14.32		
	BHJ/08	448093.87	107650.23	16.23	5.6	0.5	5.0	10.73	13.73	10.73
	BHK/08	447876.69	107309.59	20.03	8.0	0.9	5.4	13.73	16.53	13.53
	BHL/08	448109.14	107324.77	16.40	1.4	0.6	0.8	-		
2018	WG02	447645.82	108293.54	22.44	6.7	0.6	5.6	16.24	20.74	15.74
	WG08	447589.13	107536.46	20.34	7.0	1.1	4.3	14.94	18.64	14.34
	WG11	448112.03	107321.30	16.33	4.5	0.7	3.3	12.33	14.63	11.83
	W01	447427.05	108160.76	18.80	12.5	1.5	5.5	11.80	11.3	6.3
	W02	447649.45	108297.56	22.44	10.7	0.6	5.4	16.44	15.74	11.74
	W03	447878.27	108351.57	21.61	8.7	0.6	2.0	19.01	17.91	12.91

Date Drilled	Location	Easting (m)	Northing (m)	Surface Elevation (mAOD)	Base of borehole (mBGL)	Overburden Thickness (m)	RTD Thickness (m)	Top of Solid (mAOD)	Top of response zone (mAOD)[1]	Base of response zone (mAOD)[1]
	W05	447509.19	107851.10	20.61	12.0	1.5	5.0	14.11	13.61	8.61
	W06	447972.26	107917.16	19.41	8.5	0.5	2.5	16.41	15.91	10.91
	W08	447588.11	107536.47	20.02	11.2	1.4	4.3	14.32	13.82	8.82
	W10	448087.49	107645.84	16.50	10.2	0.5	4.2	11.80	11.3	6.3
	W11	448106.55	107322.46	16.66	9.7	0.7	3.5	12.46	11.96	6.96
	W12	447876.81	107318.46	20.12	11.7	1.5	4.7	13.92	13.42	8.42

Note: mAOD (Metres Above Ordnance Datum), mBGL (Metres below Ground Level). Note 1 top and base of response zone given where well screen installed and data available

Figure 8.4 Borehole and trial pit locations

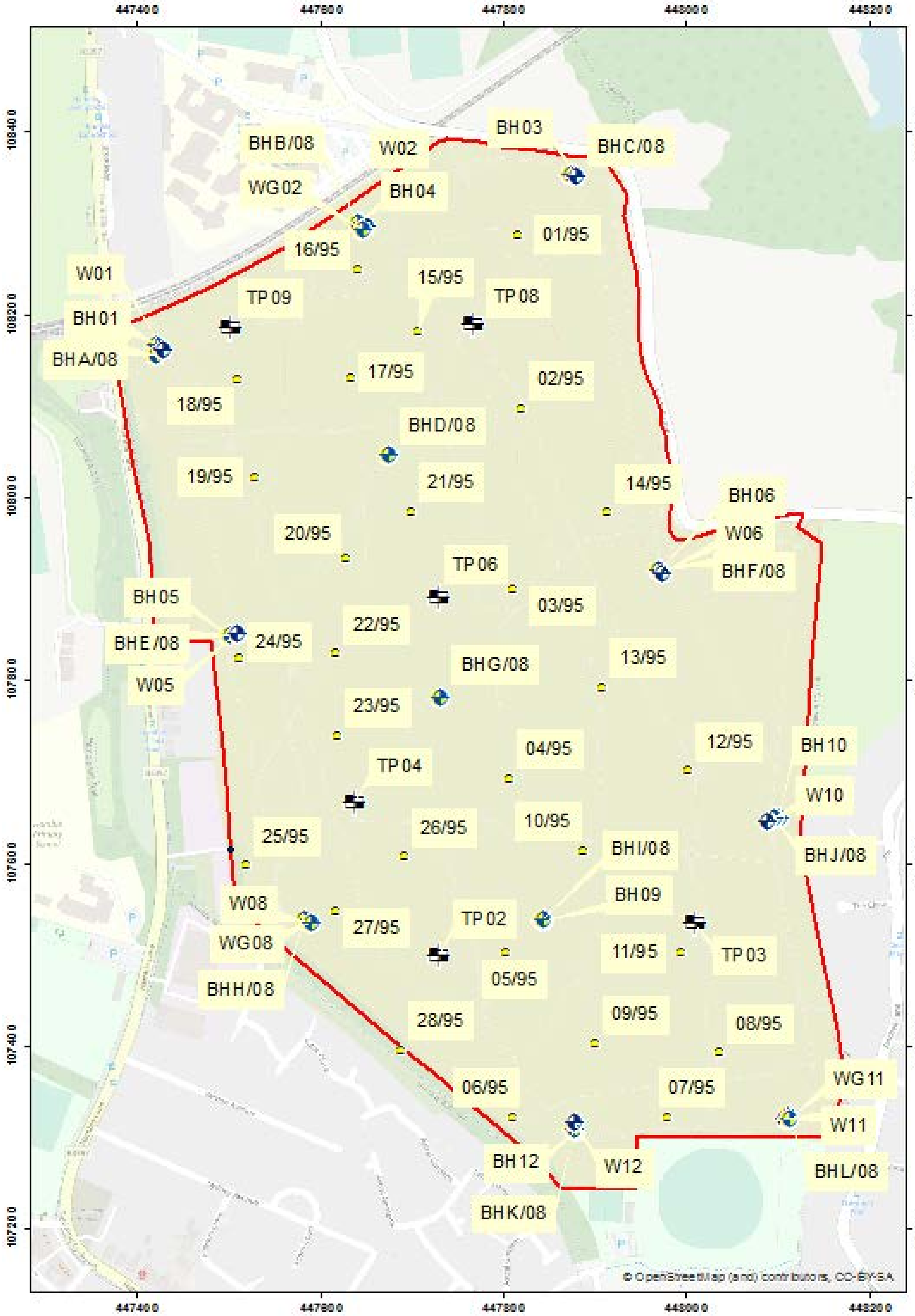


Figure 8.5 Cross section A-A'

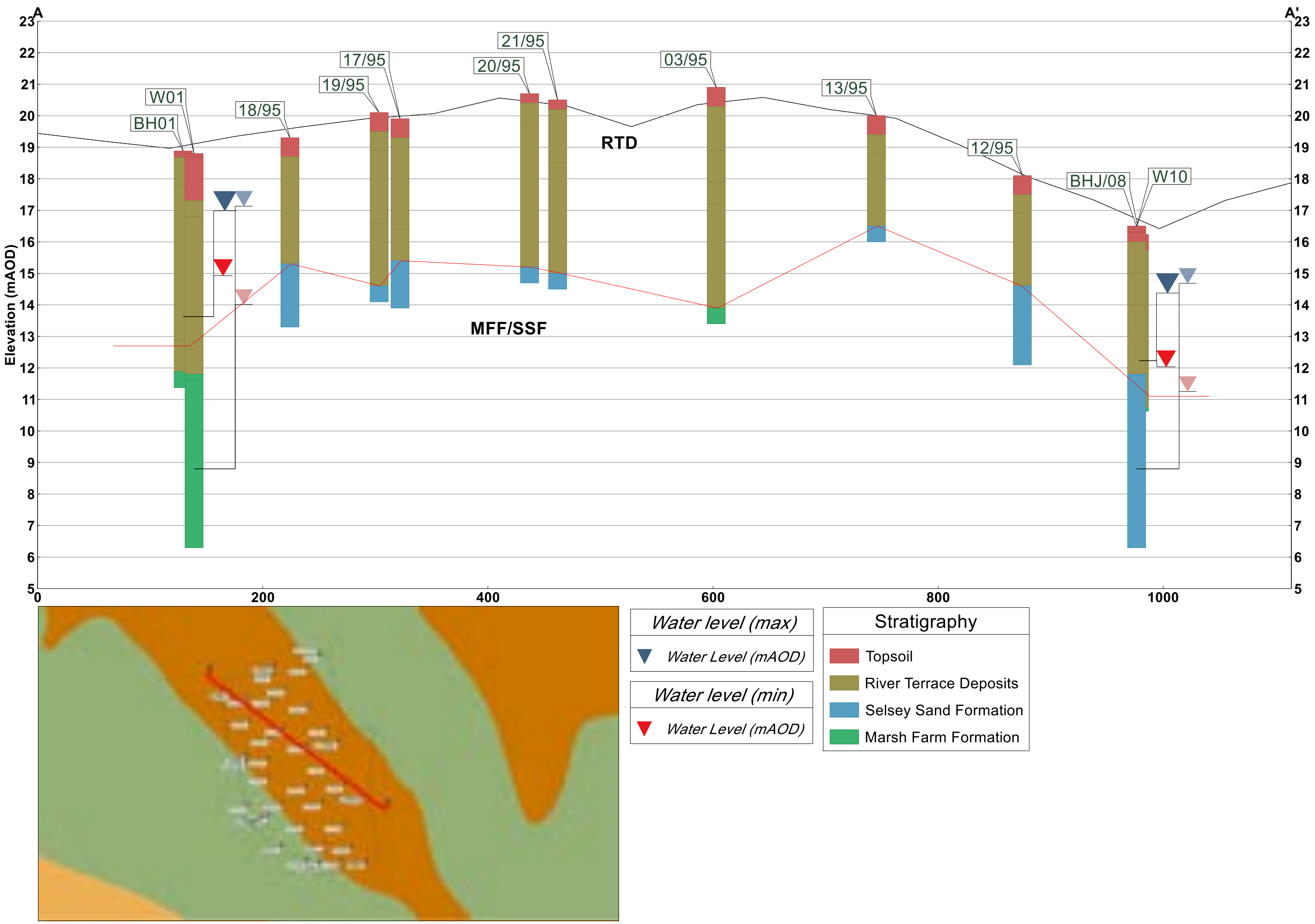


Figure 8.6 Cross section B-B'

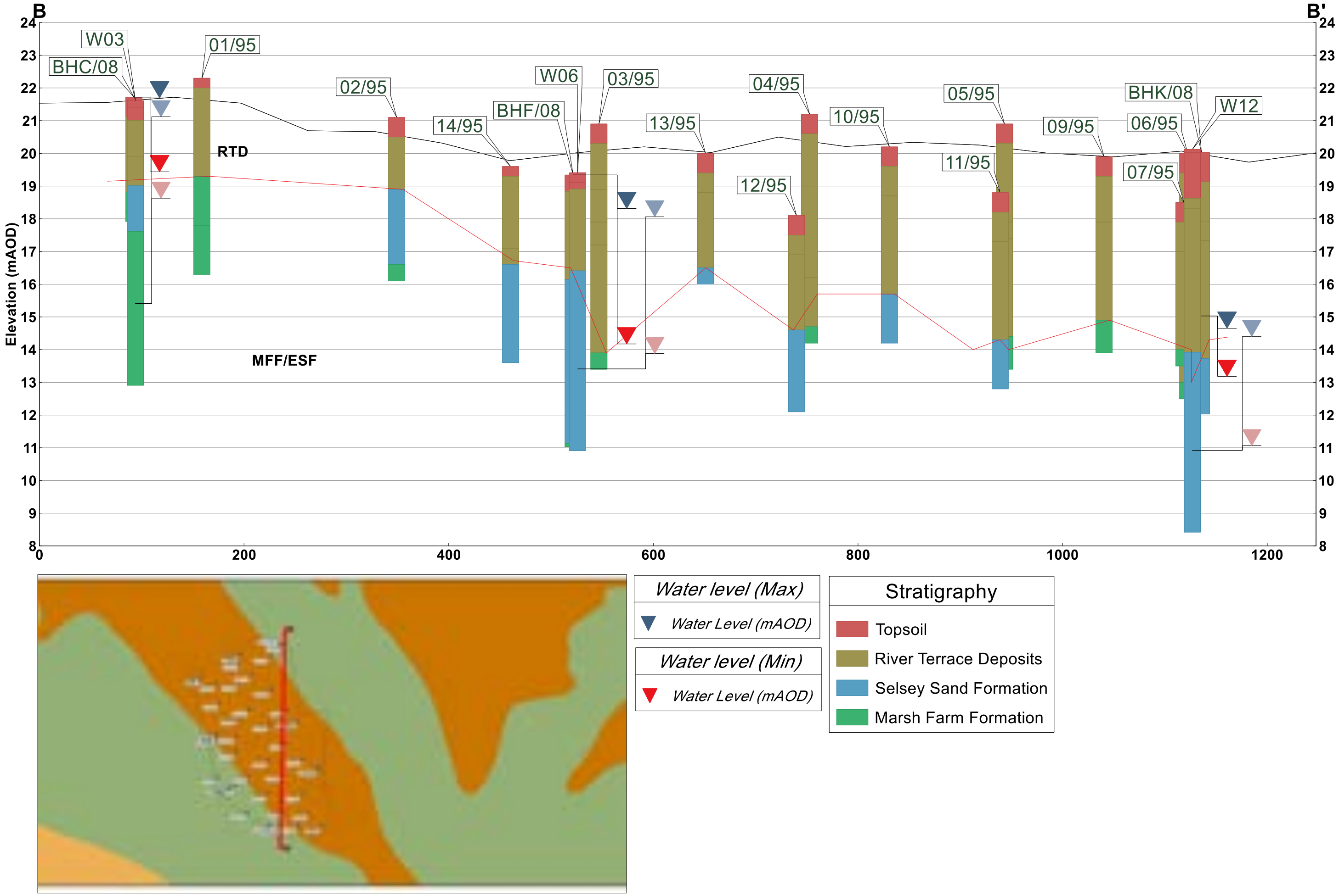
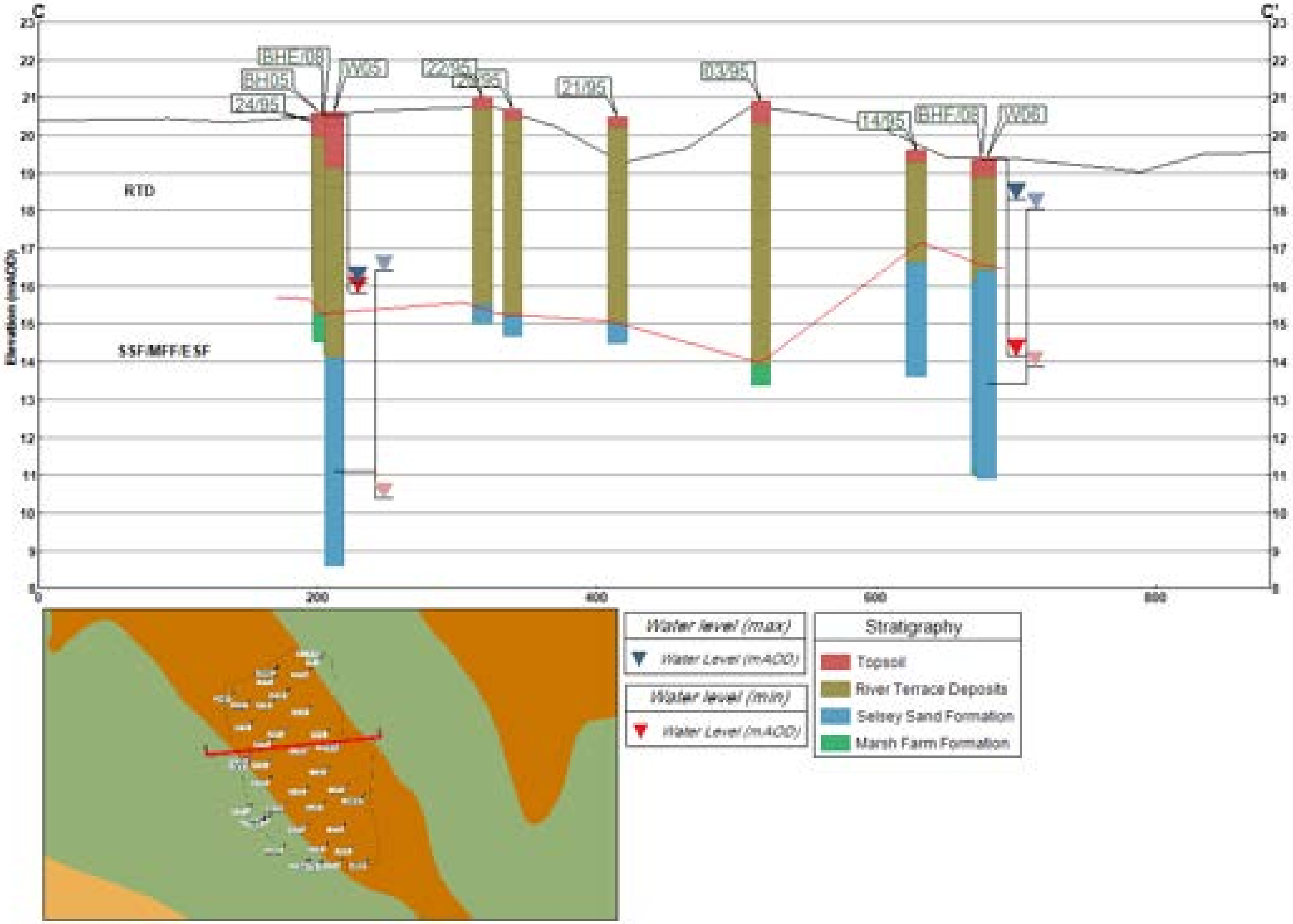


Figure 8.7 Cross section C-C'

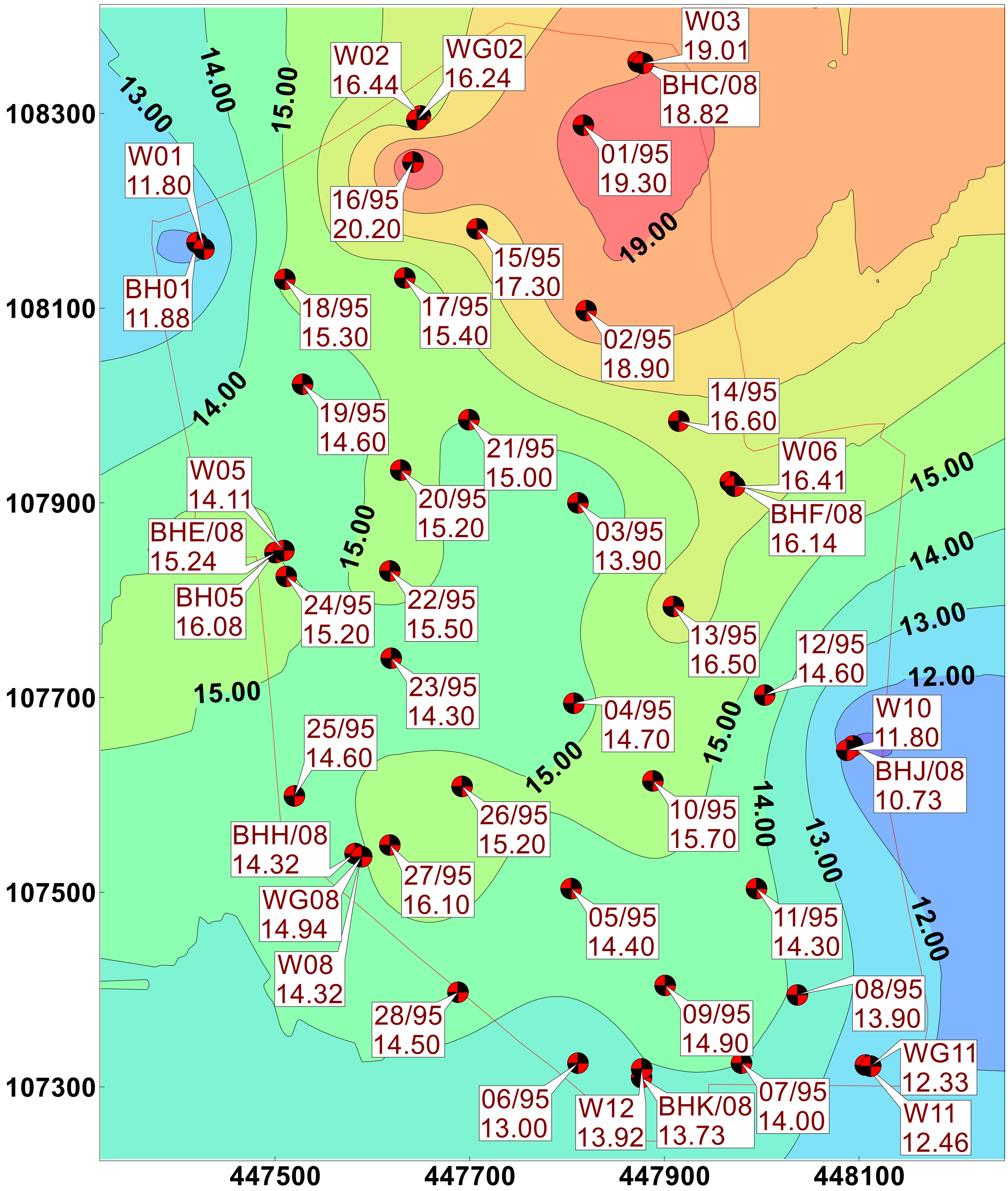


8.4.18 The borehole logs generally show that the overburden comprises topsoil with small amounts of clay with an average thickness of about 1.5 m.

8.4.19 The RTD consist of brown sandy gravel, with clay lenses and localised areas where clay dominates. The upper part of the RTD tends to be more clay dominated and is frequently referred to as 'hoggin' on the logs. The underlying yellow sand and sandy clay is interpreted to be the MFF and SSF. There appears to be some inconsistency between lithologies assigned to the MMF and SFF in the Site investigation wells. This is due to the fact that the MMF is often sandy and the SSF is often clayey. Nonetheless, the cross sections clearly show that the majority of the Site is underlain by the more permeable SSF than the less permeable MMF.

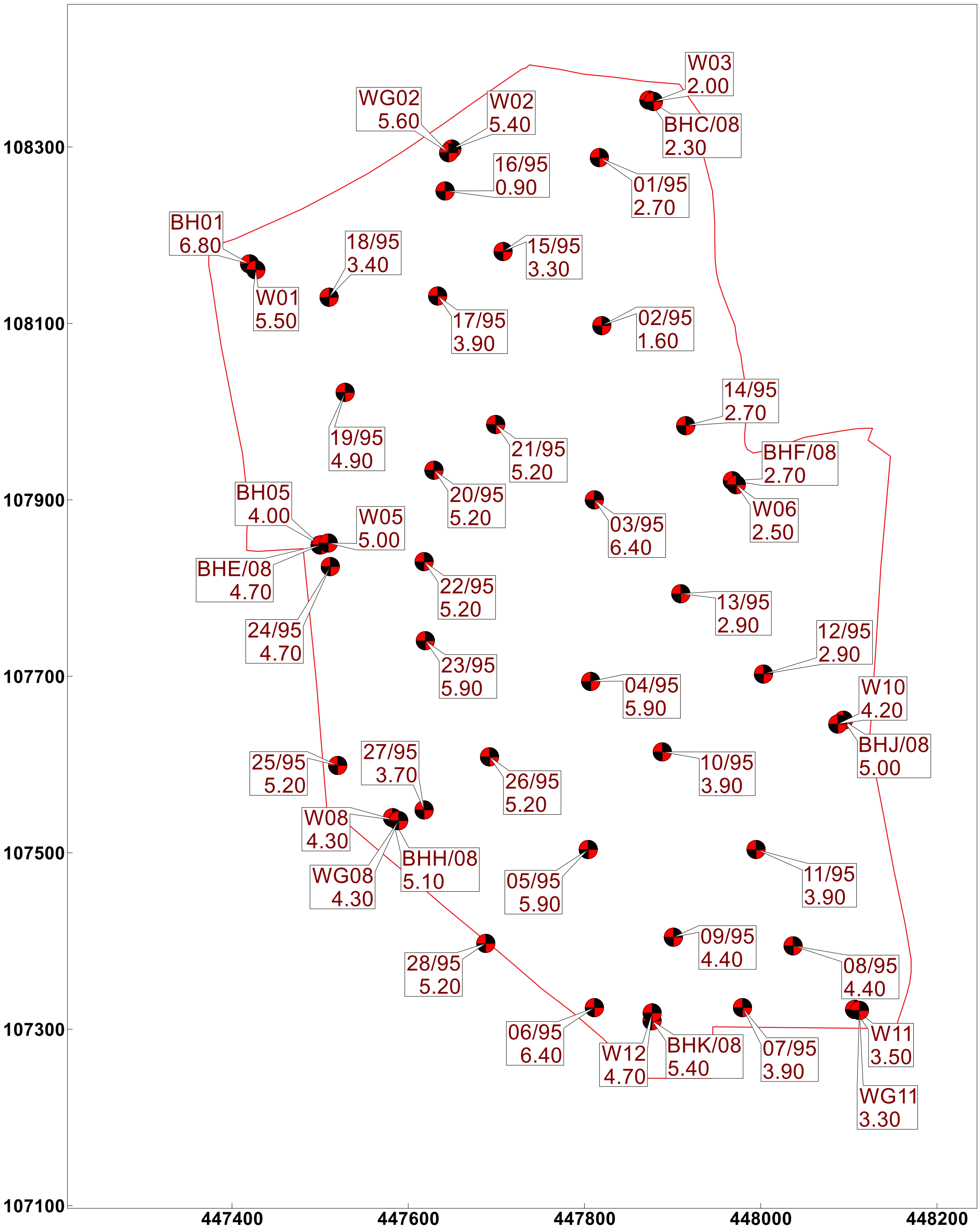
8.4.20 A contour plot showing the base of the RTD deposits is presented on Figure 8.8. This shows that the base of the RTD is highest in the north-east corner and it decreases to a low in the north-west corner as well as to the south.

Figure 8.8 Elevation of base of Sand and Gravel (mAOD)



8.4.21 The logs suggest that the mineral varies between 0.8 and 7.7 m with an average thickness of 4.3 m, which roughly accords with the geological memoir estimates for the area. A plan showing the RTD thickness at each borehole location is presented on Figure 8.9.

Figure 8.9 RTD thickness (m)



Infilled ground/landfilling

8.4.22 A number of active and historic landfills have been recorded within 2.5km of the Site and are summarised in Table 8.6 and shown on Figure 8.10.

Table 8.6 Landfill sites located within 2.5 km of the Site

Site name	Location	Status	Waste types accepted	License number
Mallards Moor Sandpit	115m north	Closed	Non-biodegredable (Inert)	EPR/FP3492HN/V002
Spear Pond Gully	740 m northwest	Historic	Household (non-hazardous)	EAHLD 20510
Land off Hound Road	830 m west	Historic	Household (non-hazardous)	EAHLD 20507
Recreation Ground at Pilands Wood	1.1 km north	Historic	Household (non-hazardous)	EAHLD 20514
Netley Landfill	1.8 km north west	Closed	Co-disposal site A1	EPR/FP3292HH/V003
Abbey Fruit Farm	2.1 km north west	Closed	Other waste A06	EPR/FP3692HA/A001
Westwood Phase 3	1.7 km north west	Historic	Household (non-hazardous)	EAHLD 20492
West Wood	2.2 km north west	Historic	Household (non-hazardous)	EAHLD 20493
Car Boot Sale Site	2.3 km north	Historic	Household (non-hazardous)	EAHLD 20513
Providence Hill	2.3 km north east	Historic	Inert	EAHLD 20516

Pollution incidents and potentially contaminated land uses

8.4.23 Information on potential historical contamination sources was gathered from the Groundsure report (GCC, 2018 – see Appendix 2.5), which provided information on four pollution incidents within 500 m of the Site as summarised in Table 8.7 below and shown on Figure 8.10 (note that one source does not have any co-ordinates provided and cannot be plotted).

8.4.24 GCC, (2018) states that there are no contaminated land sites determined under Part IIA of the Environmental Protection Act 1990 within 500 m of the Site.

8.4.25 GCC (2018) reports on 35 current industrial land uses within 250 m of the Site. The main sites which are considered to be potential sources of contamination are listed below.

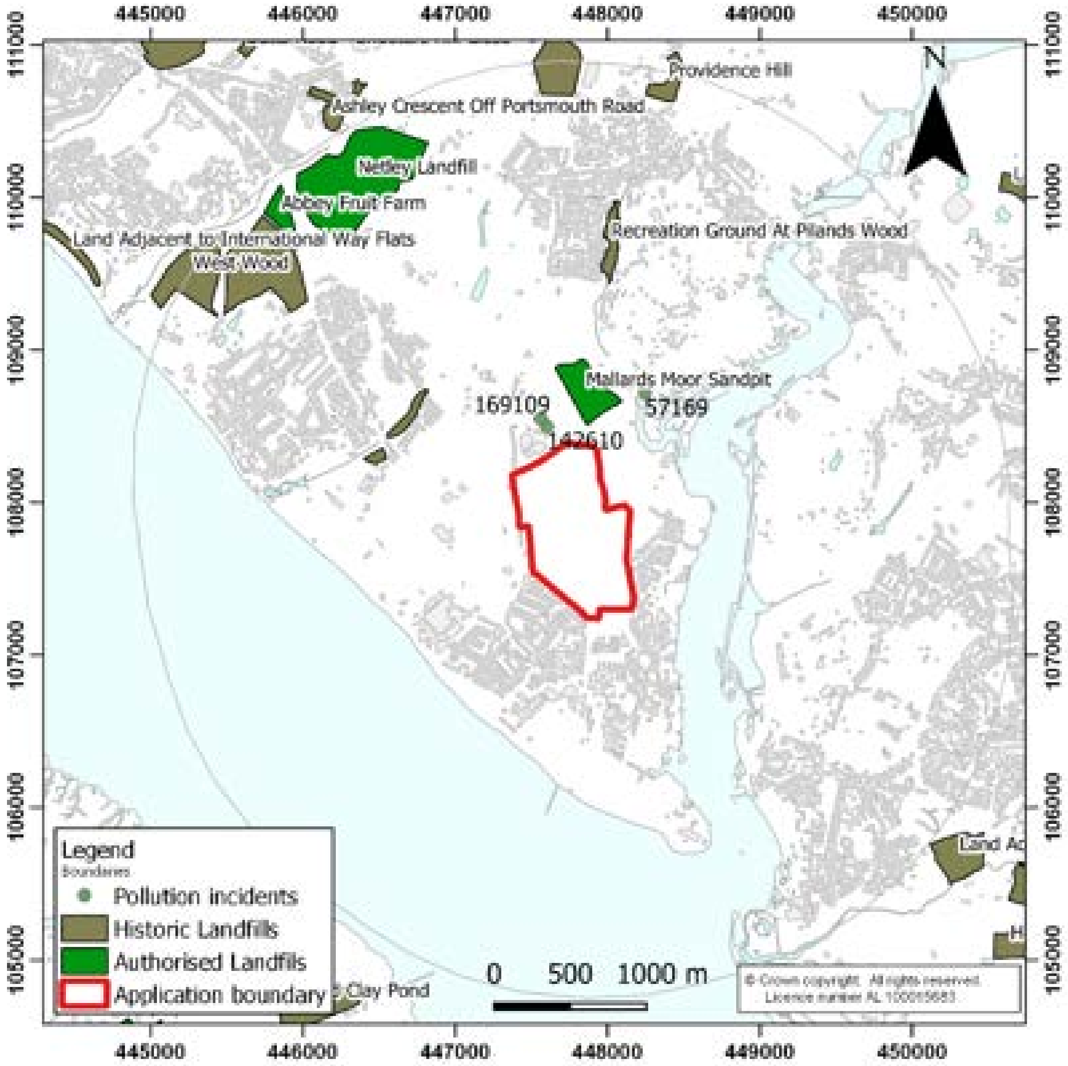
- ‘Works’ located 30 m west, 73 m south west and 124 m south west of the Site.
- A garage located 32 m west of the Site.
- A paint mixer and distributer located 68 m south west of the Site.
- A mobile wash and valet company located 81 m south west of the Site.
- A paints, varnishes and lacquers company (Avko Ltd), located 90 m south west of the Site.
- Electricity substations located 97 m east, 112 m south east, 151 m south west, 194 m south and 196 m south east, 220 m east and 242 m north west of the Site.
- ‘Tanks’ (generic), located 125 m north west and 165 m east of the Site.
- Gas Grosvenor Stations located 149 m north west and 210 m east of the Site.
- A vehicle repair, testing and servicing company located 202 m south west of the Site.

8.4.26 GCC (2018) also reports a former service station having been located 294 m south of the Site.

Table 8.7 Pollution incidents within a 500 m radius from the Site (GCC, 2018)

Distance	Notification Identifier	Date notified	Easting/ Northing	Impact	Pollutant type / List I/ II
129 m W	1240.0	05 Jul 1999	-	Priority Description: Immediate (2 Hours) Waste Description: Not Available Water Impact: Significant Impact Land Impact: Minor Impact Air Impact: No Impact Action Taken: Prosecution	Not available/ List I
166 m NW	142610	12 Mar 2003	447600 108502	Water Impact: Category 4 (No Impact) Land Impact: Category 3 (Minor) Air Impact: Category 4 (No Impact)	Rocks and Gravel / List II
228 m NW	169109	26 Jun 2003	447560 108550	Water Impact: Category 4 (No Impact) Land Impact: Category 3 (Minor) Air Impact: Category 4 (No Impact)	Other Inert Material or Waste/ List II
478 m NE	57169	08 Feb 2002	448244 108717	Water Impact: Category 3 (Minor) Land Impact: Category 4 (No Impact) Air Impact: Category 4 (No Impact)	Crude Sewage/ List II

Figure 8.10 Landfills and pollution incidents proximal to the Site



Hydrology

Water courses

8.4.27 Local surface water features are shown on Figure 8.11. The two main watercourses are the River Hamble, located c.300 m east of the Site at its closest approach and Southampton Water, located c.900 m to the south-west. Southampton Water flows generally south eastwards and the River Hamble flows from north to south, both discharging into The Solent.

8.4.28 Mallards Moor drains through Badnam Creek, c.300 m northeast of the Site and into the River Hamble. The area immediately south of Badnam Creek is used as a Marina.

8.4.29 There is a small water feature that lies within a steeply incised valley to the west of the Site (also see Figure 8.1). This is fed from a spring that lies just beyond the Site's north-western corner and discharges into Southampton Water.

8.4.30 A further small stream flows to the north-west of the Site (labelled on Figure 8.11 as Spear Pond Gully). This also discharges into Southampton Water.

8.4.31 The Site falls just outside (immediately south, downstream) of the East Hampshire Rivers operational catchment.

8.4.32 Representative hydrological catchment descriptors for the Site (directly downstream of the Site and based on natural pre-quarrying catchment), have been derived from the Flood Estimation Handbook (FEH) CD-ROM (NERC, 2009) and are provided in Table 8.8.

8.4.33 The SPRHOST value indicates that the proportion of runoff is 33.89%. Correspondingly, the value for BFIHOST is 66%, which indicates a relatively high proportion of infiltration and base flow from the catchment. This is consistent with the superficial geology and, to a certain extent, the solid geology which are reasonably permeable and transmit infiltrating rainwater to surface water bodies.

Rainfall

8.4.34 The Standard Average Annual Rainfall (SAAR) for the Site is 767 mm. The Meteorological Office reports an annual average rainfall of 779.4 mm at Southampton WC rain gauge for the period 1981-2010, about 6 km to the north-west of the Site.

8.4.35 Hydraulically Effective Rainfall (HER) is the rainfall available to infiltrate the deeper soils once evaporation and transpiration processes are accounted for. Data are not available for the Site, but a reasonable estimate for HER is half total rainfall, which is 384 mm per annum.

8.4.36 Some of the HER will run-off to surface water and some will migrate laterally through the soil zone as interflow. The balance forms groundwater recharge. If we assume that all groundwater recharge discharges to surface water as baseflow, an estimate for recharge can be made by multiplying the HER by the BFIHOST, which gives a value of 253 mm per annum.

Surface water flow

8.4.37 Both the River Hamble and Southampton Water are tidal at the Site and no flow data are collected.

Table 8.8 Hydrological catchment descriptors

Descriptor	Abbreviation	Value
Area (of catchment)	AREA	0.51 km^2
Mean altitude	ALTBAR	22 m
Mean direction of all drainage path slopes	ASPBAR	212 degrees
Base Flow Index associated with each HOST soil class	BFIHOST	0.661
Proportion of time when soil moisture deficit was equal to, or below, 6 mm during 1961-90	PROPWET	0.33 (i.e. 33% of the time)
Average Annual Rainfall (1961 – 1990)	SAAR	767 mm
Standard Percentage Runoff associated with each HOST soil class	SPRHOST	33.89%
Extent of urban and suburban land within catchment	URBEXT1990	0.0

On Site water features

8.4.38 A Site visit was undertaken by Stantec on 26 April 2018. Discontinuous perimeter drains were observed on Site. Where present, the drains measured c.0.5 m deep and c.1 m wide. Drains were often dry and filled with foliage and debris from the perimeter trees and hedgerows with some litter.

8.4.39 One segment of drain on the north-eastern boundary contained a section of stagnant water, though this was not typical of the rest of the perimeter drains. No other evidence of flow was observed at the Site perimeter.

Current Site Drainage

8.4.40 Run-off from the Site currently flows down topographic gradients to the eastern and southern margins of the Site, towards the River Hamble, Southampton Water and other minor surface water courses.

8.4.41 Combined sewers carry runoff from the roads which bound the Site, namely Hamble Road and Satchell Lane.

Licensed surface water abstractions

8.4.42 Surface water abstractions in the vicinity of the Site have been taken from GCC (2018) and are summarised in Table 8.9 and shown on Figure 8.11.

Figure 8.11 Local hydrology

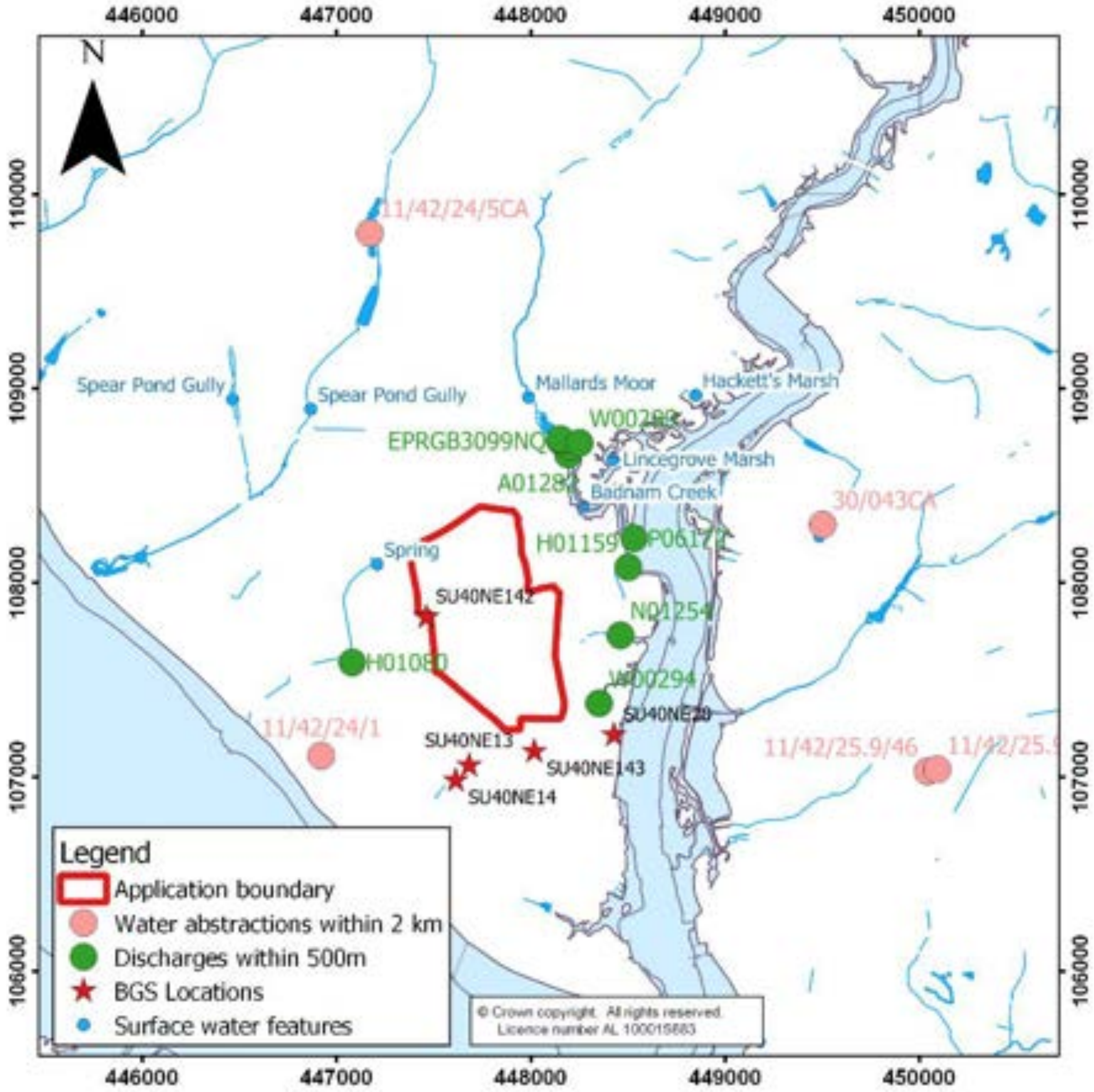


Table 8.9 Surface water abstraction and licenses within 2 km of the Site

Licence ID	Type	Source	Easting	Northing	Consented abstraction rate (m^3/day)	Use
11/42/24/5CA (Active)	Abstraction	Surface water	447170	109800	545.5	Spray Irrigation - Direct

Discharge consents

8.4.43 Twelve discharge consents were identified within 500 m of the Site in GCC (2018) and are listed in Table 8.10 and shown on Figure 8.11.

Table 8.10 Discharge consents within 500 m of Site

Licence ID	Effluent type	Receiving water	Easting	Northing	Consented discharge rate (m^3/day)	Distance / dirn from Site
W00294	Miscellaneous	Saline Estuary	448350	107380	-	180m E
N01254	Miscellaneous	Saline Estuary	448460	107730	-	331m E
H01159	Sewage discharges	Saline Estuary	448500	108080	-	368m E
A01282	Sewage discharges	Badnam Creek	448190	108660	-	399m NE
H01080	Sewage discharges	Freshwater River	447080	107590	-	418m W
EPRGB3099NQ	Sewage Discharges – STW	River Hamble Estuary	448150	108730	-	431m NE
EPRGB3099NQ	Sewage discharges	River Hamble Estuary	448150	108730	-	431m NE
W00318	Sewage discharges	Badnam Creek	448200	108700	-	436m NE
EPRGB3099NQ	Sewage discharges	River Hamble Estuary	448158	108733	-	437m NE
H01155	Sewage discharges	Badnam Creek	448150	108740	-	439m NE
P06172	Trade discharges	Saline Estuary	448530	108230	-	458m NE
W00289	Sewage discharges	River Hamble Estuary	448250	108720	-	484m NE

Flood risk

8.4.44 An FRA has been undertaken (Stantec, 2021) which is included here as Appendix 2.2.

8.4.45 The Site lies within Flood Zone 1 and is therefore not at risk of flooding from rivers or the sea. No flooding is anticipated even in the 1 in 1000 year flood event aside from two small depressions near the centre of the Site.

8.4.46 The Site is not at risk of flooding as a result of reservoir failure and the risk of groundwater flooding in the area is low.

8.4.47 A drainage scheme has been proposed which principally includes the large quarry void and northern lagoons over the operational phase of the quarry, which provide a very large stormwater attenuation capacity. Attenuated water will discharge to ground. Runoff and water balance calculations have been undertaken for Phase 4 of the development to demonstrate the validity of the scheme, although the principles of the SuDS scheme apply to all phases of the operational phase of the development (the location of the active void will move around the Site during the operational life of the quarry).

8.4.48 Following restoration, runoff will attenuate in some newly formed SuDS features (ponds and an infiltration basin) distributed across the Site. From the ponds, water would infiltrate to the sand and gravel aquifer (where it remains around the Site perimeter), via some infiltration trenches. Discharge to ground from the infiltration basin will be via the bank and base of the feature directly. Calculated off-site discharge (runoff and discharge from SuDS features) is well below the calculated greenfield rates and volumes with all SuDS features able to attenuate and discharge receiving runoff to ground. This illustrates that the SuDS schemes would provide some betterment with regards to off-site flood risk. Further in-situ soakaway testing is recommended in due course to validate the water balance calculation undertaken in this assessment.

Designated environmental sites

8.4.49 The Site and much of the surrounding area is within a nitrate vulnerable zone designated for the Hamble Estuary Eutrophic Zone, designated since 2013.

8.4.50 The Lincegrove and Hackett's Marches SSSI, located c.300 m northeast of the Site is listed as being in an 'unfavourable, recovering' state during its last assessment in 2014 (Natural England, 2018) (Figure 8.12). These mature saltmarshes are situated on the west bank of the River Hamble estuary and dissected by complex patterns of drainage creeks, their outer (river) margin terminating in 1 m – 1.5 m cliffs, which are eroding. The saltmarsh vegetation is dominated by sea purslane *Halimione portulacoides* and common cord-grass *Spartina anglica*. Structurally the marshes are one of the best examples of mature saltmarsh on the south coast. They are one of only eight extensive saltmarshes on the central south coast between Poole in Dorset and Pagham in West Sussex. Hackett's Marsh is also classed as a Local Nature Reserve (LNR).

8.4.51 The Lee-on-the-Solent to Itchen Estuary (SSSI), located c.1.3 km to the south of the Site is designated for its littoral sediment and was deemed to be in a 'favourable' condition (at its closest approach to the Site) though it is noted to be 'unfavourable, declining' state when last assessed in May 2017 in other nearby units.

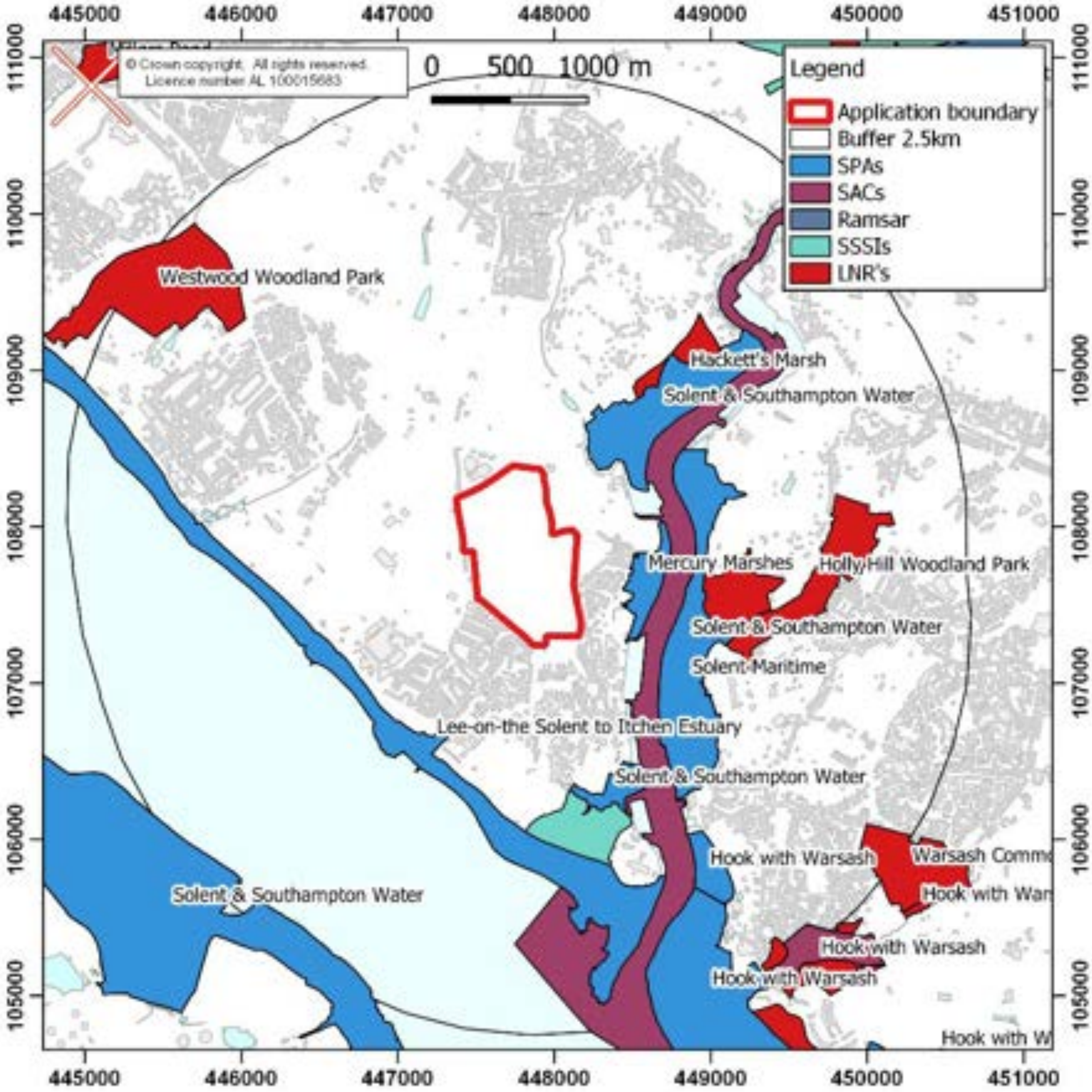
8.4.52 Solent & Southampton Water is listed as a Special Protection Area (SPA) and a Ramsar Site.

8.4.53 The area of Hamble River estuary and Southampton Water is classed as Solent Maritime Special Area of Conservation (SAC).

8.4.54 The following LNRs are within 1 km of the Site:

- Mercury Marshes, 305 m, east;
- Hook with Warsash, 549 m east;
- Hackett's Marsh, 763 m east;
- Holly Hill Woodland Park, 936 m east.

Figure 8.12 Designated sites proximate to the Site



Hydrogeology

Groundwater systems

8.4.55 The RTD is classified as a Secondary A aquifer. Secondary A aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. The Underlying solid strata are also classed as Secondary A aquifers.

8.4.56 According to Jones et al. (2000), rapid lateral and vertical variations in the sand and clay content of the formations of the Bracklesham Group have a commensurate effect on aquifer properties. In the area between Southampton and Gosport, sandy beds are fairly well developed, and boreholes of up to 200 mm diameter may yield up to 200 m^3/d; those over 400 mm diameter have given more than 1800 m^3/d from the sandier strata. However, the water may be ferruginous. Overlying clayey material may restrict recharge to the solid strata.

Aquifer properties

Superficial deposits

8.4.57 Published literature, such as Freeze and Cherry (1979), reports a broad range for hydraulic conductivity for a gravelly sand of 10^{-5} – 10^{-2} m/s (~ 1 – 1000 m/d). Intergranular flow will be the primary transport mechanism.

8.4.58 An estimate of hydraulic conductivity has been made from the particle size distribution (PSD) data available for the Site. The PSD data are available from 10 sieve tests undertaken on 7 trial pits. Trial pit locations are shown on Figure 8.4. In general, the PSD data show the samples to be very poorly sorted and this makes estimation of hydraulic conductivity difficult.

8.4.59 Hydraulic conductivity was estimated using the Hazen method (Trenter, Nov 1999). Calculations are given in Appendix 2.3. Calculations were undertaken on samples taken from the sand and gravel rather than the overburden.

8.4.60 The Hazen method assumes that the hydraulic conductivity is related entirely to the D10 size i.e. the size of sieve which allows 10% by mass of soil particles to pass through. Three of the samples TP04/17, TP09/17 (0.3 – 1.5 m) and TP09/17 (1.5- 3.0 m) had sufficient fines content that more than 10% could pass through the smallest sieve (63 µm) and thus it is not possible to estimate hydraulic conductivity using this method. Hydraulic conductivity data for these samples are presented as <3m/d which is the minimum value that can be estimated using this method.

8.4.61 On the basis of the Hazen calculations, the hydraulic conductivity ranges between <3 and 122 m/d with an average1 value of 46 m/d.

8.4.62 Nearby boreholes SU40NE13 and SU40NE14 (see Figure 8.11 for locations) reported yields of between 36.77 m3/hr and 42.64 m3/hr using the distance-drawdown method. The aquifer from which the groundwater is abstracted is not known but is unlikely to be the shallow RTD which is the focus of interest of this assessment.

Solid strata

8.4.63 Jones et al. (2000) provides limited aquifer property data for the Bracklesham Group. We note that neither the MFF, SSF nor ESF are designated as 'formations that act as minor aquifers' in Table 4.5 of Jones et al. (2000).

8.4.64 In the Fawley area (on the opposite site of Southampton Water) it has been assumed that the Bracklesham Group and Whitecliff Sands (within the London Clay Formation) act as a single aquifer; they have an aquifer transmissivity of 50 to 100 m^2/d and confined storage coefficients of between 0.01 and 0.1%. In the aquifer outcrop area, an unconfined storage coefficient of about 2% is estimated.

8.4.65 The Site geology suggests that the solid strata ranges between clay to clayey / silty fine sands. These lithologies are likely to have a horizontal hydraulic conductivity that ranges between 10-8 – 10-6 m/s (0.001 – 0.1 m/d) (Freeze

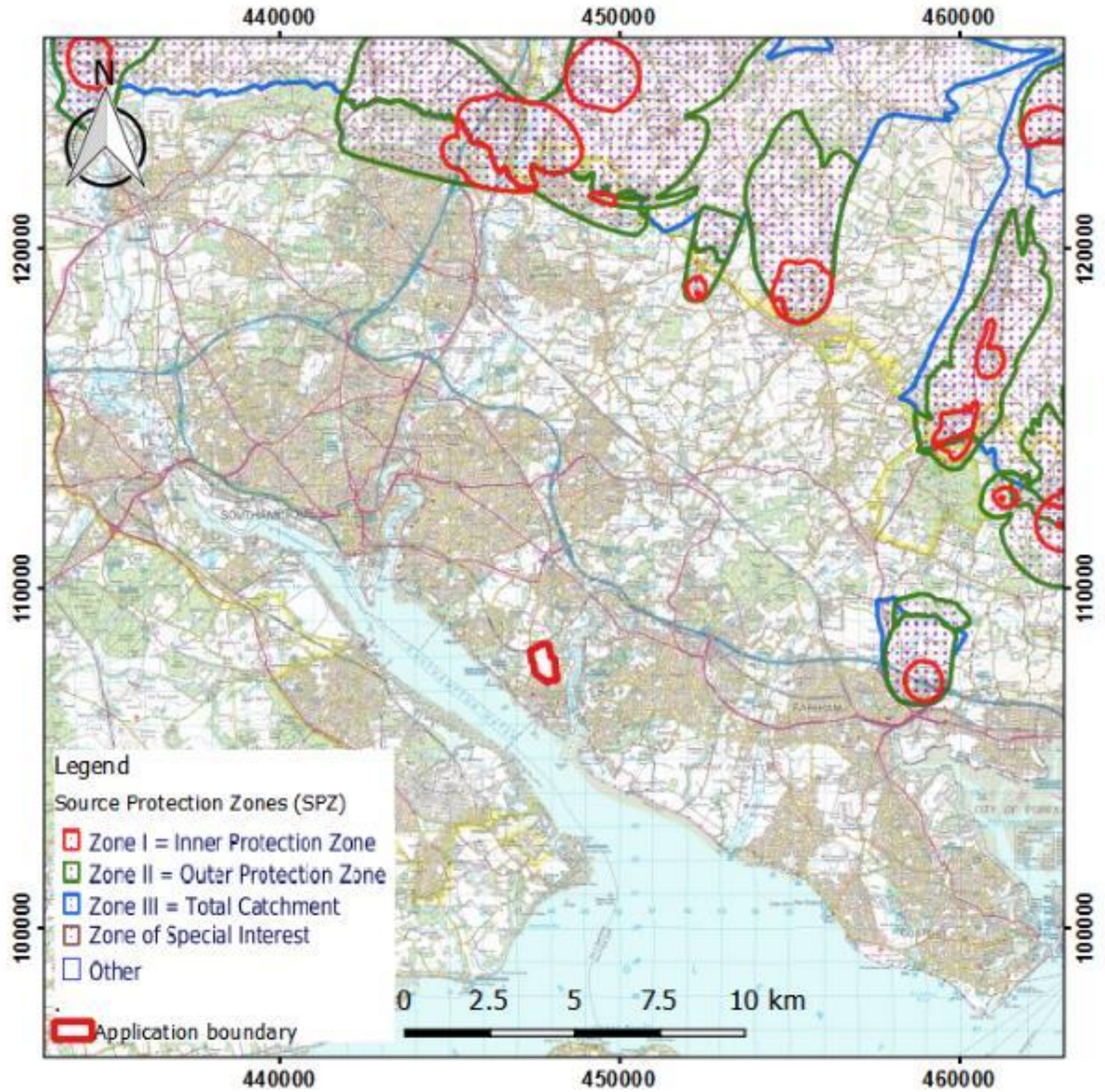
[1] Average calculated assuming that TP04/17, TP09/17 (0.3 – 1.5m) and TP09/17 (1.5- 3.0m) have a D10 of 63µm.

and Cherry, 1979). The strata are likely to have significant horizontal heterogeneity due to the sand and clay interbedding such that vertical hydraulic conductivity may be one or two orders of magnitude lower than horizontal hydraulic conductivity.

Source Protection Zones

8.4.66 The Site is not located within a Source Protection Zone (SPZ) with the nearest SPZ located c.10 km to the east and are located within the Chalk, which is hydraulically separated from the Bracklesham Group, (Figure 8.13).

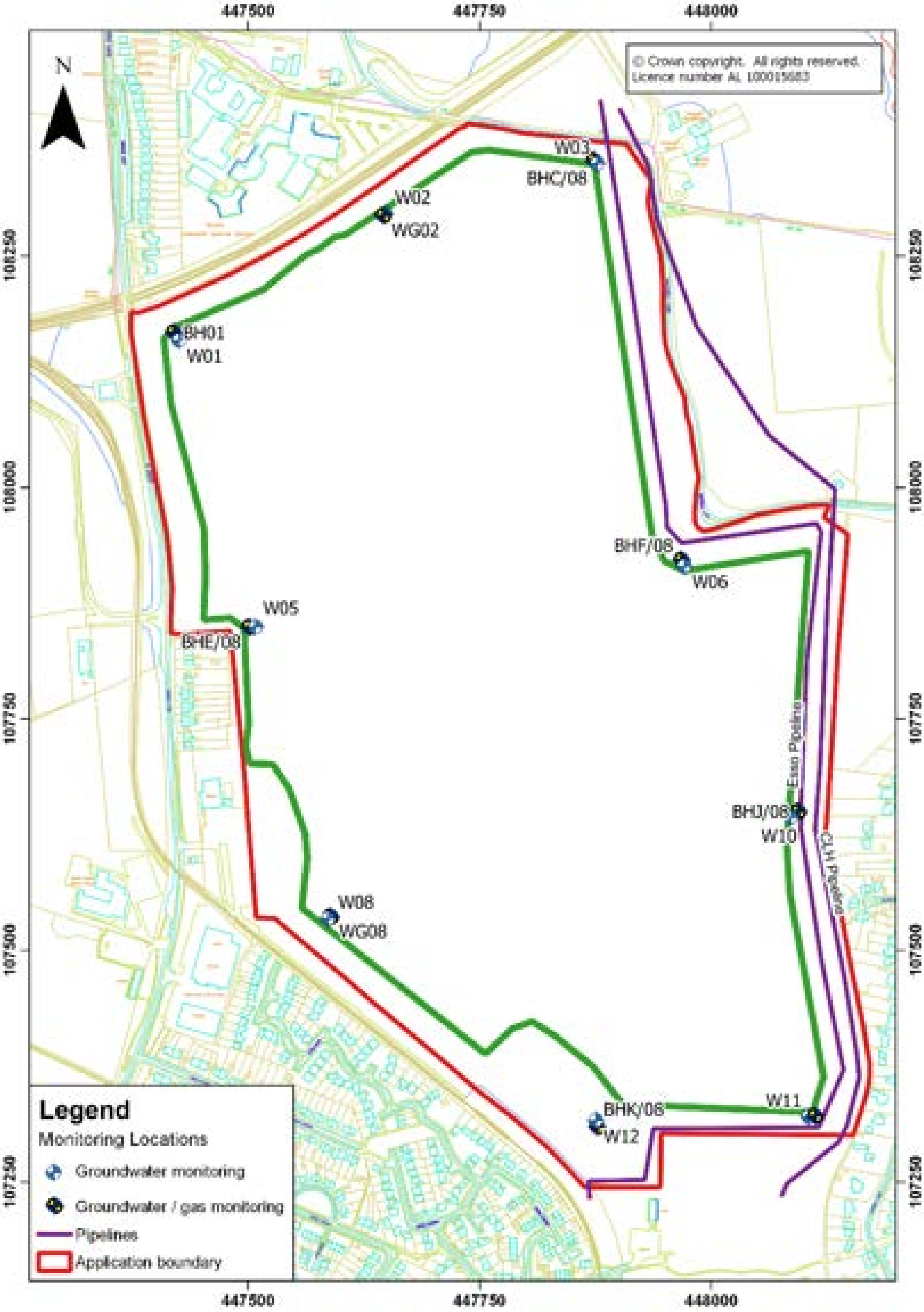
Figure 8.13 Source protection zones



Groundwater levels and flow

8.4.67 Groundwater levels are currently monitored at the locations shown on Figure 8.14. There have been significant issues with vandalism on the Site and many of the groundwater monitoring wells installed in 2008 and 2011 were found not to be fit for purpose. Therefore, remedial works were undertaken during 2018 to clear out damaged wells and replace those which could not be remediated. At the same time, groundwater monitoring wells for the solid strata (SSF, ESF and MMF) were installed, so there is now a pair of wells at each monitoring location. Data collected since January 2019 is deemed to be reliable.

Figure 8.14 Current groundwater monitoring locations



River Terrace Deposits

8.4.68 Groundwater hydrographs for the currently monitored wells that are installed in the RTD are shown on Figure 8.15 and contours for average levels between January and July 2019 are shown on Figure 8.17. This shows that groundwater is highest in the north-east corner and decreases towards the north west corner and to the south east where the RTD is often dry. It is noted that this closely mirrors the topography of the base of the RTD as shown on Figure 8.8. Plots of dip and plumbed depth are presented in Appendix 2.4. These data all show that there is limited groundwater present within the RTD. Saturated thickness is greatest in the north-west corner of the Site (BH01) where it is between 3 and 3.5 m. Elsewhere along the northern and eastern edges of the Site the saturated thickness is typically 1.5 – 2.5 m. Along the western and southern edges of the Site, the saturated thickness is typically less than 1 m.

8.4.69 The data show a period of low groundwater levels between April and November 2020 when many of the RTD wells are recorded as being dry. This is likely to be associated with a period of low rainfall.

8.4.70 On the basis of the water levels at BHC/08 and BHK/08, which are 1,045 m apart, the hydraulic gradient from north to south across the Site is 0.006.

8.4.71 The topographic plan (Figure 8.1) also shows that immediately to the west of the Site lies a surface water channel which is fed from a spring close to the Site's north- western boundary. Figure 8.2 shows this to be filled with alluvial deposits i.e. the RTD is not present. It is likely that there is an element of shallow groundwater flow in this direction from the Site.

Solid strata

8.4.72 Hydrographs for wells that monitor the solid strata are presented on Figure 8.16 and contours for average levels between January and July 2019 are shown on Figure 8.18. The solid strata hydrographs show a very similar pattern of response and groundwater flow direction as the RTD hydrographs, indicating that there is a good degree of hydraulic connection between the two units. On the basis of the water levels at W03 and W12, which are 1,045 m apart, the hydraulic gradient from north to south across the Site is also 0.006. These data also show a period of low groundwater levels April and November 2020.

Figure 8.15 Groundwater hydrographs for current groundwater monitoring wells in RTD

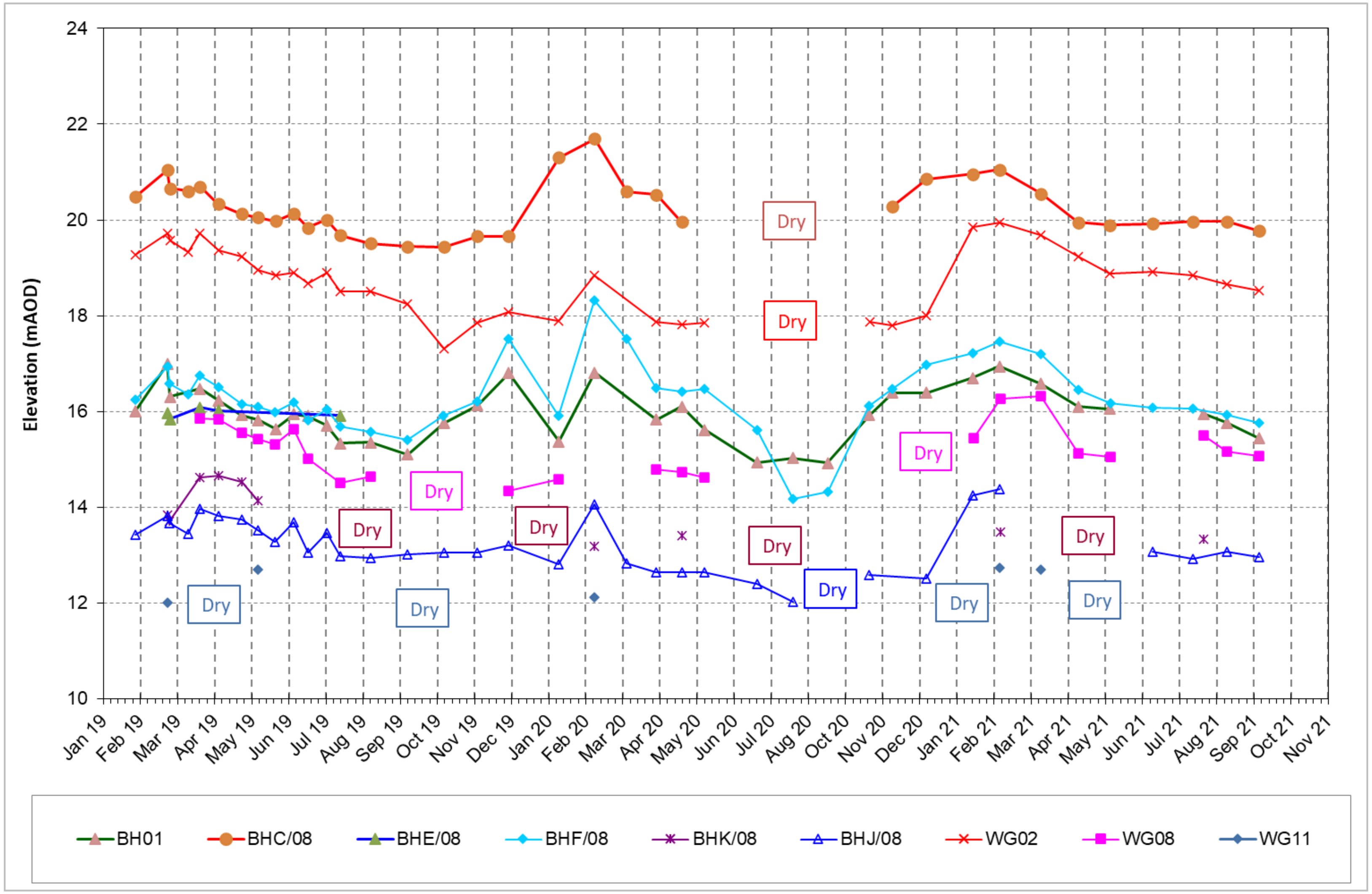


Figure 8.16 Groundwater hydrographs for solid strata monitoring wells

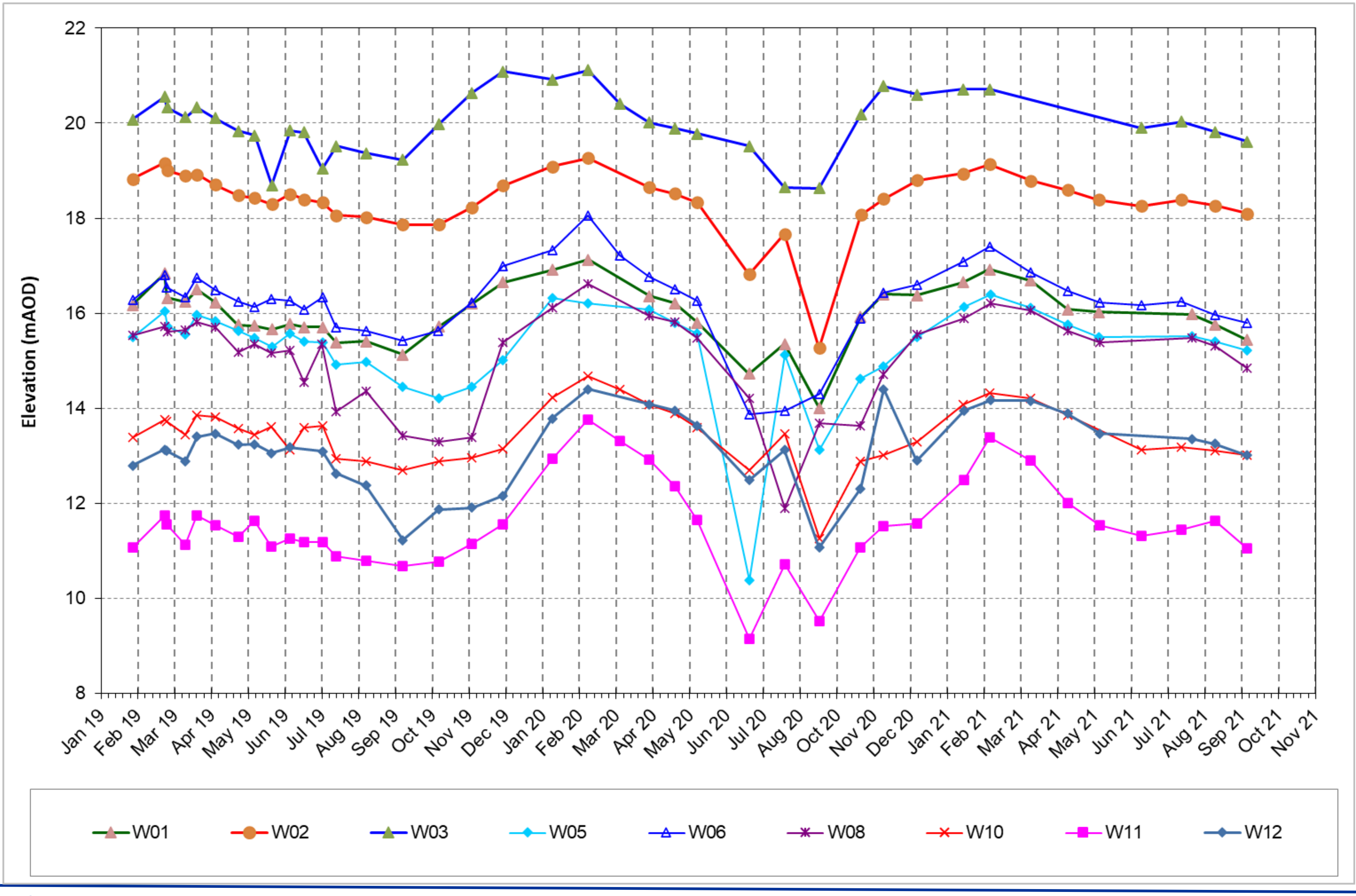


Figure 8.17 RTD groundwater level contours: average data Jan to July 2019

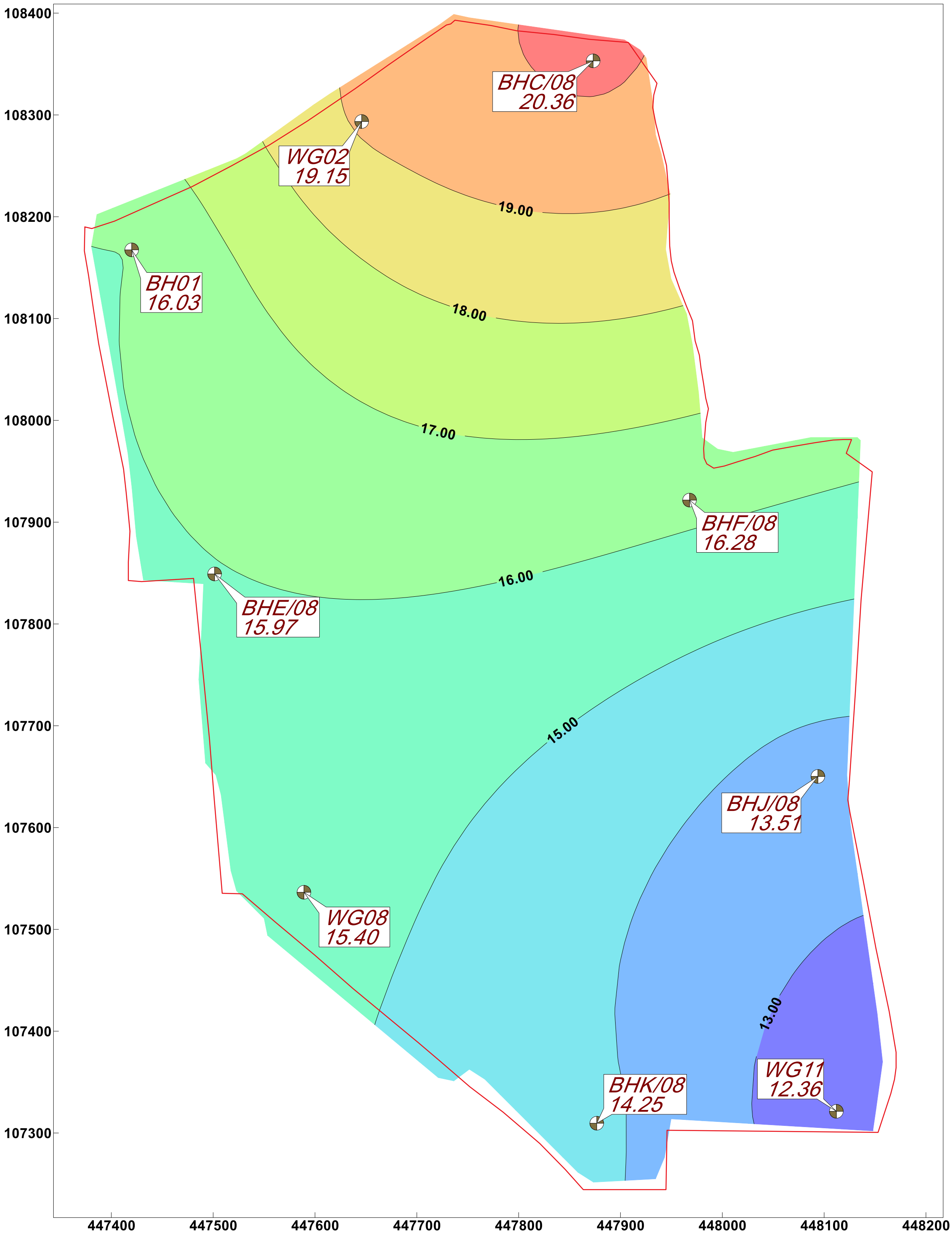
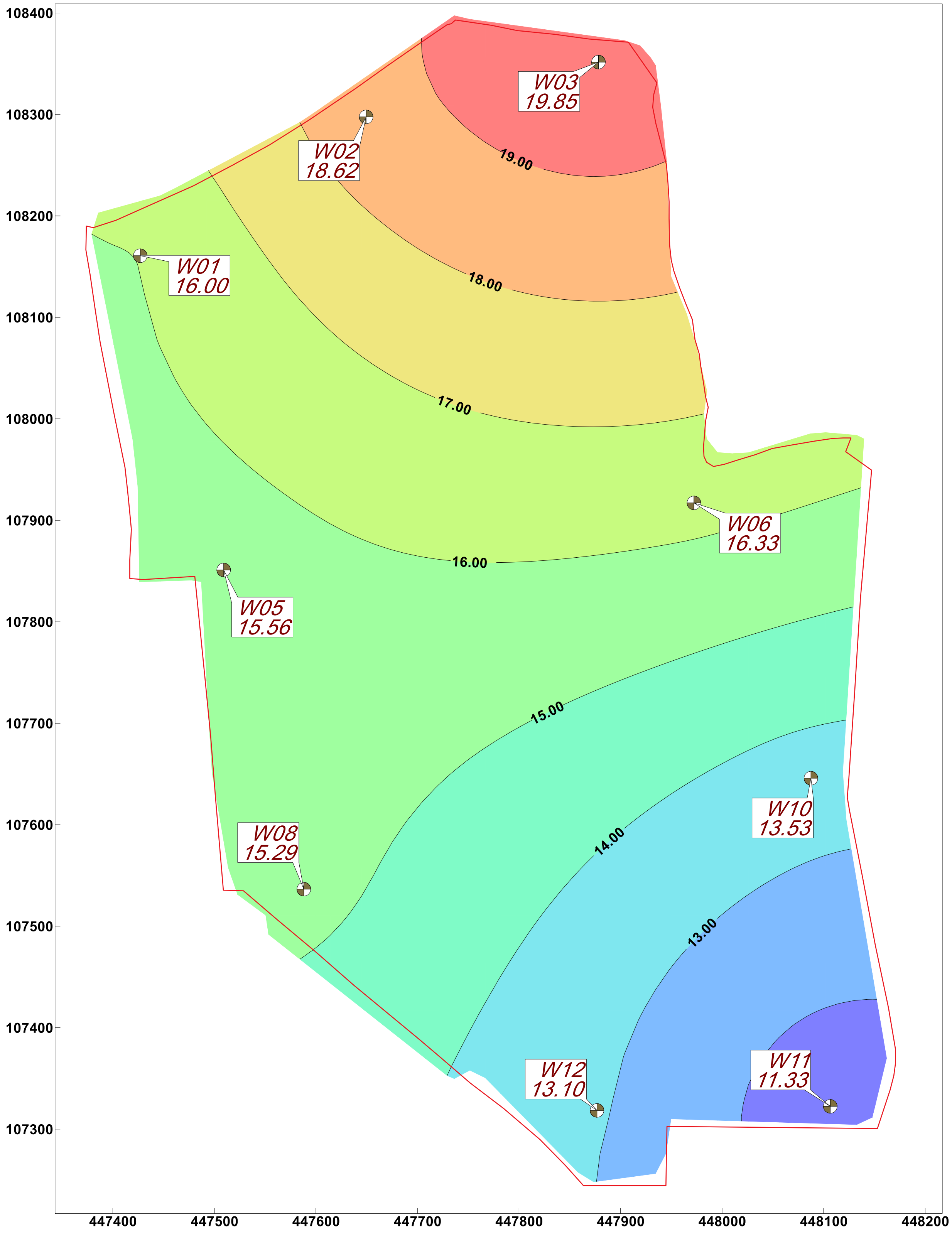


Figure 8.18 Solid strata groundwater level contours: average data Jan to July 2019



Vertical gradients

8.4.73 Hydrographs of the 9 pairs of wells are presented on Figure 8.19, orientated on the page as they are located on Site. This also shows that the RTD and solid strata groundwater shows a similar pattern, falling from the winter high in January to the summer low in July. At most locations there is a negligible vertical gradient.

8.4.74 WG02 / W02 and BHC/08 / W03 and possibly WG08 / W08 and BHJ/08 / W10 show higher water levels in the RTD when water levels are declining and lower levels when they are rising. This is mostly likely due to differences in storage in the two formations with groundwater levels recovering faster in the deeper, confined solid strata with less storage compared to the unconfined RTD.

8.4.75 It is also likely that varying amounts of clay present in the underlying solid strata will act to locally restrict the vertical movement of water to depth. The vertical gradients are also shown on the cross sections (Figure 8.5 to Figure 8.7) where the minimum and maximum water level in the RTD and solid strata are presented.

Licenced water abstractions and discharges

8.4.76 GCC (2018) lists water abstraction licenses within 2 km of the Site, their location, abstraction rate and reported use (Table 8.11). Locations are shown on Figure 8.11. None of these abstractions are for potable use.

Table 8.11 Water abstraction and licenses within 2km of the Site

Licence ID	Type	Source	Easting	Northing	Consented abstraction rate (m^3/day)	Use
11/42/25.9/46 (Historical)	Abstraction	Groundwater	450040	107030	n/a	Spray Irrigation - Direct
11/42/25.9/46 (Historical)	Abstraction	Groundwater	450090	107040	n/a	Spray Irrigation - Direct
30/043CA (Active)	Abstraction	Groundwater	449500	108300	172	Fish Farm/Cress Pond Throughflow
11/42/24/1 (Active)	Abstraction	Groundwater	446920	107110	455	General Use

8.4.77 Details of private water supplies within 5 km of the Site were requested from Eastleigh Borough Council in April 2018. However, no private water supplies were found in this search as the Council indicated that it has no records of private supplies within the Council boundaries.

Groundwater quality

8.4.78 Groundwater quality monitoring has been carried out at the Site since June 2011. A summary of the groundwater quality is presented in Table 8.12 for the RTD and Table 8.13 for the solid strata alongside Drinking Water Standards (DWS), for reference.

8.4.79 RTD water quality shows relatively low concentrations of major ions which is reflected in the low electrical conductivity readings. pH is acidic to neutral. Minor ion concentrations are also low with just 2% of iron concentrations above the UK Drinking Water Standard (DWS) concentrations. Ammoniacal nitrogen concentrations are also generally low and the 95th percentile concentration is below the UK DWS. However, there have been some occasional higher readings and 5% of results are above the UK DWS (Figure 8.20).

8.4.80 The solid strata water quality is very similar to the RTD water quality. Major ion concentrations are low which is reflected in the low electrical conductivity readings. pH is acidic to neutral. Minor ion concentrations are also low with just 5% of iron concentrations above the UK Drinking Water Standard (DWS) concentrations. Lead is also above the DWS on 1% of occasions. Ammoniacal nitrogen concentrations are also generally low and the 95th percentile concentration is below the UK DWS. However, there have been some occasional higher readings and 5% of results are above the UK DWS (Figure 8.21).

Figure 8.19 Vertical hydraulic gradients (red is deep response zone, blue is shallow)

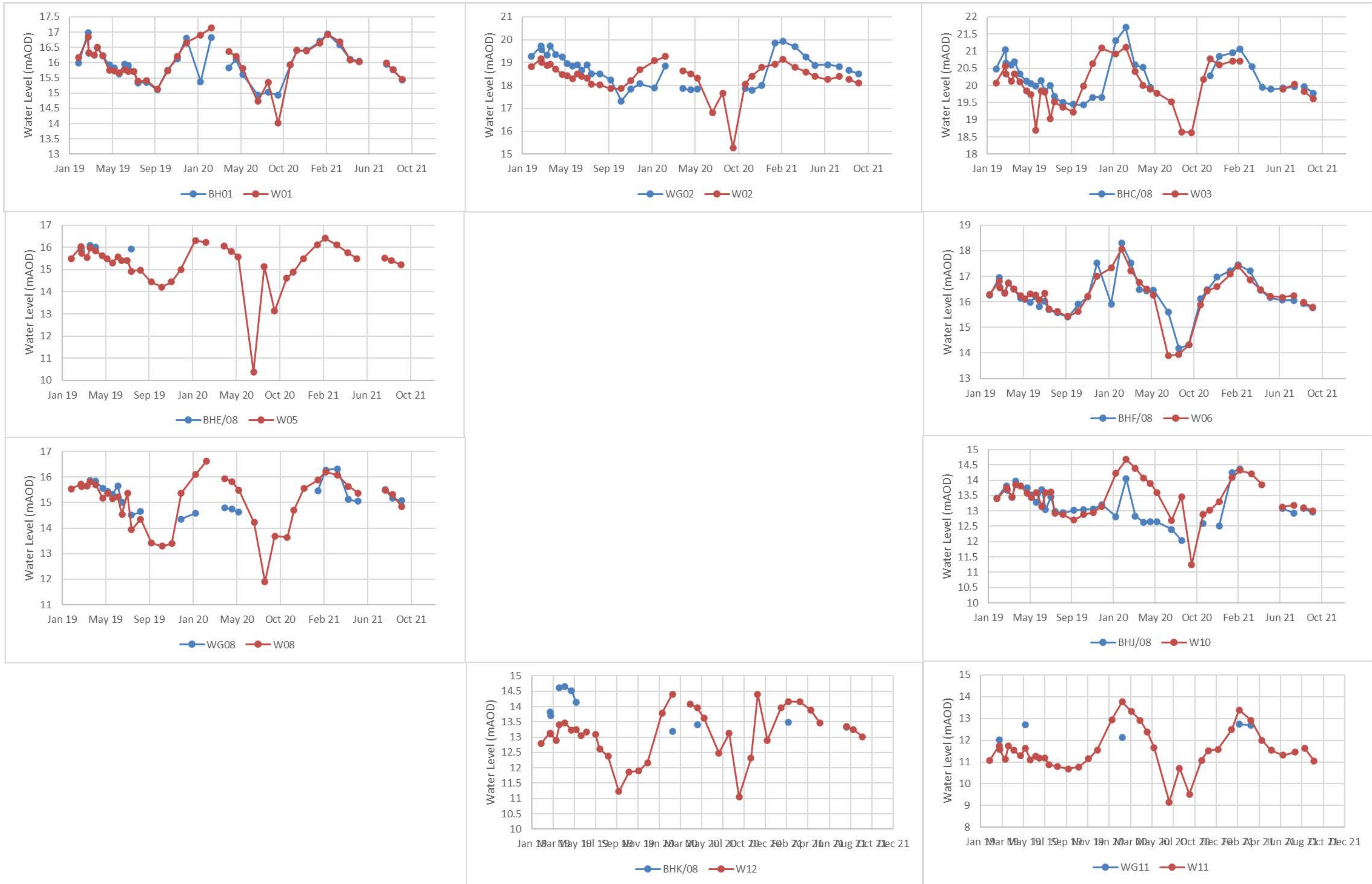


Table 8.12 Summary of groundwater quality in RTD

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Field / lab parameters														
Conductivity- Electrical (Field)	101	µS/cm	1	1738	481	330	466	109	1659	101	100	0	0	2500
Conductivity- Electrical 20deg	118	µS/cm	92.1	491	225	176	106	97.7	406	118	100	0	0	2500
pH	120	pH units	4.9	7.9	6.47	6.45	0.715	5.1	7.4	120	100	60	50	6.5 - 9.5
pH (Field)	98	pH units	4.53	8.34	6.59	6.57	0.853	5.21	7.81	98	100	47	49	6.5 - 9.5
Temperature (Field)	98	deg c	4.8	18.4	12.8	12.9	2.86	8.14	16.8	98	100	0	0	
Major ions														
Alkalinity as CaCO3	120	mg/l	<2.3	181	66.4	52.6	51.4	5	164	119	99.2	0	0	-
Calcium	120	mg/l	5.41	74.3	30.4	22.1	20.6	6.95	67.3	120	100	0	0	-
Chloride	120	mg/l	11.6	64.2	23.2	19.9	10	13.4	42.9	120	100	0	0	250
Magnesium	120	mg/l	2.2	9.1	4.49	4.35	1.35	2.6	6.8	120	100	0	0	-
Potassium	120	mg/l	<0.18	4.16	0.637	0.615	0.429	0.23	1.07	119	99.2	0	0	-
Sodium	120	mg/l	5.86	27.1	10.9	9.3	4.27	6.65	18.4	120	100	0	0	200
Sulphate as SO4	120	mg/l	<4.4	45.9	18.3	18.1	7.67	9.49	32.1	119	99.2	0	0	250
Minor ions														
Arsenic	117	mg/l	<0.0002	0.004	0.000343	n.d.	0.000392	n.d.	0.0005	28	23.9	0	0	0.01
Cadmium	120	mg/l	<0.0006	<0.0006	n.d.	n.d.	n.d.	n.d.	n.d.	0	0	0	0	0.005
Chromium	120	mg/l	<0.002	0.002	n.d.	n.d.	n.d.	n.d.	n.d.	2	1.67	0	0	0.05

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	% Exceeding	Action Level
Copper	120	mg/l	<0.009	0.015	n.d.	n.d.	n.d.	n.d.	0.012	14	11.7	0	0	2
Iron	120	mg/l	<0.23	0.473	n.d.	n.d.	n.d.	n.d.	n.d.	2	1.67	2	2	0.2
Lead	120	mg/l	<0.006	0.008	n.d.	n.d.	n.d.	n.d.	n.d.	2	1.67	0	0	0.01
Nickel	120	mg/l	<0.003	0.01	0.00286	n.d.	0.00156	n.d.	0.00505	40	33.3	0	0	0.02
Zinc	120	mg/l	<0.018	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	5	4.17	0	0	-
Nitrogen species														
Ammoniacal Nitrogen as N	120	mg/l	<0.06	1.4	0.0858	n.d.	0.168	n.d.	0.365	35	29.2	6	5	0.39
Nitrogen (total oxidised) as N	120	mg/l	<0.7	3.1	0.843	0.7	0.566	n.d.	2.01	66	55	0	0	-

Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Table 8.13 Summary of groundwater quality in solid strata

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Field / lab parameters														
Conductivity- Electrical (Field)	259	µS/cm	100	1901	250	196	184	139	417	259	100	0	0	2500
Conductivity- Electrical 20deg	280	µS/cm	112	549	196	162	77.7	123	353	280	100	0	0	2500
pH	**280**	**pH units**	**5**	**8**	**6.22**	**6.2**	**0.489**	**5.4**	**7.1**	**280**	**100**	**202**	**72**	**6.5 - 9.5**
pH (Field)	259	pH units	4.82	9.55	6.56	6.52	0.762	5.43	7.85	259	100	126	45	6.5 - 9.5
Temperature (Field)	259	deg c	7.1	155	13.9	13.5	9.24	8.8	18.9	259	100	0	0	
Major ions														
Alkalinity as CaCO3	280	mg/l	<2.8	274	34	22.8	33.4	7.18	100	279	99.6	0	0	-
Calcium	280	mg/l	6.08	70.6	18.2	13.6	11.5	7.49	40.6	280	100	0	0	-
Chloride	280	mg/l	10.5	75.3	24.8	21.4	10	14.6	45.8	280	100	0	0	250
Magnesium	280	mg/l	1.4	24.9	4.78	4.65	2.18	1.7	7.11	280	100	0	0	-
Potassium	280	mg/l	0.2	7.74	1.2	0.83	1.08	0.31	2.88	280	100	0	0	-
Sodium	280	mg/l	6.45	30.7	12.6	11.1	5	7.43	23.5	280	100	0	0	200
Sulphate as SO4	280	mg/l	10.5	50.3	25.8	25.5	8.48	13.6	39.6	280	100	0	0	250
Minor ions														
Arsenic	271	mg/l	<0.0002	0.0014	n.d.	n.d.	n.d.	n.d.	0.0005	39	14.4	0	0	0.01
Cadmium	280	mg/l	<0.0006	0.0015	n.d.	n.d.	n.d.	n.d.	n.d.	6	2.14	0	0	0.005
Chromium	280	mg/l	<0.002	0.005	n.d.	n.d.	n.d.	n.d.	n.d.	7	2.5	0	0	0.05
Copper	280	mg/l	<0.009	0.073	n.d.	n.d.	n.d.	n.d.	0.0141	35	12.5	0	0	2
Iron	280	mg/l	<0.23	1.8	n.d.	n.d.	n.d.	n.d.	n.d.	13	4.64	13	5	0.2
Lead	280	mg/l	<0.006	0.068	n.d.	n.d.	n.d.	n.d.	n.d.	8	2.86	3	1	0.01

Determinand	No. of Results	Unit	Min	Max	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Nickel	280	mg/l	<0.003	0.019	0.00458	0.003	0.0035	n.d.	0.011	143	51.1	0	0	0.02
Zinc	280	mg/l	<0.018	0.106	n.d.	n.d.	n.d.	n.d.	0.02	15	5.36	0	0	-
Nitrogen species														
Ammoniacal Nitrogen as N	280	mg/l	<0.06	3.31	0.114	n.d.	0.31	n.d.	0.37	99	35.4	13	5	0.39
Nitrogen (total oxidised) as N	280	mg/l	<0.7	4.4	1.16	0.8	0.943	n.d.	3	152	54.3	0	0	-

Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Figure 8.20 RTD ammoniacal nitrogen concentrations

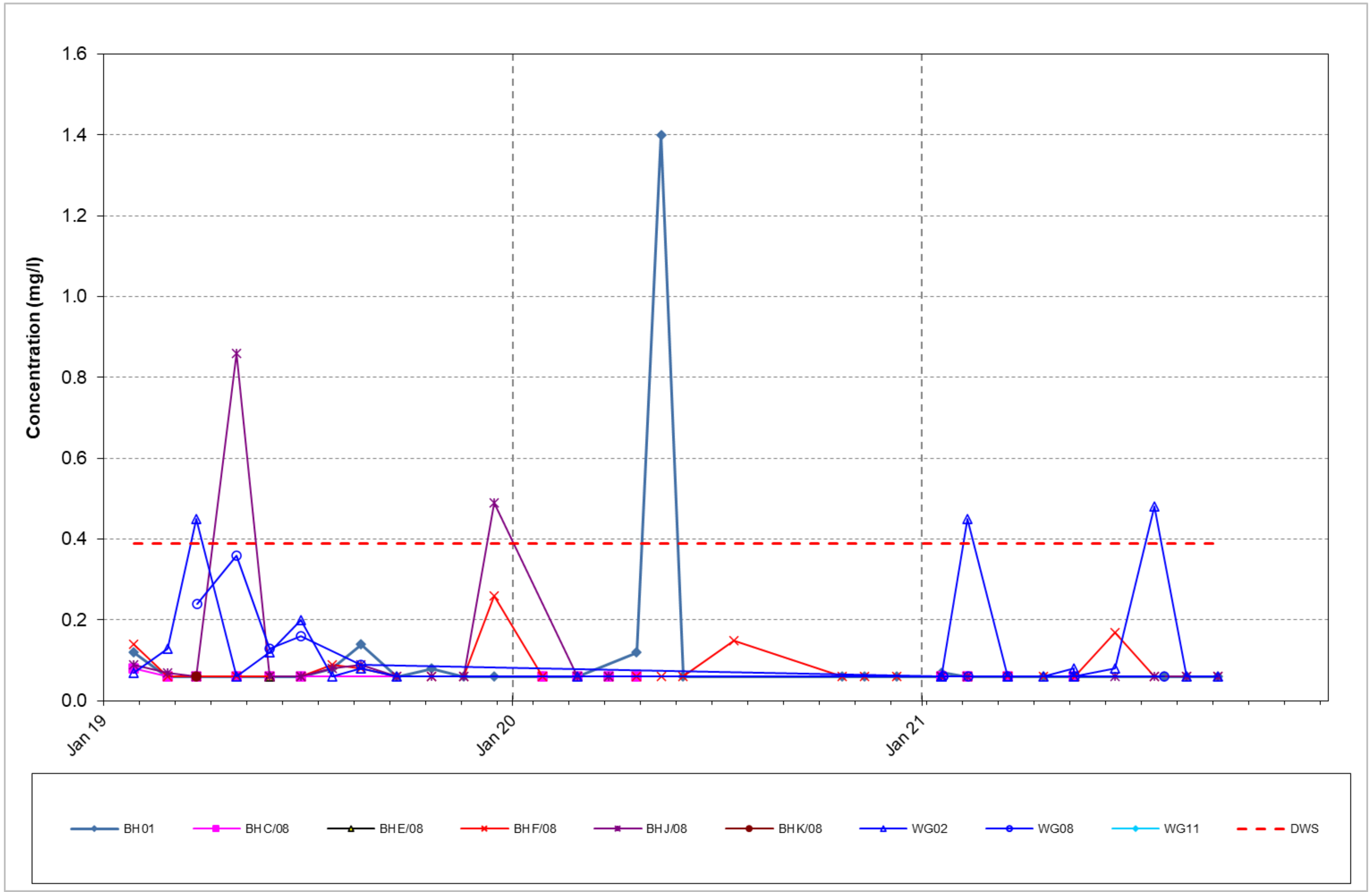
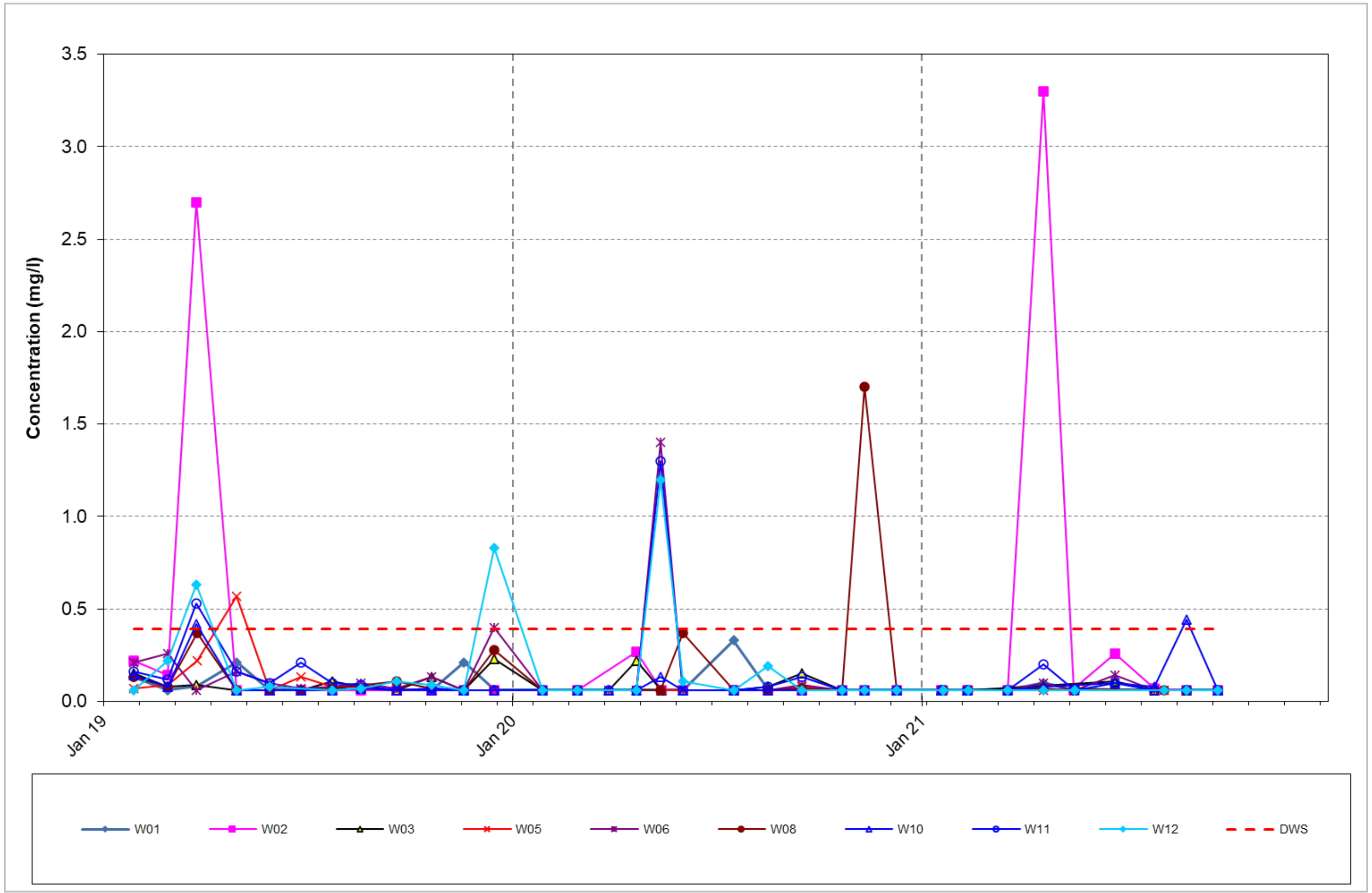


Figure 8.21 Solid strata ammoniacal nitrogen concentrations



8.5 Hydrogeological Conceptual Model

8.5.1 The Site lies on a peninsular between Southampton Water and the River Hamble. The elevation of the Site is between 15 and 20 mAOD with a gradual fall from north to south. To the south-west and east the land falls more steeply to these water bodies.

8.5.2 Figure 8.22 shows surface water catchments computed from LiDAR data. The Site itself is located on an interfluve with surface water drainage to the west within Catchments 2 and 3 and drainage to the east within Catchments 4, 5, 6, 7 and 8. RTD groundwater contours from Figure 8.17 are superimposed over the surface water catchments. The groundwater contours mostly cross the surface water catchment boundaries at right angles confirming that groundwater catchments are similar to surface water catchments.

8.5.3 Groundwater present in the north of the Site (at BHC/08) lies within Catchment 4 and it is likely that groundwater in this part of the Site flows towards Mallards Moor and Badnam Creek.

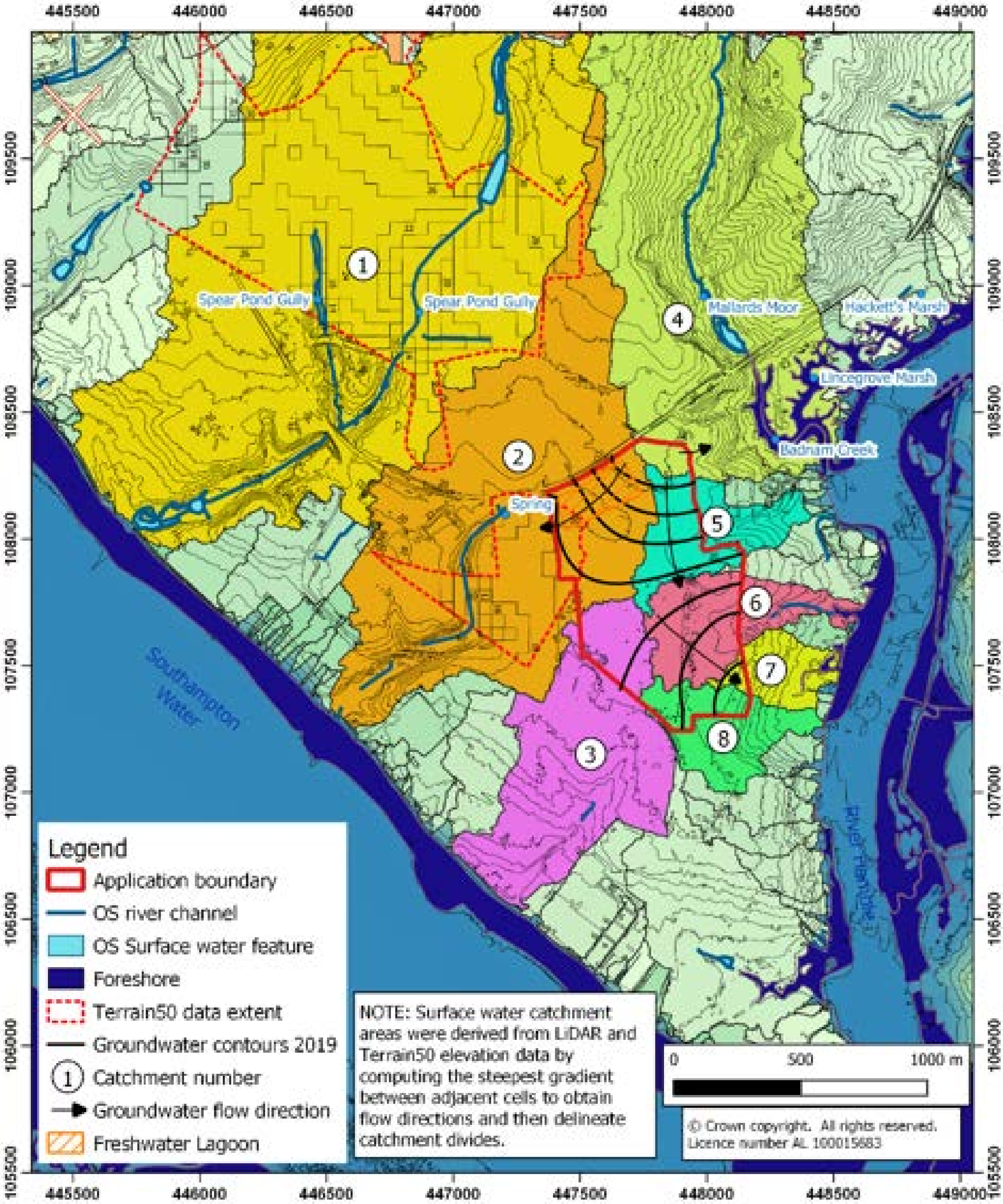
8.5.4 To the west of the Site the land falls away to a small water course which is fed from a spring close to the north-west corner of the Site. This spring is probably located at the base of the RTD, where it is cut through by the stream valley. Groundwater in the north-western third of the Site probably discharges to this water course. Groundwater contours suggest that groundwater flow is approximately parallel to the Site's northern boundary and thus there is little natural groundwater flow into the Site across this boundary.

8.5.5 Groundwater in the north-eastern part of the Site, that lies within Catchment 5 flows due south into the southern part of the Site. Groundwater in the southern part of the Site flows to the southeast discharging into the River

Hamble through surface water Catchments 6, 7 and 8 (which probably act as a single groundwater catchment).

8.5.6 Further to the northwest lies a stream that flows through Spear Pond Gully, which is located within surface water Catchment 1. Inspection of the geological map shows that the valley formed by this latter water feature cuts off the RTD to the northwest of the Site.

Figure 8.22 Surface water catchments



8.6 Proposed development

8.6.1 Phasing Plans for the proposed development are shown on Drawings 21-10_HAMBLE_PHASE 1.LSS to 21-10_HAMBLE_PHASE 9.LSS and the Restoration Plan is shown on Drawing 2021 21-08-HAMB-1717-P1-REST.

8.6.2 Sand and gravel will be extracted from the RTD only, so groundwater flow in the solid strata beneath the Site will remain unaffected.

8.6.3 During Site operation the applicant proposes to construct a freshwater lagoon in the Site's north-western corner, and it is anticipated that much of the groundwater flow in the RTD to the north of the Site will be captured by this lagoon and used for quarry operations. Thus, the net groundwater discharge from the Site during sand and gravel extraction will be reduced. The position of the freshwater lagoon is shown on Figure 8.22.

8.6.4 There may be a requirement to construct a low permeability geological barrier or attenuation layer around the perimeter and base of the imported material.

8.6.5 Given the limited groundwater saturated thickness at the Site, it is anticipated that limited dewatering will be required. Water collecting in the void, either from groundwater inflow, direct rainfall or rainfall runoff, will be pumped out to an adjacent area, thus allowing the mineral to be dug dry and facilitate the placement of the low permeability geological barrier / attenuation layer.

8.6.6 Following sand and gravel extraction, the Site will be restored using Site overburden and imported inert restoration materials. These materials, as well as the geological barrier / attenuation layer, are likely to be less permeable than the RTD that has been removed. A surface water drainage system is presented in the FRA (Stantec, 2021, Appendix 2.2) to manage surface runoff. Net infiltration to ground will be reduced compared to the baseline conditions and this may slightly reduce groundwater levels and flow directly under the

Site. However, excess water will be directed to linear infiltration trenches along the Site boundary outside of the excavation / infilled zone where it will infiltrate to ground and which will act to mitigate against any reduction in groundwater level and flow.

8.6.7 Given the Site's position on the interfluve, and as shown on Figure 8.22, there is likely to be relatively little groundwater inflow across the Site boundaries. Under baseline conditions rainfall recharge across the site forms the source of groundwater at the Site which then flows out of the Site to the northeast, west and southeast. Groundwater outflows from the Site are likely to be slightly reduced compared to the baseline.

8.7 Preliminary water risk assessment

8.7.1 The conceptual model can be described in terms of potential sources of contamination, receptors and pathways that link the sources to the receptors.

8.7.2 The potential source of contamination relates to the on-Site mineral extraction, processing activity and restoration of the Site. This includes the processing plant and associated fuel storage, offices, vehicle maintenance areas, etc. Imported restoration materials may also present a source of contamination.

8.7.3 The receptors of concern are groundwater, surface water and the spring present to the west of the Site as shown on Figure 8.22.

8.7.4 Pathways are likely to include:

- pathway from source to groundwater; and
- pathway from source to surface water via groundwater.

8.7.5 Risks associated with this source, pathway, receptor linkages are presented in the following sections.

8.8 Embedded Mitigation

8.8.1 The Site is located on the interfluve with surface water and groundwater drainage to the north-east, west and south-east. Thus, there is relatively little groundwater inflow across the Site boundary which will mitigate any groundwater head building up against the lower permeability material used to restore the Site.

8.8.2 Rainwater falling to the ground will infiltrate the topsoils where it will be subject to evaporation and transpiration losses. The ground surface at the Site is quite flat and it is expected that the balance of water will form recharge to the underlying RTD. Replacing the RTD with quarry overburden or imported inert materials may result in a reduction in the infiltration capacity of the ground, with a higher proportion of rainwater draining to surface water features. A post restoration surface water drainage strategy has been developed for the Site and is discussed in the FRA (Stantec, 2021, Appendix 2.2).

8.8.3 During the operational phase the Site will consume some groundwater from a freshwater lagoon to be constructed in the northwest corner of the Site. It is estimated that only 5% of the water taken for gravel processing is lost (primarily due to retention in the product) with the remaining 95% returned to the silt lagoons where the silt settles out and this water is recycled. It is estimated that the Site will consume between 10 and 40 m3/hr. Thus, during this phase there will be a small net reduction in groundwater discharge from the Site.

8.8.4 The post restoration surface water drainage system is designed to manage surface runoff and route it to surface water courses and / or wetland features where it can be lost as evapotranspiration and provide additional ecological benefit. Excess water will be routed to linear infiltration trenches along the boundary of the Site (outside of the excavation/infilled zone) where it will infiltrate the RTD.

8.8.5 There are no significant surface water bodies at the Site under baseline conditions that need protecting.

8.8.6 Groundwater level and quality monitoring is undertaken at the Site allowing a comprehensive baseline dataset to be assembled. This monitoring will continue during the operational, restoration and, for a limited time, post-restoration phases to ensure the Site is performing as anticipated and is not having a detrimental effect on groundwater or surface water receptors.

8.8.7 The risk associated with hydrological conditions in terms of flooding is assessed in the accompanying FRA and it is considered that the restoration of the Site does not represent an increased flood risk.

8.9 Likely Significant Environmental Effects

Receptor sensitivity

8.9.1 The receptor of concern is groundwater and surface water via groundwater discharge. There are no surface water receptors at the Site. Where groundwater discharges to surface water, any impact to surface water must be less than groundwater due to dilution within the groundwater and surface water bodies. Therefore, there may be an indirect effect on surface water.

8.9.2 Groundwater under the site (in the RTD and solid strata) is a Secondary A aquifer. Groundwater quality at the Site is of a high quality. Following the guidance given in Table 8.1, groundwater under the Site is therefore considered to be of high sensitivity.

Impact magnitude

1 - Potential changes to long term groundwater level and flow due to quarrying activities

8.9.3 Given the Site's position on an interfluve with little groundwater present within the RTD, there will be very little impact on groundwater level or flow. During the operational phase there may be a very small net reduction in groundwater level as groundwater will be used for mineral processing purposes. Post-restoration, the topsoils and subsoils placed back on the Site will be the same as the baseline. There may be less rainwater infiltration into the Site due to the lower permeability restoration materials and excess surface water will be routed to surface water features. There will be overflows from these surface water features to linear infiltration trenches along the boundary of the Site (outside of the excavation / infilled zone) where the water will infiltrate to ground. Therefore, the net magnitude of the impact on groundwater level and flow is assessed as being negligible.

2 - Potential impacts on designated environmental sites

8.9.4 As shown on Figure 8.12 there are designated environmental sites along the foreshore of the River Hamble and Southampton Water. These are associated with brackish and estuarine waters. The very small reduction in groundwater flow as a result of the Site development is considered to have negligible impact on these sites.

3 - Potential Impacts from spills from plant operating on site

8.9.5 There is relatively little groundwater in the RTD. At the excavation face, any groundwater ingress or rainwater collection will be pumped away to a different part of the Site, thus keeping it dry. Any fuel or oil leaks from machinery operating at the excavation face can therefore easily be observed and cleaned up.

8.9.6 No fuel will be stored, and no fuelling activities carried out within the extraction / restoration areas. Fuel storage tanks will be bunded in line with good management practice. The Site drainage system will be inspected on a regular basis to ensure that the there is no visible oil present and there are no reported incidents of spills. An environmental management system would remain in place to ensure best practice occurs.

8.9.7 Should spills get into groundwater, there would be limited opportunity for dilution or attenuation due to the limited flow at the Site. Therefore, the impact magnitude is assessed as being moderate.

4 - Potential Impacts from importation of restoration materials

8.9.8 There is the potential for contaminants present in the restoration materials to leach into groundwater. However, only inert restoration materials will be accepted to the Site and the Applicant will apply strict acceptance procedures to ensure that contaminated material is not accepted. Restoration via imported materials would be undertaken via an Environmental Permit and additional controls such as a geological barrier / attenuation layer may be required to further protect groundwater. Therefore, this impact magnitude is assessed as slight.

5 - Changes to flood storage

8.9.9 An FRA (Stantec, 2021) has been undertaken for the site and is provided as Appendix 2.2. During the operational phase, the freshwater lagoon will provide additional flood storage capacity. The lagoon will be filled in as part of the restoration, but the final restoration includes additional surface water bodies. Calculations show that the Site's proposed surface water drainage scheme would be capable of attenuating all incoming runoff from a 1 in 100-year storm event, after allowing for a 40% increase due to climate change without surcharging water off-site. Given the Site's position on an interfluve, the sensitivity of this receptor is medium. This impact magnitude is assessed as slight improvement.

Significance and nature of effects

8.9.10 Table 8.14 presents a summary of the receptor sensitivity and impact magnitude and the resulting significance as defined in Table 8.3.

Table 8.14 Summary of receptor sensitivity, impact magnitude and significance

Number	Nature of Impact	Receptor	Sensitivity	Magnitude	Significance
1	Water Level & flow	Groundwater	High	Negligible	Neutral
2	Designated environmental sites	Groundwater	high	Negligible	Neutral
3	Water quality from quarrying activities	Groundwater	High	Moderate	Major/ Intermediate
4	Water quality from restoration activities	Groundwater	High	Slight	Intermediate/ Minor
5	Changes to flood storage	Surface water	Medium	Slight (improvement)	Minor (improvement)

8.10 Additional Mitigation, Compensation, Enhancement Measures

8.10.1 Water quality impacts from quarrying activities are assessed as having major / intermediate significance. Following good Site management practice, keeping fuels in bunded tanks and keeping spill kits on Site in case of accidents will provide the necessary mitigation to reduce the significance to minor or neutral.

8.10.2 The restoration activities will be undertaken in accordance with an Environmental Permit as to be agreed with the Environment Agency. Risk assessments will be provided with the Permit application to demonstrate that there will be no adverse risk to groundwater. These risk assessments may result in more stringent controls being applied to the restoration materials accepted at the Site. It is also likely that there will be a requirement to install a geological barrier / attenuation layer below and around the imported material. These measures will ensure that the significance is reduced to minor or neutral.

8.10.3 Groundwater level and quality will continue to be monitored at the Site perimeter wells throughout the operational lifetime of the Site and for at least five years of aftercare. The purpose of this monitoring will be to confirm the expected impacts on groundwater level, flow and quality.

8.11 Conclusion

8.11.1 The hydrogeology and hydrology chapter considers the potential hydrological and hydrogeological impacts associated with the proposed excavation of sand and gravel, together with progressive restoration of the site using existing overburden and imported inert restoration materials.

8.11.2 The Site lies on an interfluve with surface water shed to the east towards the River Hamble and west towards Southampton Water. A small spring is present to the west of the Site at the head of a small stream that discharges to Southampton Water.

8.11.3 The Site is underlain by RTD overlying clayey material comprising the MFF and sandier material comprising the SSF. Given the Site's position on the interfluve, there is relatively little groundwater present within the RTD.

8.11.4 An impact assessment has been undertaken of the proposed excavation and subsequent restoration with imported inert restoration materials. A number of embedded mitigation factors are taken into account and the impact assessment suggests that there will be no significant impacts on groundwater, surface water or the spring feature.

8.11.5 A number of additional mitigation, compensation and enhancement measures are proposed to ensure that impacts from the Site are not significant.

8.11.6 Groundwater monitoring for level and quality will continue at the existing Site perimeter monitoring wells for a period of time post restoration to confirm that the Site is not having an impact on groundwater or surface water.

8.12 References

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