Hampshire Water Transfer and Water Recycling Project

6.2 Environmental Statement Vol II Appendix 11.2 Geotechnical and geo-environmental reports - 6 of 18 documents - Geotechnical and Geo-environmental Interpretative Report for Ground Investigation in Section H (Phase 2 and Phase 3B/3C) Addendum to Summary Report

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1 Introduction and Objectives

This document has been updated at Deadline 1 to include groundwater sampling results in Appendix D for locations 3H4517SA and 3H4600SA. References to other Application documents have not been updated from the original submission. Please refer to the latest version of the Guide to the Application (Document reference 1.3, Volume 1) for the list of current versions of documents.

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1.1 Background and Scheme Overview

Water for Life Hampshire (WfLH) is a programme being undertaken by Southern Water Services Limited (hereafter referred to as 'the Applicant') to address the sustainability objectives of reduced abstractions on Hampshire's two main rivers, the River Test and River Itchen, and to ensure a resilient water supply for the Applicant's customers during times of drought. The Hampshire Water Transfer and Water Recycling Project (HWTWRP) (hereafter referred to as the 'Proposed Development') is the Strategic Resource Option project being delivered as part of the WfLH programme (Southern Water, 2024). An overview of the Proposed Development, at the time of this report production, is provided in the Applicant's HWTWRP Technical Document Technology Guide (Southern Water, 2024).

1.2 Terms of Reference

Strategic Solutions Partner (SSP) has been instructed by the Applicant as part of the Proposed Development to produce a Geotechnical and Geo-environmental Interpretative Report for ground investigations (GI) completed for the construction of the proposed underground pipeline within the Draft Order Limits (DoL). The Proposed Development has been divided into 12 Sections by the Applicant; these are referred to as Sections A to M (excluding I).

1.3 Ground Investigation Programme

The GI for the Proposed Development is being completed using a phased approach, as shown in **Table 1.1**~~**Table 1.1**~~. This document reports the findings of the GI works completed during Phase 2 and Phase 3B/3C within Section H only.

Table 1.1: Ground Investigation Programme

GI Phase	Description
Phase 0	This, with Phases 1 and 3A, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), as specified by SSP (AECOM), primarily for the purpose of tunnel and shaft design (Sections B, C, D and M only) and comprised 11 boreholes.
Phase 1	This, with Phases 0 and 3A, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), as specified by SSP (AECOM), primarily for the purpose of tunnel and shaft design (Sections B, C, D, L and M only) and comprised 35 exploratory hole locations.
Phase 2	This is part of a wider phased GI conducted along the route between February 2023 and July 2023 by SOCOTEC for Clancy (Principal Contractor), as specified by SSP, primarily for the purpose of investigating areas for non-pipeline infrastructure, trenchless crossings and potential sources of contamination (PSC).
Phase 3A	This, with Phases 0 and 1, was completed between July 2022 and October 2023 by SOCOTEC for Clancy (Principal Contractor), as specified by SSP (AECOM), primarily for

GI Phase	Description
	the purpose of tunnel and shaft design (Sections B, C, D, L and M only) and comprised 14 exploratory hole locations.
Phase 3B/3C	This, with several Phase 2 GI locations was completed between May 2023 and May 2024 by SOCOTEC for Clancy (Principal Contractor), as specified by SSP, primarily for the purpose of investigating areas for non-pipeline infrastructure, trenchless crossings, PSCs and the linear route.

1.4 Section H Ground Investigation Objectives

The Phase 2 & Phase 3B/3C Section H GI investigated the following:

- Several areas of potential sources of contamination (PSCs) deemed of moderate/low risk or higher, as identified within HWTWRP Geotechnical and Geo-Environmental Desk Study Version 4 (SSP, 2024).
- The linear route at regular intervals to prove the geological conditions in line with Eurocode 7: Part 2 (BSI, 2007) recommendations.
- Trenchless crossings beneath major roads including A334 Winchester Road; Shirell Heath High Street and Winchester Road (B2177).

The Phase 2 and Phase 3B/3C Section H GI comprised the following:

- Two exploratory hole locations associated with launch/reception locations at the proposed trenchless crossing beneath Shirell Heath High Street (2H4500DR and 2H4501DR).
- Two exploratory hole locations (2H4502DS and 2H4503DS) positioned south of a historical landfill (Shirell Heath Sand Pit), and approximately 20 m and 5 m respectively from the DoL.
- One exploratory hole location associated with the reception shaft location at the proposed trenchless crossing beneath Winchester Road B2177 (3H4517SA).
- One exploratory hole location associated with the launch location at the proposed trenchless crossing beneath Winchester Road A334 (3H4600SA).
- Eight locations to prove the geology along the linear route to comply with Eurocode 7: Part 2 comprising 3H4507HP, 3H4511HP, 3H4513HP, 3H4514HP, 3H4515HP, 3H4602HP, 3H4603HP and 3H4606HP.

Borehole 3H4600SA corresponds with 3G4102SA on the western side of the trenchless crossing of A334 (Winchester Road). As the boundary of Section G / H is between 3G4102SA and 3H4600SA, 3G4102SA is discussed within Section G GIR (710166-SWS-XX-XX-RP-GE-00103). Similarly, borehole 3H4517SA connects with 3J5002SA on the western side of the trenchless crossing of B2177 Winchester Road, borehole 3J5002SA is discussed in Section J GIR (710166-SWS-XX-XX-RP-GE-00109).

The GI targeted identified PSCs with a risk rating of moderate/low or higher as identified within HWTWRP Geotechnical and Geo-Environmental Desk Study Version 4 (SSP, 2024). Several PSCs identified within a 50 m radius of the proposed DoL in Section H were not investigated during Phase 2 and Phase 3B/3C. These included unspecified ground workings (PSC 445), which may be associated with an old sand pit (PSC 103), disturbed ground (PSC 78), former tanks (PSCs 80 and 81) and a possible pig farm (PSC 512). One hand dug trial pit was excavated in the area of the possible pig farm. It is expected that the contractor will further assess identified PSCs (where additional information is needed), and other, additional PSCs, identified during subsequent phases of the Proposed Development as part of their construction phase works, to understand and comply with contaminated land, health & safety, waste classification and any other relevant guidance.

1.5 Report Format

This report comprises both geotechnical and geo-environmental interpretation of data collated during the GI as outlined below:

Section 1 Introduction and report objectives.

Section 2 Description including the location and site description.

Section 3 Summary of the Ground Investigation (SOCOTEC, 2023) (SOCOTEC, 2024).

Section 4 Ground Model.

Section 5 GI results, data interpretation and geo-environmental risk assessment, and geo-environmental considerations for the outline proposed works.

Section 6 Development of the land contamination risk assessment model from the GI.

Section 7 Geotechnical testing and assessment including geotechnical summary tables and figures and design parameters.

Section 8 Geotechnical considerations including hazard and mitigation table, discussions on ground conditions, foundation design, excavations, groundwater control, flotation, trenchless construction and concrete aggressivity.

Section 9 Conclusions.

Section 10 Recommendations based on the results of the GI.

This report provides a summary of encountered ground conditions, existing GI results, geotechnical and geo-environmental interpretation of analysis undertaken to inform design of potential future structures and pipeline, health and safety of construction and future ground workers (construction), and excavated materials (waste) management.

A land contamination risk assessment for other potential future receptors such as farmers/ farm workers or members of the public accessing and working within the Proposed Development is outside the scope of this report. Further ground investigation and human health risk assessment may be required to determine the risk to these, and any other identified potential future receptors, particularly in regard to appropriate excavated materials management (e.g. proposed reuse of soils).

Assessment of the GI data collected across the other Proposed Development Sections is included in the separate relevant sectional reports which are collated in the HWTWRP Geotechnical and Geo-environmental Interpretative Summary Report (Phase 2 and Phase 3B/3C) (Ref. 710166-SWS-XX-XX-RP-GE-00100).

2 Section H Description

2.1 Location and Description

The majority of the approximate 2.7 km length of Section H DI pipeline at 1200 mm diameter will be constructed using open-cut methods at between 3 and 6 m below ground level (bgl) across arable fields and minor roads with trenchless construction between approximately 5 and 9.8 m bgl beneath major roads such as High Street, Shirrell Heath. Temporary launch and reception shafts at the trenchless crossing locations will be excavated; Launch shaft dimensions will range between 9.0 – 9.5 m diameter and reception shafts will range between 5.0 – 5.4 m diameter. Section H route and exploratory holes are shown in the **Figures** section.

The Proposed Development route (from south to north) is as follows:

- Section H begins as a trenchless crossing at Winchester Road (A334) and runs parallel to Blind Lane (National Grid Reference (NGR) 456743E, 112246N) at approximately 54 m Ordnance Datum (OD).
- The route then travels northeast and north across agricultural/arable fields towards Pricketts Hill.
- The route progresses north beneath a small watercourse in an open-cut trench to the south of Cloverfield Farm (NGR 457094E, 112996N) at approximately 38 m OD, the lowest elevation of Section H.
- The route then progresses across fields, using open-cut construction, north and northwest towards Shirrell Heath, with a trenchless crossing beneath High Street.
- Finally, the Proposed Development progresses northwest and west, across agricultural/arable fields using open cut construction, to Black Horse Lane and then north and northwest ending as at a trenchless crossing at Winchester Road, north of Five Oaks Farm at approximately 66 m OD (NGR 456086E, 114059N), the highest point of Section H.

3 Phase 2 and Phase 3B/3C Ground Investigation

3.1 Rationale for Ground Investigation Locations

The Phase 2 GI across Section H focused on one PSC identified by the desk study to have a risk classification of Moderate for human health (construction workers, maintenance workers and future site users) (SSP, 2024); Shirrell Heath Sand Pit Historical Landfill (PSC 90) located within the 50 m boundary of the DoL. Other boreholes were drilled to target proposed excavation areas for trenchless crossings.

Phase 3B/3C investigations were completed to target proposed excavation areas for trenchless crossings, the linear route and to allow geotechnical testing to be undertaken. Several of these GI locations coincided with areas within 50m of identified PSCs and geo-environmental testing was scheduled. The rationale for the Phase 2 and Phase 3B/3C GI borehole locations is summarised in **Table 3.1.**

Table 3.1: Rationale for Locations in Section H

Hole ID	Rationale for GI Location [1]
3H4600SA	To investigate the proposed excavation area for the launch location at the trenchless crossing beneath Winchester Road A334. The data obtained are also used to investigate potential contamination from a potentially infilled gravel pit (PSC 45 approximately 45 m south of the borehole and approximately 5 m from the DoL).
3H4602HP	To confirm the geology along the linear route.
3H4507HP	To confirm the geology along the linear route. The data obtained has also been used to investigate potential contamination from a possible pig farm (PSC 512). The hand pit is located within the DoL and within the PSC.
3H4511HP	To confirm the geology along the linear route.
3H4603HP	
3H4513HP	
3H4514HP	
3H4515HP	To confirm the geology along the linear route. The data obtained can also be used to investigate potential contamination from possibly infilled land – disturbed ground (PSC 78) located within the DoL. The hand pit is located within the DoL approximately 30 m north of the PSC.
2H4500DR	To investigate proposed excavation areas for trenchless crossing (east of High Street, Shirrell Heath)
2H4501DR	To investigate proposed excavation areas for trenchless crossing (west of High Street, Shirrell Heath)
2H4502DS	To investigate potential contamination from the nearby Shirrell Heath Sand Pit Landfill (PSC 90). The boreholes are located approximately 20 m from the PSC, and approximately 20 m and 5 m respectively from the DoL[2].
2H4503DS	
3H4606HP	To confirm the geology along the linear route. The data obtained can also be used to investigate potential contamination from PSC 90 located approximately.70 m northeast of the hand pit.
3H4517SA	To investigate proposed excavation area for the reception shaft at the proposed trenchless crossing beneath Winchester Road B2177. The data obtained can also be used to investigate potential contamination from a potentially infilled sand pit (PSC 103 c.20 m west of the borehole), and from an area of unspecified worked ground (PSC 445 c. 35 m north of the borehole).

[1] PSCs within a 50 m buffer of the Section H DoL, which warranted further investigation, were identified by the desk study (SSP, 2024).
[2] 2H4502DS and 2H4503DS were originally planned within the DoL, though due to ecological reasons, the boreholes had to be moved to their drilled locations after the GI specification was issued. They are still between the PSC and proposed DoL.

3.2 Section H Ground Investigation

GI was carried out at selected locations across Section H by SOCOTEC. The investigation was completed between 28th February 2023 and 25th April 2023 (Phase 2) and then 1st November 2023 to 22nd May 2024 (Phase 3B/3C). The investigation scope was specified by SSP (SSP, 2022a), (SSP, 2023b) (SSP, 2023c).

The following exploratory holes were completed during the Phase 2 GI:

- Two boreholes (2H4500DR and 2H4501DR), completed by dynamic sampling with rotary coring follow-on, to depths of 20.0 m and 20.2 m below ground level (bgl).
- Two boreholes (2H4502DS and 2H4503DS), completed by dynamic sampling only, to depths of 4.0 m and 5.45 m bgl.

The following exploratory holes were completed during the Phase 3B/3C GI:

- Two boreholes (3H4517SA and 3H4600SA), completed by cable percussion, to depths of 18.50 m and 20.00 m bgl.
- Eight hand excavated trial pits were completed (3H4507HP, 3H4511HP, 3H4513HP, 3H4514HP, 3H4515HP, 3H4602HP, 3H4603HP and 3H4606HP) to depths between 1.10 and 1.20 m bgl.

A plan showing the exploratory hole locations is presented in the **Figures** section. The scope of the GI included: in-situ geotechnical tests, resistivity testing, hand vane and falling head permeability testing, volatile headspace testing by Photo Ionisation Detector (PID), geotechnical and geo-environmental sampling and groundwater and gas monitoring.

The details of the GI, tests and laboratory analysis are presented in the SOCOTEC Ground Investigation Report (SOCOTEC, 2023) (SOCOTEC, 2024). A description of GI locations is shown in **Table 3.2**.

Table 3.2: Description of GI Locations

Hole ID	National Grid Reference [1]	Location Description
3H4600SA	456776, 112113	Located in a field 25 m east of A334 Winchester Road, northwest of Wickham.
3H4602HP	457072, 112188	Located in a field approximately 150 m south of Blind Lane, north of Wickham.
3H4507HP	457145, 112357	Located in a field approximately 25 m south of Blind Lane, north of Wickham.
3H4511HP	457138, 112467	Located in a field between Pricketts Hill and approximately 85 m north of Blind Lane, north of Wickham.
3H4603HP	457114, 112665	In a field approximately 30 m north of Pricketts Hill, southeast of Shedfield.
3H4513HP	457045, 112950	Located in a farmer's field east of residential housing and approximately 130 m east of Pricketts Hill, southeast of Shedfield.
3H4514HP	457000, 113116	Located in a farmer's field amongst farm buildings approximately 155 m to the east of Pricketts Hill, southeast of Shedfield.
3H4515HP	456986, 113268	Located in a farmer's field immediately adjacent to a private road, approximately 230 m east of Pricketts Hill, east of Shedfield.
2H4500DR	456963, 113619	Located within a field accessed by a track approximately 120 m southeast of Nightingale Crescent off High Street, Shirrell Heath.
2H4501DR	456830, 113718	Located within a field approximately 25 m northwest of High Street and approximately 15 m to 20 m southwest of residential housing (Earlsfield).
2H4502DS	456696, 113886	

Hole ID	National Grid Reference [1]	Location Description
3H4600SA	456776, 112113	Located in a field 25 m east of A334 Winchester Road, northwest of Wickham.
3H4602HP	457072, 112188	Located in a field approximately 150 m south of Blind Lane, north of Wickham.
3H4507HP	457145, 112357	Located in a field approximately 25 m south of Blind Lane, north of Wickham.
3H4511HP	457138, 112467	Located in a field between Pricketts Hill and approximately 85 m north of Blind Lane, north of Wickham.
2H4503DS	456656 113905	Located within a field approximately 230 m to 270 m northwest of High Street, Shirrell Heath. Both GI locations are approximately 20 m southwest of Shirrell Heath Sand Pit Historical Landfill.
3H4606HP	456628, 113869	Located in a farmer's field approximately 305 m east of Winchester Road B2177, orth east of Shedfield.
3H4517SA	456425, 113815	Located in a farmer's field adjacent to forest, approximately 105 m east of Winchester Road B2177, north of Shedfield.

[1] As provided in the Final factual GI reports (SOCOTEC, 2023) (SOCOTEC, 2024).

3.3 Exploratory Holes and Monitoring Well Installations

The exploratory hole locations and borehole logs are presented in SOCOTEC's Ground Investigation Reports (Factual Account of Fieldwork Monitoring and Laboratory Testing) (SOCOTEC, 2023) (SOCOTEC, 2024).

Table 3.3 provides a summary of the locations and installation response zones. Groundwater and gas monitoring wells were installed in 2H4501DR, 2H4502DS, 2H4503DS, 3H4517SA and 3H4600SA.

Table 3.3: Summary of Groundwater and Ground Gas Monitoring

Hole ID	Response Zones (m bgl)	Groundwater Monitoring Rounds	Gas Monitoring Rounds	Groundwater Samples Collected
2H4500DR	0.0 – 6.5 (Whitecliff Sand Member)	12 No. 26/04/23, 15/05/23, 19/06/23, 17/07/23, 15/08/23, 12/09/23, 09/10/23, 13/11/23, 12/12/23, 10/01/24, 08/02/24, 06/03/24	N/A (only monitored for groundwater)	1 No. 17/07/23
2H4501DR	3.0-11.0 (Whitecliff Sand Member)	13 No. 04/05/23, 24/05/23, 19/06/23, 17/07/23, 15/08/23, 12/09/23, 10/10/23, 13/11/23, 11/12/23, 10/01/24, 08/02/24, 06/03/24, 09/04/24	13 No. 04/05/23, 24/05/23, 19/06/23, 17/07/23, 15/08/23, 12/09/23, 10/10/23, 13/11/23, 11/12/23, 10/01/24, 08/02/24, 06/03/24, 09/04/24	3 No. 03/05/23, 17/07/23, 16/09/23
2H4502DS	1.0-3.0 (Whitecliff Sand Member)	6 No. 26/04/23, 03/05/23, 04/05/23, 24/05/24, 19/06/24, 17/07/23	5 No. 04/05/23, 24/05/23, 19/06/23, 15/08/23, 12/09/23	1 No. 04/05/23
2H4503DS	1.0-5.0 (Head & Whitecliff Sand Member)	6 No.	7 No. 19/04/23, 04/05/23, 24/05/23, 19/06/23,	4 No. 28/02/23, 03/05/23, 17/07/23, 16/09/23

Hole ID	Response Zones (m bgl)	Groundwater Monitoring Rounds	Gas Monitoring Rounds	Groundwater Samples Collected
		19/04/23, 03/05/23, 04/05/23, 24/05/24, 19/06/24, 17/07/23	17/07/23, 15/08/23, 12/09/23	
3H4517SA	5.0 – 11.0 (Whitecliff Sand Member & London Clay Formation)	8 No. 03/04/24, 17/04/24, 01/05/24, 08/05/24, 22/05/24, 29/05/24, 17/06/24, 03/07/24	8 No. 03/04/24, 17/04/24, 01/05/24, 08/05/24, 22/05/24, 29/05/24, 17/06/24, 03/07/24	*3 No. 17/04/24, 01/05/24, 22/05/24
3H4600SA	7.0 – 10.0 (Wittering Formation)	6 No. 29/07/24, 12/08/24, 20/08/24, 28/08/24, 02/09/24, 30/09/24	6 No. 29/07/24, 12/08/24, 20/08/24, 28/08/24, 02/09/24, 30/09/24	2 No. 12/08/24, 20/08/24

Response zones depths and monitoring/sampling dates are taken from the SOCOTEC Ground Investigation Reports (SOCOTEC, 2023) (SOCOTEC, 2024).
*4 collected though only 3 samples analysed by the lab.

3.4 Geo-Environmental Testing

Geo-environmental laboratory testing was scheduled by SSP on selected soil and groundwater samples recovered during the GI works. The testing was carried out by SOCOTEC at their UKAS accredited environmental chemistry laboratory at Bretby, near Burton-on-Trent, in accordance with MCERTS accreditation (where applicable). The scope of testing is listed in **Appendix B** and shows that for several soil samples taken during the Phase 2 GI requested chemical analyses were not included in either AGS format or the Ground Investigation Report (SOCOTEC, 2023) (SOCOTEC, 2024). Subsequent requests were made to the analytical laboratory but the data has not been forwarded.

3.5 Geotechnical Testing

Geotechnical testing was scheduled, by SSP, on selected soil samples recovered during the GI works. The testing was carried out by nominated UKAS accredited geotechnical laboratories including: GEOLABS, near Watford, The Testing Lab (TTL) near Doncaster, and Derwentside Environmental Testing Services Ltd (DETS) near Durham. Depending on the samples available, the testing comprised a combination of moisture content, Atterberg limits, density (linear), particle size distribution, saturation moisture content (chalk), unconfined compressive strength, point load index testing, unconsolidated undrained triaxial, compaction, chalk crushing value, chalk carbonate content, BRE testing, organic matter content and loss on ignition, as appropriate. The tests completed are presented in the SOCOTEC final factual reports (SOCOTEC, 2023) (SOCOTEC, 2024).

4 Ground Model

4.1 Geological Setting

Head Deposits underlie Section H, between approximately the Pricketts Hill road crossing and around 200m southeast of the trenchless crossing at High Street, Shirrell Heath. River Terrace Deposits are encountered between A334, Blind Lane and Mill Lane. Superficial deposit extents are shown in **Table 4.1**.

Table 4.1: Summary of Mapped Superficial Deposits at Ground Level

Chainages	Geology	Typical Description
18700 - 19170	River Terrace Deposits	Undifferentiated sand and gravel
19170 - 19730	Not present	-
19730 - 20200	Head Deposits	Variable deposits of sandy silty clay, locally gravelly; chalky and flinty in dry valleys
20200 - 21300	Not present	-

The chainages have been provided by the Applicant as of 12 March 2024 as part of the Summer 2024 Design Consultation Route.

London Clay Formation bedrock crops out east of the route. Bedrock is shown to comprise Wittering Formation (clay and sand) between A334, Blind Lane and northwards to Pricketts Hill. To the north of Pricketts Hill Road, the London Clay Formation has a distinct mapped member, Whitecliff Sand Member, that outcrops for approximately 170 m in a northern direction. The London Clay Formation continues north to within approximately 80 m to 400 m southeast of Nightingale Crescent, transitioning back to its distinct Whitecliff Sand Member around the trenchless crossing, which also crops out northwest along the pipe route towards Gamblins Lane. Mapped bedrock extents are shown in **Table 4.2**.

Table 4.2: Summary of Mapped Bedrock at Ground Level

Chainages	Geology	Typical Description
18700 - 19500	Wittering Formation	Olive grey, laminated clays with sand and silt.
19500 - 19700	London Clay Formation - Whitecliff Sand Member	Fine silty sand with rounded pebbles beds.
19700 - 20100	London Clay Formation	Grey and brown silty and sandy clays with sandy and pebbly beds.
20100 - 20375	London Clay Formation - Whitecliff Sand Member	Fine silty sand with rounded pebbles beds.
20375 - 20665	London Clay Formation	Grey and brown silty and sandy clays with sandy and pebbly beds.
20665 - 21400	London Clay Formation - Whitecliff Sand Member	Fine silty sand with rounded pebbles beds.

The chainages have been provided by the Applicant as of 12 March 2024 as part of the Summer 2024 Design Consultation Route.

4.2 Section H Ground Investigation Results

4.2.1 Encountered Ground

A brief summary of the ground conditions encountered during the GI is provided in **Table 4.3** and **4.4**. Exploratory hole logs and more details are presented in the Factual GI Reports (SOCOTEC, 2023) (SOCOTEC, 2024) .

Chainages across the route for Section H are between 18700 and 21400.

In general, ground conditions encountered in the exploratory holes match that predicted by the geological mapping, however there were several instances where mapping wasn't correct. Geological maps are for guidance only, and minor variations between the encountered ground conditions and geological mapping are to be expected.

A layer of 'dense black well-rounded medium and coarse gravel of flint with a matrix of grey locally shelly clay' was encountered in 2H4500DR between 18.50 and the base of the borehole at 20.00 m bgl. London Clay Formation in this region generally comprises four upward coarsening sedimentary cycles comprising a basal flint pebble bed followed by a silty clay, and then a sand bed at the top. In this case, the Whitecliff Sand Member is categorised by King as marking the upper bed 'D' cycle (King, 1981). The dense black gravel may mark the base of bed D (i.e. D/C boundary), though this is not certain.

3H4517SA had a scheduled depth of 20.0 m but terminated at 18.50 m bgl due to very stiff clay / hard strata. Drillers were unable to seal the borehole to prevent groundwater ingress and undertake chiselling.

Table 4.3: Summary of Encountered Ground Conditions for Section H Exploratory Holes

Exploratory Hole ID:		2H4500DR	2H4501DR	2H4502DS	2H4503DS	3H4507HP	3H4511HP	3H4513HP	3H4514HP
Chainage (m)		20630	20800	21020	21075	19235	19345	19870	20075
Ground Level (m OD)		+61.33	+66.16	+61.46	+60.03	+57.94	+60.95	+43.12	+47.35
Strata	Typical description	Top to base (m bgl)							
Topsoil	Very soft to soft dark brown sandy gravelly CLAY locally SILT with frequent rootlets. / Dark brown slightly gravelly clayey or silty SAND with abundant rootlets. Gravel is of flint and chert.	0.00 – 0.25	0.00 – 0.42	0.00 – 0.28	0.00 – 0.15	0.00 – 0.35	0.00 – 0.25	0.00 - 0.40	0.00 - 0.30
Head Deposits	Orangish brown gravelly clayey fine to coarse SAND. Gravel is subangular to subrounded fine to medium chert.	-	-	-	-	-	-	-	0.30 – 0.60
	Soft to firm light yellowish brown sandy gravelly CLAY, with low cobble content. Sand is fine to coarse. Gravel and cobbles are of flint.	0.25 – 0.80	-	-	0.15 – 3.95	-	-	0.40 – 1.20	0.60 – 1.20
Wittering Formation	Orangish brown sandy CLAY. Sand is fine.	-	-	-	-	0.35 – 1.20	0.25 – 1.20	-	-
London Clay Formation - Whitecliff Sand Member	Dense to very dense (locally loose within 2H4503DS at 4 m bgl) light greyish brown clayey fine to coarse SAND, locally with thick lamination to very thin beds and lenses/pockets of firm grey clay.	0.80 – 7.50	5.45 – 11.75	0.28 – 4.00	3.95 – 5.45	-	-	-	-
London Clay Formation	Stiff orangish brown and light brownish grey silty CLAY/ Very stiff dark grey silty CLAY with occasional partings or lenses of grey silt and fine sand.	7.50 – 18.50	0.42 – 5.45 and 11.75 – 20.20	-	-	-	-	-	-
London Clay Formation - Possible D/C basal bed	Dense black well-rounded medium and coarse GRAVEL of flint with a matrix of grey locally shelly clay.	18.50 – 20.00	-	-	-	-	-	-	-
End of Hole (m bgl)		20.00	20.20	4.00	5.45	1.20	1.20	1.20	1.20

Table 4.4: Summary of Encountered Ground Conditions for Section H Exploratory Holes

Exploratory Hole ID:		3H4515HP	3H4517SA	3J5002SA[1]	3H4600SA	3G4102SA[2]	3H4602HP	3H4603HP	3H4606HP
Chainage		20255	21275	21435	18700	18600	19015	19555	21050
Ground Level (m OD)		+53.86	+54.62	+50.56	+54.21	+55.20	+54.68	+53.72	+58.79
Strata	Typical description	Top to base (m bgl)							
Topsoil	Soft brown sandy gravelly SILT / CLAY. Sand is fine. Gravel is subangular to subrounded fine to medium chert.	0.0 – 0.25	-	-	0.0 – 0.40	0.00 – 0.35	0.0 – 0.25	0.0 – 0.30	-
	Dark grey fine to medium SAND.			0.0 – 0.20	-	-	-	-	-
Made Ground	Dark brown gravelly silty SAND. Sand is medium to coarse. Gravel is subangular to subrounded medium chert and brick.	-	0.0 – 0.25	-	-	-	-	-	0.0 – 0.40
River Terrace Deposits	Soft to firm brown sand clayey gravelly CLAY / clayey GRAVEL. Gravel is subangular to subrounded fine to coarse chert.	-	-	-	0.40 – 1.70	0.35 – 4.00	0.25 – 0.95	-	-
Wittering Formation	Firm to stiff orange, grey sandy silty CLAY. Sand is fine to coarse. Rare gypsum crystals.	-	-	-	1.70 – 9.45	-	-	-	-
	Dense to very dense greenish brown glauconitic SAND. Sand is fine to coarse.	-	-	-	9.45 – 10.00	4.00 – 13.10	0.95 – 1.10	-	-
London Clay Formation - Whitecliff Sand Member	Medium dense to very dense brown clayey silty gravelly SAND. Sand is fine to medium. Gravel is subangular to subrounded fine chert	0.25 – 1.20	0.25 – 7.70	0.20 – 7.10	-	-	-	0.30 – 1.20	0.40 – 1.20
London Clay Formation	Stiff to very stiff locally firm brown gravelly sandy CLAY. Sand is fine. Gravel is subangular to rounded medium to coarse chert.	-	7.70 – 17.65	7.10 – 18.00	10.00 – 20.00	13.10 – 20.45	-	-	-
	Very stiff to hard grey gravelly sandy SILT. Gravel is subrounded to rounded medium to coarse chert. (Gravel bed)	-	17.65 – 18.50	-	-	-	-	-	-
London Clay Formation - Possible Portsmouth Sand Member	Dense grey clayey SAND.	-	-	18.00 – 20.00	-	-	-	-	-
End of Hole (m bgl)		1.20	18.50[3]	20.00	20.00	20.45	1.10	1.20	1.20

[1]3J5002SA is included in Table 4.2 as it is at the proposed location of the launch shaft at the trenchless crossing beneath Winchester Road and St Annes Lane, paired with 3H4517SA within the reception shaft location.
[2]3G4102SA is included in Table 4.2 as it is at the proposed location of the reception shaft at the trenchless crossing beneath Winchester Road, paired with 3H4600SA within the launch shaft location.
[3]SPT refusal at 18.50 m.

4.2.2 Groundwater Levels

Groundwater level and ground gas monitoring took place in selected boreholes specified by SSP. Monitoring was carried out by SOCOTEC during, and after, the main fieldwork period. **Table 4.5** summarises the groundwater strikes, and groundwater spot monitoring data collected at monitoring well locations.

Table 4.5: Summary of Groundwater Strikes and Spot Monitoring Records

Exploratory Hole	Response zone (m bgl)	Strike During Drilling – Depth and Elevation	Stratum Within Which Strike Was Recorded	Spot Monitoring – Depth and Elevation	Data Logger – Minimum/ Maximum Depth
2H4500DR	1.0 – 6.5 (Whitecliff Sand Member)	Not encountered	N/A	0.81 to 4.00 m bgl 60.52 to 57.33 m OD	N/A
2H4501DR	3.0 – 11.0 (London Clay Formation including Whitecliff Sand Member)	Seepage at 0.60 m bgl 65.56 m OD	London Clay Formation	8.05 to 9.70 m bgl 58.08 to 56.46 m OD	N/A
2H4502DS	1.0 – 3.0 (Whitecliff Sand Member)	Not encountered	N/A	2.19 m bgl to 2.38 m bgl 59.27 to 59.08 m OD	N/A
2H4503DS	1.0 – 5.0 (Head & Whitecliff Sand Member)	3.10 m bgl 56.93 m OD	Head Deposits	0.61 to 2.02 m bgl 59.42 to 58.01 m OD	N/A
3H4517SA	5.0 – 11.0 (Whitecliff Sand Member & London Clay Formation)	11.20 m bgl 43.42 m OD	London Clay Formation	1.52 to 2.55 m bgl 53.10 to 52.07 m OD	N/A
3H4600SA	7.0 – 10.0 (Wittering Formation)	3.00 m bgl 51.21 m OD	Wittering Formation	5.50 to 6.45 m bgl 48.71 to 47.76 m OD	N/A

4.2.3 Visual and/or Olfactory Contamination

There were no visual and/or olfactory evidence of contamination recorded on the Phase 2 and Phase 3B/C exploratory hole logs.

5 Generic Quantitative Risk Assessment (GQRA)

This report section assesses the soil, soil leachate, groundwater and gas data collected within the DoL for Section H only.

In accordance with the 'Land Contamination Risk Management' (LCRM) guidance (Environment Agency, 2023), the results of the geo-environmental laboratory testing undertaken on the samples of soil and groundwater recovered during the 2023 and 2024 SOCOTEC GI have been compared to current published generic assessment criteria (GAC) to identify potential hazards to the plausible receptors.

The 35 No. soil samples included 7 No. samples of topsoil, 2 No. of Made Ground, 6 No. of Head Deposits, 2 No. of River Terrace Deposits, 4 No. of Whittering Formation, 7 No. of London Clay Formation and 7 No. of Whitecliff Sand Member.

5.1 Soil Results

5.1.1 Assessment of Potential Risk to Human Health Receptors

There are no recorded exceedances of the human health GAC (commercial land use). Details of the GAC used for screening are provided in **Appendix G**.

5.1.2 Notable Soil Concentrations

GAC are not available for all determinands analysed. Chemical concentrations which appear to be elevated compared to other chemical results recorded during the GI are included in **Table 5.1.** Asbestos screening was requested for 3 No. soil samples from Phase 2 GI, but results have not been provided to date. Asbestos screening was undertaken on 5 No. soil samples from Phase 3B/3C GI; asbestos was not detected.

Table 5.1: Notable Soil Concentrations

BH ID	Location	Depth (m bgl)	Determinand	Concentration (mg/kg)	Notes
3H4507HP	c.105 m east of Winchester Road B2177	1.0 (Whittering Formation)	Cresols	0.15	Typically not expected in natural soils

In-situ PID testing results greater than the detection limit were recorded in half of the soil samples retrieved from the two exploratory locations drilled within approximately 20 m of the Shirrell Heath Sand Pit Landfill (2H4502DS and 2H4503DS). Notable concentrations include 7.1 ppm in 2H4502DS Whitecliff Sand Member sample taken at 1.7 m bgl, 22 ppm in 2H4503DS topsoil sample, and 25.9 ppm in 2H4503DS Whitecliff Sand Member sample taken at 4.5 m bgl. The in-situ PID testing undertaken in Phase 3B/3C GI locations recorded a peak value of 0.9 ppm in 3H4600SA 1.1 m bgl sample.

5.1.3 Soil Sample Deviations

Methodology deviations arose due to the acceptable (holding) time between the sampling date and laboratory analysis being exceeded, headspace presence in selected samples collected for volatile compounds, insufficient sample volumes to complete analysis, use of a non-standard volume or mass in the test, sample matrix interferences and samples failing to wholly meet the laboratory Quality Management System (QMS) requirements. Further details of the soil sample deviations are provided in **Appendix C**.

5.2 Soil Leachate and Groundwater Results

5.2.1 Comparison of Soil Leachate Results Against GAC

Of the six soil leachate (2:1 ratio) analysis requested from Phase 2 GI locations, none were reported by the analytical laboratory. One soil sample was collected during the Phase 3B/3C GI from 3H4600SA (3.3m), the location of a proposed trenchless crossing (A334 Winchester Road) and sent for leachate analysis.

Soil leachate concentrations have been compared to the Drinking Water Inspectorate Drinking Water Standard (DWS) guidance (Drinking Water Inspectorate, 2025) and the withdrawn Water Supply (Water Quality) Regs 1989 (WQS) for petroleum hydrocarbons. Concentrations of Total Ammonia as nitrogen have been compared to the Water Framework Directive (WFD) criteria (Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015). Screening against the Environmental Quality Standard (EQS) has not been performed due to absence of surface water receptors within 250 m of GI locations for which soil leachate data are available. Details on the selection of water GAC is provided in **Appendix G.**

Table 5.2: Soil Leachate Sample Exceedances of the DWS

BH ID	Depth (m bgl)	Ground Conditions	Determinand	Concentration (µg/l)	Generic Assessment Criteria (µg/l)
3H4600SA	3.30	Wittering Formation	TPH (C_6-C_{40})	110*	10**

* cleanup not reported
** Withdrawn Water Supply (Water Quality) Regulations 1989 threshold

No deviations have been reported for soil leachate samples.

5.2.2 Comparisons of Groundwater Results Against GAC

Groundwater sampling was carried out at five monitoring wells from the Phase 2 and Phase 3B/3C investigations over several monitoring rounds, and 14 No. samples were collected and analysed. Samples were screened against the same GAC used for soil leachate: DWS, WQS and WFD, and concentrations exceeding these criteria are shown in **Table 5.3 and Appendix D**. Screening against GAC protective of controlled waters (i.e. the EQS) has not been performed due to absence of surface water receptors within 250 m of GI locations for which groundwater data are available.

Table 5.3: Groundwater Exceedances of the DWS

BH ID	Sampling Date	Determinand	Concentration (µg/l)	Generic Assessment Criteria (µg/l)
2H4502DS	03/05/2023	Iron	**1,200**	200
		Lead	**15**	10
		Manganese	**2,680**	50
		TPH (C_8-C_{40})	**11,260***	10**
2H4503DS	28/02/2023	Manganese	**130**	50
		TPH (C_8-C_{40})	**330***	10**
	03/05/2023	Manganese	**50 (equal)**	50
		TPH (C_8-C_{40})	**440***	10**
	17/07/2023	Manganese	**370**	50
		TPH (C_8-C_{40})	**1,200***	10**

BH ID	Sampling Date	Determinand	Concentration (µg/l)	Generic Assessment Criteria (µg/l)
	12/09/2023	Manganese	**1,060**	50
		TPH C_8-C_{40}	**62,470***	10**
2H4500DR	19/07/2023	GRO (C_6-C_{10})	**115**	10**
2H4501DR	06/05/2023	TPH (C_6-C_{40})	**160**	10**
	16/09/2023	TPH (C_6-C_{40})	**130**	10**
3H4517SA	17/04/2024	Ammonium (NH_4)	**5,134**	500
		Nitrite (NO_2)	**1,010**	500
	01/05/2024	Lead	**14**	10
		Nickel	**24**	20
		Ammonium (NH_4)	**5,260.8**	500
		Nitrite (NO_2)	**670**	500
		TPH (C_6-C_{40})	**170***	10**
	22/05/2024	Lead	**20**	10
		Nickel	**31**	20
		Ammonium (NH_4)	**5,136.5**	500
3H4600SA	12/08/2024	TPH aromatic (C_8-C_{40})	**150**	10**
	20/08/2024	TPH aromatic (C_8-C_{40})	**250**	10**

* clean-up not reported ** Withdrawn Water Supply (Water Quality) Regulations 1989 threshold

Groundwater sample deviations and potential contaminants for which the laboratory Method Detection Limit (MDL) exceeded the corresponding GAC are presented in **Appendix C**. It is noted that testing with a MDL lower than the GAC for the PAHs listed is typically not offered by standard commercial laboratories. For all determinands analysed, but not listed in **Appendix C**, the MDLs were below the relevant GAC.

5.2.3 Notable Groundwater Concentrations

A PFOA detection of 0.012 µg/l in groundwater was recorded at 2H4503DS during the September 2023 monitoring. Chemical concentrations appear to be elevated compared to other chemical results recorded during the previous groundwater sampling rounds which were below detection**.** There were no additional groundwater sampling rounds after September 2023 at 2H4503DS.

5.3 Excavated Materials (Waste) Management

5.3.1 Hazardous Properties

Soil analytical results for the 35 soil samples have been screened for hazardous properties as identified in Technical Guidance WM3 - Waste Classification - Guidance on the Classification and Assessment of Waste First Edition Version 1.2 (Environment Agency, 2021). This screen was carried out using HazWasteOnline™ (HazWasteOnline, 2024) (HazWasteOnline, 2023). The results are provided in **Appendix E.**

None of the soil samples analysed were identified to possess hazardous properties, and therefore, are classified as non-hazardous for waste disposal purposes.

5.3.2 Waste Acceptance Criteria (WAC)

WAC testing was completed in accordance with BSEN 12457/2 on 1 No. sample of topsoil, 2 No. samples of Made Ground and 8 No. samples of natural soils retrieved from Phase 2 and Phase 3B/3C Section H GI locations. Results were screened against landfill waste acceptance criteria limit values for Inert Landfill.

All samples met the criteria for disposal to Inert Landfill.

It is important to note that specific inert landfills may have stricter and/or additional limits imposed for waste soil disposal, and the above assessment should be treated as indicative only. Suitability of material for disposal must be discussed with the landfill operator in advance. It is likely that additional soil sampling with chemical and WAC testing will be required beyond this preliminary ground investigation to inform on suitable disposal routes. Topsoil is not normally accepted at Inert Landfill due to its high organic content.

5.4 Ground Gas Monitoring

Ground gas monitoring results are tabulated in SOCOTEC's Ground Investigation Reports (SOCOTEC, 2023) (SOCOTEC, 2024). Up to thirteen gas monitoring visits were completed in 2H4501DR, 2H4502DS and 2H4503DS between 19th April 2023 and 9th April 2024. Up to 8 gas monitoring rounds have been completed in 3H4517SA and 3H4600SA between 3rd April 2024 and 30th September 2024. Peak concentrations (minimum for oxygen) recorded during each monitoring round are presented in the summary tables in **Appendix F**.

It is noted that 2H4503DS had less than 1 m depth between the top of the slotted standpipe and the water level on three occasions (19th June, 17th July and 15th August 2023), reducing the volume of ground gas available for analysis. In these instances, the reliability of the recorded ground gas concentrations may be reduced due to a smaller volume of accumulated gas.

The response zone in 2H4503DS was fully flooded on three occasions (19th April, 4th May and 24th May 2023), whereas in 3H4517SA and in 3H4600SA this was the case on all monitoring visits (3rd April 2024 to 30th September 2024).

In view of the flooded wells, the data from these monitoring rounds have been assessed as indicative as: "*The response zone of the gas monitoring standpipe should be wholly or partly above groundwater level to provide valid data... [and] gas standpipes with flooded response zones might exhibit measurements of elevated methane or carbon dioxide… due to dissolved gases or the presence of biodegradable material in the groundwater*" (BSI, 2015a).

Maximum peak concentrations (minimum for oxygen) are presented in the summary **Table 5.4**. Although there are no permanent building structures proposed for these areas of the scheme, the ground gas regime at 2H4501DR, 3H4517SA and 3H4600SA should be considered at the preconstruction phase in terms of risks to groundworkers. In particular, temporary deep excavations are planned as launch or reception pits for the trenchless crossings of the Shirrell Heath High Street and Winchester Road (A334 and B2177).

5.4.1 Gas Thresholds

Maximum concentrations recorded in monitoring wells have been compared to the following gas threshold concentrations:

- BSI (The British Standards Institution) Health and Safety in tunnelling in the construction industry - Code of Practice [BS 6164:2019] (BSI, 2019).
- EH40/2005 (fourth edition 2020) Workplace Exposure Limits (HSE, 2020).

Exceedances of these thresholds are shown in **Table 5.5**.

Table 5.4: Ground Gas Monitoring Results Summary

BH ID	Response Zone (m bgl) and Stratum	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
		CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
GI locations within 20m of PSC 90 Shirrell Heath Sand Pit Landfill								
2H4502DS	1.0 – 3.0 London Clay Formation including Whitecliff Sand Member	0.1	6.9	12.9	1.0	1.0	0.8	<0.1
2H4503DS	1.0 – 5.0 Head & London Clay Formation (Whitecliff Sand Member)	<0.1	10.2	10.2	1.0	1.0	0.6	<0.1
Trenchless Crossing reception shaft west of Shirrell Heath High Street								
2H4501DR	3.0 – 11.0 London Clay Formation including Whitecliff Sand Member	1.8	7.5	6.9	6.0	1.0	2.0	0.5
Trenchless Crossing reception shaft c.105 m east of Winchester Road B2177								
3H4517SA*	5.0 – 11.0 London Clay Formation including Whitecliff Sand Member	<0.1	1.0	19.3	27**	10	1.3	29.6 (-67.9
Trenchless crossing reception shaft c.25 m east of A334 Winchester Road								
3H4600SA*	7.0 – 10.0 Wittering Formation	<0.1	4.4	8.9	0	<10	40	-50.1

Notes: CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds, ppmv - Part per Million Volume
* - well flooded during all monitoring rounds, for full readings see Appendix F
** - all other monitoring rounds concentration recorded at 0 or below instrumentation detection limit

Table 5.5: Exceedances of Gas Thresholds

Area	BH ID	CH_4	CO_2	O_2	CO	H_2S	VOC
Location / Substance (threshold)		4.4 % vol (LEL) to 17 % vol (UEL)	0.5 % vol (LTL) 1.5 % vol (STL)	<19% by volume	20 ppm (LTL) 100 ppm (STL)	5 ppm (LTL) 10 ppm (STL)	Approx. 10000 ppmv[1] (LEL)[1]
Trenchless crossing reception shaft – west of Shirrell Heath High Street	**2H4501DR**	N/A	**Yes**	**Yes**	N/A	N/A	N/A
c.20 m southwest of Shirrell Heath Sand Pit Landfill (PSC 90)	**2H4502DS**	N/A	**Yes**	**Yes**	N/A	N/A	N/A
	2H4503DS	N/A	**Yes**	**Yes**	N/A	N/A	N/A
Trenchless crossing – launch shaft c.105 m east of Winchester Road B2177	**3H4517SA***	N/A	**Yes (LTL)**	N/A	N/A *(27 ppm recorded during one monitoring round considered an anomaly)*	N/A *(10 ppm recorded during one monitoring round considered an anomaly)*	N/A
Trenchless crossing – reception shaft c.25 m east of A334 Winchester Road	**3H4600SA***	N/A	**Yes**	**Yes**	N/A	N/A	N/A

N/A – not applicable due to no exceedance, LEL – Lower explosive limit, UEL – Upper explosive limit, STL – Short Term Limit, LTL – Long Term Limit, [1] – dependant on constituents
* - well flooded during all monitoring rounds, assessment is indicative

6 Land Contamination Risk Assessment Model

6.1 Approach and Revised Conceptual Site Model

The land contamination risk assessment presented in this section is a revised risk assessment, that has been undertaken in accordance with the procedure outlined in LCRM (Environment Agency, 2023). This revised risk assessment uses information collated as part of the Phase 2 and Phase 3B/3C GI and builds on the existing preliminary risk assessment completed as part of the desk study. The revised risk assessment will allow for recommendations to be made based on the identification and assessment of potential contaminant linkages. A summary of the guidance for the assessment of land contamination, and the approach developed and adopted by SSP is presented in the Summary Report HWTWRP Geotechnical and Geo-environmental Interpretative Summary Report (Ref. 710166-SWS-XX-XX-RP-GE-00100).

6.2 Potential Sources of Contamination

The exploratory hole locations, discussed herein, were drilled primarily to investigate the moderate / low and higher potential risks to human health and controlled waters from PSCs within and outside of the DoL. The PSC and GI data are discussed below.

Trenchless Crossing east of Winchester Road (B334)

Exploratory hole 3H4600SA was completed to investigate a proposed reception shaft location at a trenchless crossing location within the DoL, approximately 45 m north of PSC 45 (Pit-Gravel). It was drilled to a maximum depth of 20 m bgl. A review of historical data (SSP, 2024) shows the former pit has been woodland since the 1860s, suggesting that any extraction or infilling activity at this PSC occurred approximately 170 years ago or was minimal and, as such, is unlikely to be generating landfilling gases. This means that the PSC is unlikely to be a credible source of landfill gases. No GI locations were completed along the nearest point of the DoL to PSC 45 (Pit-Gravel). The ground conditions and findings at the GI location 3H4600SA is as follows:

- Made Ground was not encountered. Topsoil was underlain by River Terrace Deposits to 1.7 m bgl, followed by the Wittering Formation to 10 m bgl and then London Clay Formation to the base of excavation.
- Groundwater levels were monitored between 5.5 and 6.45 m bgl.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Asbestos screening was not undertaken as all encountered soils were natural.
- The results of the soil leachate (2:1) sample taken at 3.3 m bgl (Whittering Formation) show one exceedance of the adopted GAC protective of human health for TPH C_6-C_{40}.
- The groundwater results show exceedances of the GAC protective of human health for TPH C_8-C_{40} in both samples taken from 3H4600SA. The source of these concentrations is unconfirmed and may not be wholly associated with an anthropogenic source.
- The in-situ PID testing recorded a peak VOC concentration of 0.9 ppm in River Terrace Deposits (1.1 m bgl).
- Ground gas monitoring data has been used indicatively at this location; carbon dioxide concentrations were found to exceed both short and long term WELs and low concentrations of oxygen (8.9% v/v) were also encountered. It should be noted however, due to the well response zone being fully flooded on all monitoring visits, the readings are considered to be unrepresentative of the gas regime.

Shirrell Heath Sand Pit Landfill (PSC 90) – outside DoL. Potential for Made Ground/infill of unknown material and ground gas generation

Exploratory hole locations 2H4502DS and 2H4503DS were completed approximately 20 m southwest of Shirrell Heath Sand Pit Landfill (PSC 90), and approximately 10 to 20 m from the DoL, to a maximum depth of 5.45 m bgl. It is worth noting that these two boreholes were drilled closer to the landfill than the Proposed Development will be, and therefore the obtained data may provide conservative results.

- Made Ground was not encountered.
- Superficial deposits (Head deposits) were encountered below topsoil in 2H4503DS. Both GI locations were underlain by the Whitecliff Sand Member bedrock.
- Groundwater was encountered between 0.61 and 2.38 m bgl.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Asbestos screening was not undertaken as all samples were natural ground.
- The results of the soil leachate (2:1) samples have not been provided by the laboratory, therefore it is not possible to directly assess potential risks arising from contaminant transfer between soils and groundwater.
- Groundwater samples contained concentrations of contaminants above the adopted GAC for metals (iron, lead, and manganese), nitrite and TPH (C_8-C_{40}). TPH C_8-C_{40} was detected at both locations during all monitoring rounds; the highest concentration recorded was 62,470 µg/l in 2H4503DS on 12th September 2023 (fourth groundwater sample). The predominant TPH fraction was aliphatic C_{21}-C_{35} for all investigated samples. During soil sampling in 2H4503DS, VOC concentrations up to 25.9 ppm were measured in natural soil deposits at 4.5 m depth (Whitecliff Sand Member). These soils were below the water table at the time of sampling.
- The source of TPH in groundwater is thought likely to be the nearby Shirrell Heath Sand Pit Landfill. Given the age of the landfill, active between 1976 and 1987 (SSP, 2024), it is likely any leachable concentrations of contaminants from the landfill are dispersed into the surrounding environment.
- Ground gas monitoring data from 2H4502DS and 2H4503DS recorded methane concentrations below the LEL, whereas carbon dioxide levels exceeded both short- and long-term workplace exposure limits (WELs). The lowest recorded oxygen level was 10.2 % vol.

Exploratory hole location 3H4606HP was completed within the DoL approximately 70 m southwest of PSC 90 to a maximum depth of 1.2 m bgl. Although the primary purpose of the hole was to investigate the geology along the linear route, the obtained geo-environmental analysis results can provide further insight into the potential impact from PSC 90.

- Made Ground was encountered from ground level to 0.4 m bgl and was underlain by Whitecliff Sand Member to the base of excavation.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Asbestos screening was undertaken on one Made Ground sample; no asbestos was detected.
- Soil leachate (2:1) analysis was not requested.
- Groundwater was not encountered during the GI.
- The in-situ PID testing did not record VOC concentrations above the instrument's detection limit. Follow-up ground gas monitoring was not undertaken.

Exploratory Hole 3H4517SA (approximately 15 m east of the proposed trenchless crossing shaft for Winchester Road B2177)

Exploratory hole location 3H4517SA was completed within the DoL approximately 15 m east of the proposed trenchless crossing shaft reception location. The GI location is approximately 20 m east of PSC 103 (Pit-Sand) and approximately 35 m south of PSC 445 (Worked Ground) to a maximum depth of 18.5 m bgl. Exploratory hole locations not advanced to directly investigate the PSC and no GI data has been obtained from within the footprint of these PSCs. The ground conditions and findings at the GI location 3H4517SA is as follows:

- Made Ground was not encountered
- Groundwater was encountered between 1.52 and 2.55 m bgl.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Asbestos screening was undertaken; no asbestos was detected.
- Soil leachate (2:1) analysis was not requested.
- Four groundwater samples were taken from this trenchless crossing GI location. The results show exceedances of the GAC protective of human health for lead, nickel, ammonium, nitrite and TPH (C_6-C_{40}). The TPH exceedance was recorded in one out of the three monitoring rounds. The source of these concentration is unconfirmed.
- The in-situ PID testing did not record VOC concentrations above the instrument's detection limit.
- Ground gas monitoring data has been used indicatively at this location; carbon dioxide concentrations were found to exceed the long term WEL. It should be noted however, due to the well response zone being fully flooded on all monitoring visits, the readings are considered to be unrepresentative of the gas regime.

Trenchless Crossing Shirrell Heath High Street

Exploratory hole locations 2H4500DR and 2H4501DR were completed within the DoL at the proposed trenchless crossing shaft reception locations for the Shirrell Heath High Street crossing. The GI locations did not target specific PSCs, however it is noted that a farm building (PSC 545) is located approximately 30 m southwest of 2H4501DR.

- Made Ground was not encountered.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Soil leachate (2:1) analysis was requested but not received from the analytical laboratory.
- Groundwater samples collected and tested yielded TPH exceedances of GAC protective of human health. The source of these concentrations is unconfirmed.
- Ground gas monitoring recorded carbon dioxide concentrations exceeding the short- and long-term WELs. Oxygen-depleted conditions were also detected, with minimum oxygen concentrations recorded at 6.9 % vol.

Former Pig Farm (potential) (PSC 512) within the DoL

Exploratory hole location 3H4507HP was advanced in the northwestern area of PSC 512 within the current DoL. 3H4507HP was completed to a maximum depth of 1.2 m bgl. The ground conditions and findings at the GI location 3H4507HP is as follows

- Made Ground was not encountered.
- Soil chemical analysis shows no exceedances of the commercial land use GAC.
- Asbestos screening was undertaken; no asbestos was detected.
- Soil leachate (2:1) analysis was not requested.
- Groundwater was not encountered during the GI.
- The in-situ PID testing did not record VOC concentrations above the instrument's detection limit. Follow-up ground gas monitoring was not undertaken.

As only one hand pit (3H4507HP) has been advanced within the footprint of this PSC, the nature and extent of ground conditions and potential contaminants across other areas is unconfirmed. Potential contaminants include metals, parasites, pathogens and pesticides/herbicides.

6.3 Identification of Potential Pathways

During and post construction works in Section H, the following potential pathways are considered:

- Dermal contact, ingestion and inhalation of dusts, gases and vapours.
- Gas and vapour migration through permeable materials / strata and accumulation in voids and below ground chambers / receptor pits.
- Leaching through unsaturated soil to underlying groundwater.
- Migration of contamination through proposed pipe bedding.

6.4 Identification of Potential Receptors

Based on the proposed construction works, end use and surrounding land uses, the following potential receptors previously identified in the desk study preliminary risk assessment have been further assessed following Phase 2 and Phase 3B/3C GI data:

- Construction and maintenance workers.
- Future site users (workers and maintenance workers).
- Adjacent land users – only applicable to PSCs within the DoL.
- On Site existing and future property (buildings and below ground chambers / receptor pits).
- Groundwater (River Terrace Deposits, Whittering Formation and Whitecliff Sand Member are Secondary A Aquifers).
- Surface water (land drains) – only applicable to PSCs within the DoL.

Risks to off-Site receptors such as adjacent land users, surface water bodies within 250 m of the DoL and ecological receptors (statutory designated areas and ancient woodlands within 250 m of the DoL) have not been considered for the PSCs outside the DoL targeted during Phase 2 and Phase 3B/3C GI in Section H.

The proposed pipeline has not been included as a potential receptor to contaminants, that could be present in soils or groundwaters, because the pipe material will be selected during design to prevent impact from existing PSCs.

6.5 Risk Assessment

An evaluation of the above pollutant linkages has been used to undertake a qualitative risk assessment. The method of risk evaluation adopted in this document is consistent with LCRM (Environment Agency, 2023) and has been carried out in accordance with CIRIA C552 (CIRIA C552, 2001) using probability, consequence and risk classifications as shown in **Appendix I**.

Preliminary risk estimation is based on the evaluation of both desk study information collated for the route together with the Phase 2 and Phase 3B/3C GI data. For each of the identified areas with a high potential for the presence of contamination (within the search radius), a preliminary risk assessment has been completed and presented in **Table H1.0 (Appendix H)**. Definitions for probability and consequence are in Table A and Table B of **Appendix I** (respectively).

Table 6.1 summarises the risk classification (without mitigation measures) for the investigated PSCs and exploratory hole locations where unexpected contamination was encountered. The risk classification ratings are taken from the risk assessment tables (**Appendix H**). Where more than one pathway has been evaluated, the pathway with the highest risk rating is presented in **Table 6.1**. For the majority of the investigated areas

in Section H the risk rating for construction, maintenance workers and future site users for direct contact (including dermal contact, ingestion and inhalation of dusts) and inhalation of gases and vapour pathway is Moderate/Low. These evaluated pathways are detailed in the risk assessments in **Appendix H**. **Table 6.1** summarises the risk classification (without mitigation measures) for the investigated PSCs.

Table 6.1: Summary of Risk Classification for Construction and Maintenance Activities for Areas Investigated in Section H

GI Locations/Location Description	Contaminants Encountered	Risk Classification (without mitigation measures) for Potential Receptors[1]					
		Construction, maintenance workers and future site users	Adjacent Land Users	On Site existing and future property	Surface Water	Groundwater	Ecology
PSCs Targeted							
2H4502DS and **2H4503DS** 20 m southwest. PSC 90 30 m northeast of DoL.	**Shirrell Heath Sand Pit Landfill:** Groundwater sampling yielded DWS exceedances of iron, lead, and manganese, nitrite and TPH (C_8-C_{40}). TPH C_8-C_{40} the highest recorded concentration was 62,470 µg/l in 2H4503DS. Landfill gas (carbon dioxide levels exceeded both short- and long-term workplace exposure limits (WELs).	Moderate/Low	Low	Very Low	Very Low	Moderate	Low
3H4507HP advanced within the footprint of the PSC 512 Agricultural Land	**Former Pig Farm (potential):** No Made Ground encountered. No exceedances of the adopted soil GAC. Leachate testing was not carried out. Groundwater sampling was not carried out.	Moderate/Low**	Moderate/Low**	Low	Low	Moderate/Low**	Very Low
Trenchless Crossings							
2H4500DR and **2H4501DR** Shirrell Heath High Street – Trenchless Crossing PSC 545 farm building approx. 30m Southwest of 2H4501DR	Groundwater samples collected and tested yielded TPH exceedances of GAC. Carbon dioxide concentrations exceed the short- and long-term WELs. Oxygen-depleted conditions were also detected, with minimum oxygen level at 6.9 %.	Moderate/Low	Low	Low	Low	Low	Low
3H4517SA was completed within the DoL approximately 20 m east of PSC 103 and 35 m south of PSC 445. Agricultural Land approximately 100 m east of Winchester Road, where Sections H and J intersect at a Trenchless Crossing.	Groundwater sampling yielded exceedances of lead, nickel, ammonium, nitrite and TPH (C_6-C_{40}). Although gas monitoring was carried out at the location, high groundwater levels has resulted in the well becoming flooded, gas results are therefore indicative and are considered as unrepresentative of the gas regime beneath the site. However, recorded concentrations of carbon dioxide were recorded above both short and long terms WELs.	Moderate/Low*	Low	Low	Very Low	Moderate	Low
3H4600SA is located approximately 45 m north of PSC 45 (Pit-Gravel), the former pit is c. 5 m south of the DoL at the closest point. Land just to the east of Winchester Road, A334. Trenchless Crossing beneath the road.	One leachate sample tested, and two groundwater samples collected and tested yielded exceedances of TPH C_6-C_{40}. Although gas monitoring was carried out at the location, high groundwater levels has resulted in the well becoming flooded, gas results are therefore indicative and are considered as unrepresentative of the gas regime beneath the site. However recorded concentrations of carbon dioxide exceeded both short and long term WELs.	Moderate/Low* *(dermal contact, ingestion and inhalation of dusts*	Low	Low	Very Low	Moderate/Low	Low

[1] Based on available data
*Conservative risk based on indicative ground gas data, flooded wells mean it is considered unlikely for gas data to be representative of the ground gas regime.
**Risk rating carried forward from the version 4 Desk Study (SSP, 2024) due to a lack of GI data.

6.6 Summary

The Phase 2 GI comprises four GI locations. Two GI locations were focused at Shirrell Heath Sand Pit Landfill (PSC 90). The current proposed DoL is within 30 m of PSC 90. Two GI locations were completed at the proposed trenchless crossing at Shirrell Heath High Street.

The Phase 3B/3C GI in Section H comprised GI locations to collect ground conditions data for the linear route. Two trenchless crossing locations at proposed road crossings were also investigated. Several PSCs within a 50 m buffer zone of the DoL were close to these locations. These included Pit-Sand (PSC 103), Pit-Gravel (PSC 45), Worked Ground (PSC 445) and possible former Pig Farm (PSC 512).

Based on the quantitative risk assessment the following risks were determined:

- A Moderate risk rating was identified for groundwater at locations advanced to investigate the DoL closest to Shirrell Heath Landfill - PSC 90 (2H4502DS and 2H4503DS**)** and at 3H4517SA due to the presence of TPH in groundwater sampling.
- A Moderate/Low risk rating was identified for groundwater (3H4600SA) approximately 45m north of a gravel pit (PSC 45) due to the recorded exceedances of the GAC and applying a conservative approach due to only one soil leachate result.
- A Moderate/Low risk classification has been identified for impact to construction, maintenance workers and future site users via direct contact and inhalation pathways at trenchless crossings, based on the findings of TPHs in groundwater and elevated ground gas concentrations. Ground gas monitoring showed carbon dioxide exceedances for short and long-term WELs and depleted oxygen levels. Though in light of the flooded well at 3H4517SA this assessment is very conservative. It should also be noted that gas risk has been reduced to a low risk for the trenchless crossing beneath Winchester Road, at the boundary between Section G and H, due to the age of the gravel pit approximately 45 m south (PSC 45).
- Risk ratings for the possible former pig farm (PSC 512) have been carried forward from the Desk Study, version 4 (SSP, 2024) due to limited GI data across the PSC footprint (one hand pit location). Moderate/Low risk ratings identified for impact to construction, maintenance workers and future site users, adjacent site users and groundwater during construction.
- All other potential contaminant linkages were either identified as having a Low or Very Low risk.

7 Geotechnical Testing and Assessment

7.1 Geotechnical Testing and Assessment Summary Table for Section H boreholes

The below **Table 7.1** shows the varying geotechnical tests per strata specific for the boreholes drilled in Section H.

Comparing with boreholes drilled for Sections F, G and J, it is noted that Head Deposits are common to all four nearest sections, which all show similar moisture, plasticity, PSD and SPT results within the same range. It is also noted that the London Clay Formation, encountered within boreholes in Section G, H and K, shows similar moisture, plasticity and SPT data. London Clay Formation Whitecliff Sand Member shows similar testing results as those from Section J, apart from plasticity index data which was not undertaken in Section J. London Clay – D/C basal bed is not encountered in neighbouring sections of the pipeline.

Table 7.1: Geotechnical Testing and Assessment Summary for Section H Boreholes

	Geotechnical Property																									
Strata	**Moisture (%)**			**Plasticity Index (%)**			**Particle Size Distribution (Average of values)**		**Triaxial Test - Undrained Shear Strength (kPa)**			**SPT Results (uncorrected N value)**			**Uniaxial Compressive Strength, UCS (MPa)**	**Point Load Index Testing, PLT (MPa)**	**Compaction – Max Dry Density (Mg/m3) (Optimum Moisture content, %)**			**Linear (Bulk) Density (Mg/m3)**		
Made Ground (MGR)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	None		**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	Not Applicable	Not Applicable	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	None			None					None			None					None			None		
Total No. of tests	0			0			0		0			0			0	0	0			0		
Head Deposits (HEAD)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	**(%)**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	Not Applicable	Not Applicable	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	16	23	28	8	19	31	**Cobbles:**	3	17	39	6	5	5	5			None			1.92		
							Gravel:	21														
							Sand:	23														
							Silt:	34														
							Clay	19														
Total No. of tests	6			4			2		2			1			0	0	0			1		
River Terrace Deposits (RTD)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	**(%)**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	Not Applicable	Not Applicable	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	10	10	10	15	15	15	**Cobbles:**	0	None			8	8	8			None			None		
							Gravel:	71														
							Sand:	14														
							Silt:	9														
							Clay	6														
Total No. of tests	2			1			3		0			1			0	0	**0**			0		
Wittering Formation (WTT)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	**(%)**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	Not Applicable	Not Applicable	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	19	30	58	31	39	44	**Cobbles:**	0	87	108	140	20	21	21			1.73 (19)	1.73 (19)	1.73 (19)	None		
							Gravel:	15														
							Sand:	31														
							Silt:	28														
							Clay	26														

	Geotechnical Property																														
Strata	**Moisture (%)**			**Plasticity Index (%)**			**Particle Size Distribution (Average of values)**		**Triaxial Test - Undrained Shear Strength (kPa)**			**SPT Results (uncorrected N value)**			**Uniaxial Compressive Strength, UCS (MPa)**			**Point Load Index Testing, PLT (MPa)**			**Compaction – Max Dry Density (Mg/m3) (Optimum Moisture content, %)**			**Linear (Bulk) Density (Mg/m3)**		
Total No. of tests	7			**3**			3		3			2			0			0			1			0		
London Clay Formation Whitecliff Sand Member (WHI)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	**(%)**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	Not Applicable			Not Applicable			**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	5	19	31	NP^	12	24	**Cobbles:**	0	None			8	38	>50							1.61 (14)	1.68 (15)	1.79 (15)	None		
							Gravel:	1																		
							Sand:	93																		
							Fines (Silt + Clay)	6																		
Total No. of tests	11			2			6		0			25*			**0**			**0**			**4**			**0**		
London Clay Formation (LC)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	(%)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	20	27	74	25	33	44	**Cobbles:**	0	100	286	520	14	33	>50	0.09	0.21	0.30	0.01	0.13	0.47	1.68 (15)	1.68 (15)	1.68 (15)	2.03	2.06	2.09
							Gravel:	0																		
							Sand:	23																		
							Silt:	45																		
							Clay:	32																		
Total No. of tests	18			10			5		8			16**			6			5 No. sets of 10 determinations			1			2		
London Clay Formation – Possible D/C basal bed	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	**Particle Size**	(%)	**Min**	**Av**	**Max**	**Min**	**Av**	**Max**	None			None			**Min**	**Av**	**Max**	**Min**	**Av**	**Max**
	15	15	15	None			**Cobbles**	0	None			50	50	50							None			None		
							Gravel:	68																		
							Sand:	9																		
							Silt:	13																		
							Clay:	10																		
Total No. of tests	1			**0**			1		0			1			0			0			0			0		

*For London Clay Formation - Whitecliff Sand Member, 12 out of 25 No. SPTs were refusals and did not achieve a full 0.45 m penetration depth due to dense - very dense sands.
** For London Clay Formation, 3No. out of 16 No. SPTs was a refusal and did not achieve a full 0.45m penetration depth due to poor recovery and very dense sands of the LC and WHI boundary between 3.20 – 5.95 m bgl.
^One result tested as non-plastic.

Table 7.2: Additional Geochemical Testing

	Geochemical Testing			
Geology	**BRE SD1 values[1]**			
Head Deposits (HEAD)	**Test type**	**Min**	**Max**	**Characteristic Value**
	Water soluble SO4 (mg/l)	9	100	100
	Acid soluble SO4 (%)	0.02	0.03	0.03
	Total Sulphur (%)	0.01	0.01	0.01
	Total Potential Sulphate (%)	0.03	0.03	0.03.
	pH	7.4	7.9	7.4
No. Tests	2			
River Terrace Deposits	**Test type**	**Min**	**Max**	**Characteristic Value**
	Water soluble SO4 (mg/l)	Below limit of detection	Below limit of detection	<500
	Acid soluble SO4 (%)	Below limit of detection	Below limit of detection	Below limit of detection
	Total Sulphur (%)	0.03	0.03	0.03
	Total Potential Sulphate (%)	0.09	0.09	<0.24
	pH	8.4	8.4	8.4
No. Tests	1			
Wittering Formation	**Test type**	**Min**	**Max**	**Characteristic Value**
	Water soluble SO4 (mg/l)	620	820	800
	Acid soluble SO4 (%)	0.28	0.40	0.40
	Total Sulphur (%)	0.45	0.97	0.97
	Total Potential Sulphate (%)	1.35	2.91	2.91
	pH	8.3	8.5	8.3
No. Tests	2			
London Clay Formation - Whitecliff Sand Member	**Test type**	**Min**	**Max**	**Characteristic Value**
	Water soluble SO4 (mg/l)	Below limit of detection	100	100
	Acid soluble SO4 (%)	Below limit of detection	0.1	0.1
	Total Sulphur (%)	Below limit of detection	0.07	0.07
	Total Potential Sulphate (%)	Below limit of detection	0.21	< 0.24
	pH	5.8	8.6	5.8
No. Tests	6			
London Clay Formation	**Test type**	**Min**	**Max**	**Characteristic Value**
	Water soluble SO4 (mg/l)	60	280	300
	Acid soluble SO4 (%)	0.08	0.14	0.14
	Total Sulphur (%)	0.30	0.62	0.62
	Total Potential Sulphate (%)	0.90	1.86	1.86
	pH	7.4	8.5	7.4
No. Tests	4			
London Clay - Possible D/C basal bed	No Geochemical Testing available			

No BRE testing undertaken on encountered Made Ground at 3H4606HP, as no geotechnical samples were required as hand pit was to confirm geology along linear route.

Additional Geochemical / Geotechnical Testing

- River Terrace Deposits has a mass loss on ignition of 1%
- Wittering Formation has a mass loss on ignition of 2.5%.
- London Clay Formation - Whitecliff Sand Member has an organic content of 0%.
- London Clay Formation has a hand vane undrained shear strength, C_u value of 63 kPa, an organic matter content of 0.48% and a mass loss on ignition of 3.4%.

7.2 Standard Penetration Test (SPT) vs Depth Relationship for Section H boreholes

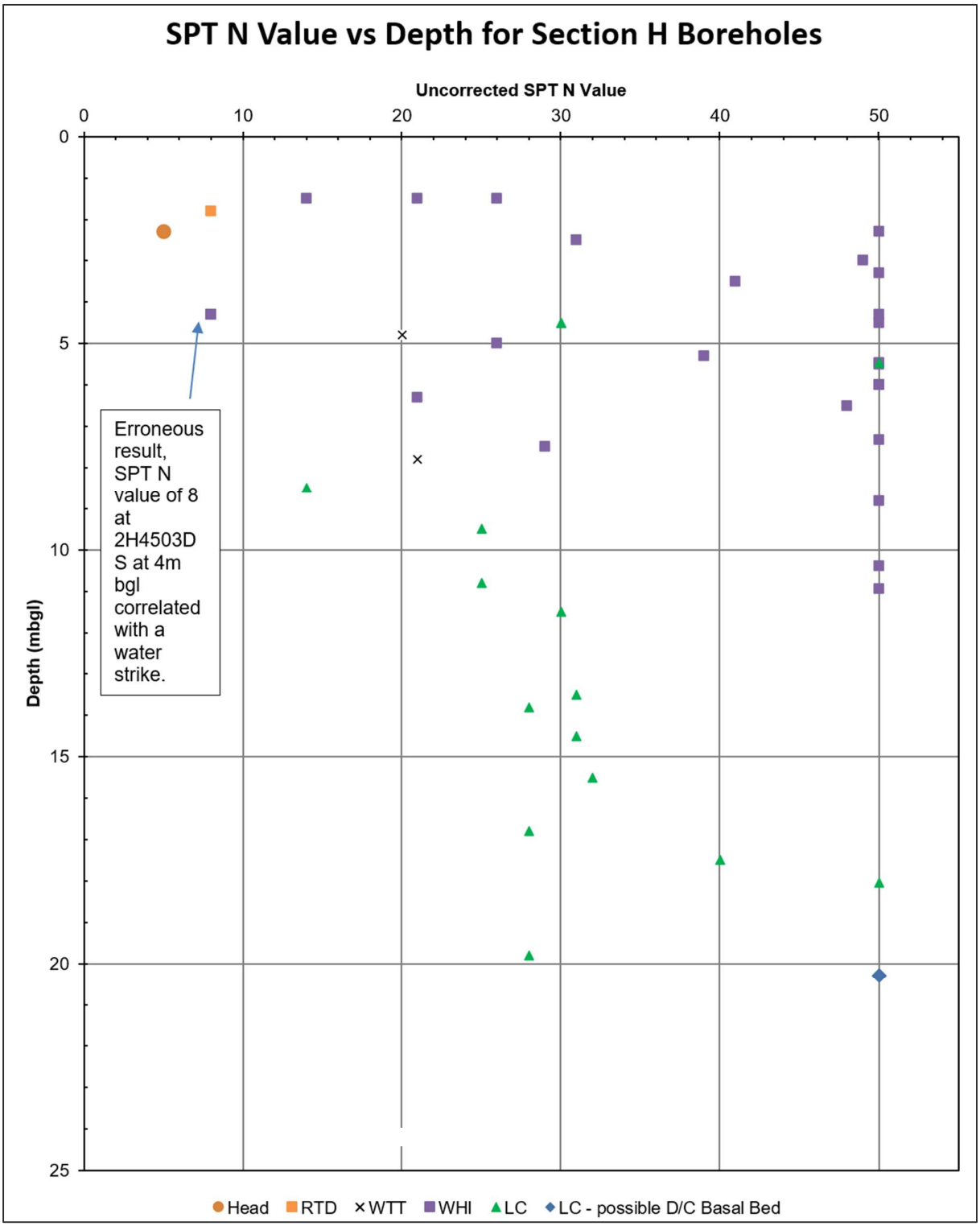
Graph 7.1 shows how SPT varies with depth across Section H boreholes. It is noted that a noticeably low uncorrected SPT N value of 8 is recorded within one test in the London Clay Formation - Whitecliff Sand Member (WHI). It is considered that this result has been affected by a water strike at the depth of this test loosening the sand within the formation, and that the other results with an uncorrected SPT N value >20 (often >50) being more applicable.

The geological boundary at 2H4500DR (for the base of the WHI) is approximately 7.90 m bgl (+53.43 m OD) while at 2H4501DR it is approximately 11.75 m bgl (+54.01 m OD). The rotary core drilling recovery within WHI was minimal due to sand being lost within the drill flush. As a result, SPTs were attempted to ascertain density/consistency, which indicated dense and very dense sand bands.

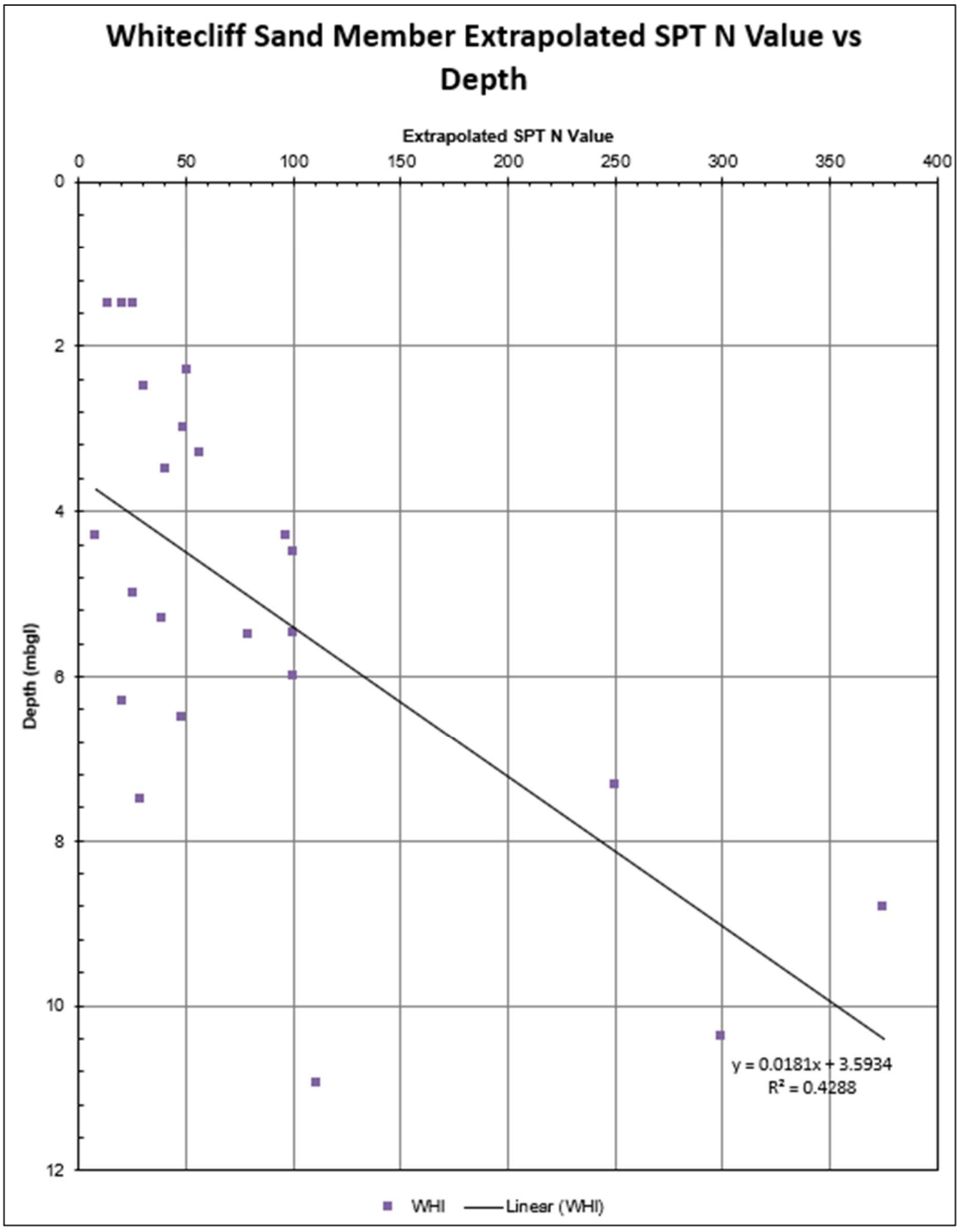
London Clay Formation shows an increase in SPT N values as depth increases. London Clay Formation - Whitecliff Sand Member does not have a relationship of increasing SPT N values with depth, and the remaining strata do not have enough data to make a statement regarding the relationship.

Approximately 50m distance separates 2H4502DS and 2H4503DS, of which 2H4502DS has consistently higher SPT N values between 1.2 m – 4 m bgl (21 at 1.20 m bgl, 50 at 2.00 m bgl, 50 at 3.00 m bgl and 50 at 4.00 m bgl) than 2H4503DS. This may be due to the water strike in 2H4503DS at 3.10 m, which rose to 1.90 m, loosening the sand resulting in lower SPT N values. Both SPT N values of 5 and 8 may be discounted as these are not typical of WHI – the stratum may be considered generally medium dense to very dense sand. 2H4502DS and 2H4503DS did not achieve their scheduled depths of 6 m bgl because of hole collapsing between 3.00 – 4.00 m bgl and 5.50 m respectively, again due to dense sand. 3 No. successive SPT refusals at 2H4502DS recording N values of 50 resulted in the borehole not achieving its scheduled depth of 6 m bgl. **Graph 7.2** shows how London Clay Formation - Whitecliff Sand Member SPT refusals are extrapolated beyond 50 blows based on recorded tool penetration.

Graph 7.1 SPT vs Depth per Strata across Section H Boreholes



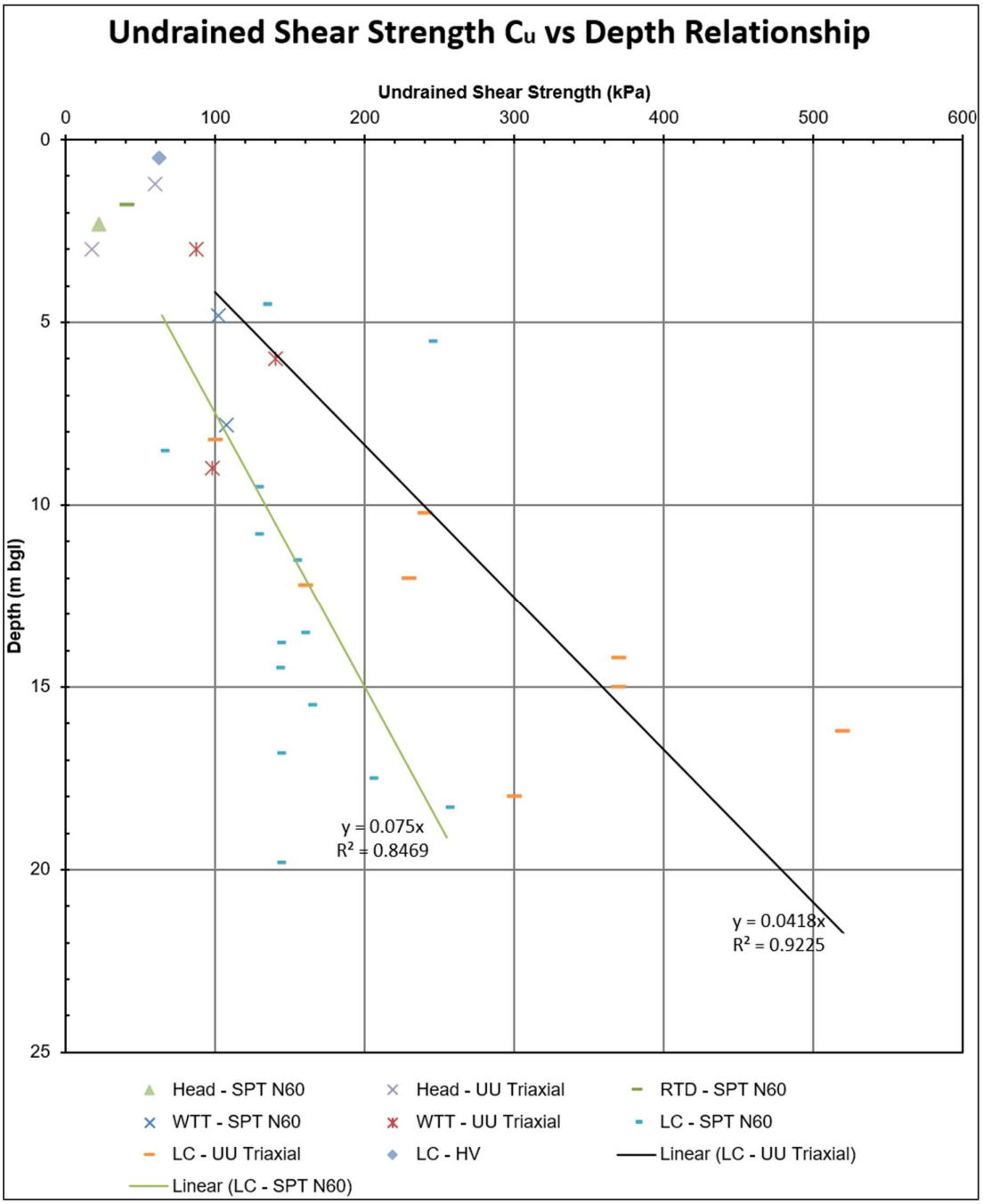
Graph 7.2 Extrapolated Whitecliff Sand Member SPT N Values vs Depth for Section H Boreholes



7.3 Undrained Shear Strength C_u vs Depth Relationship for Section H boreholes

Graph 7.3 shows the undrained shear strength vs depth relationship for Head Deposits, River Terrace Deposits, Wittering Formation and London Clay Formation. An increase in undrained shear strength with depth is visible for the London Clay Formation but not apparent for the other strata.

Graph 7.3 Undrained Shead Strength C_u vs Depth Relationship for Section H Boreholes

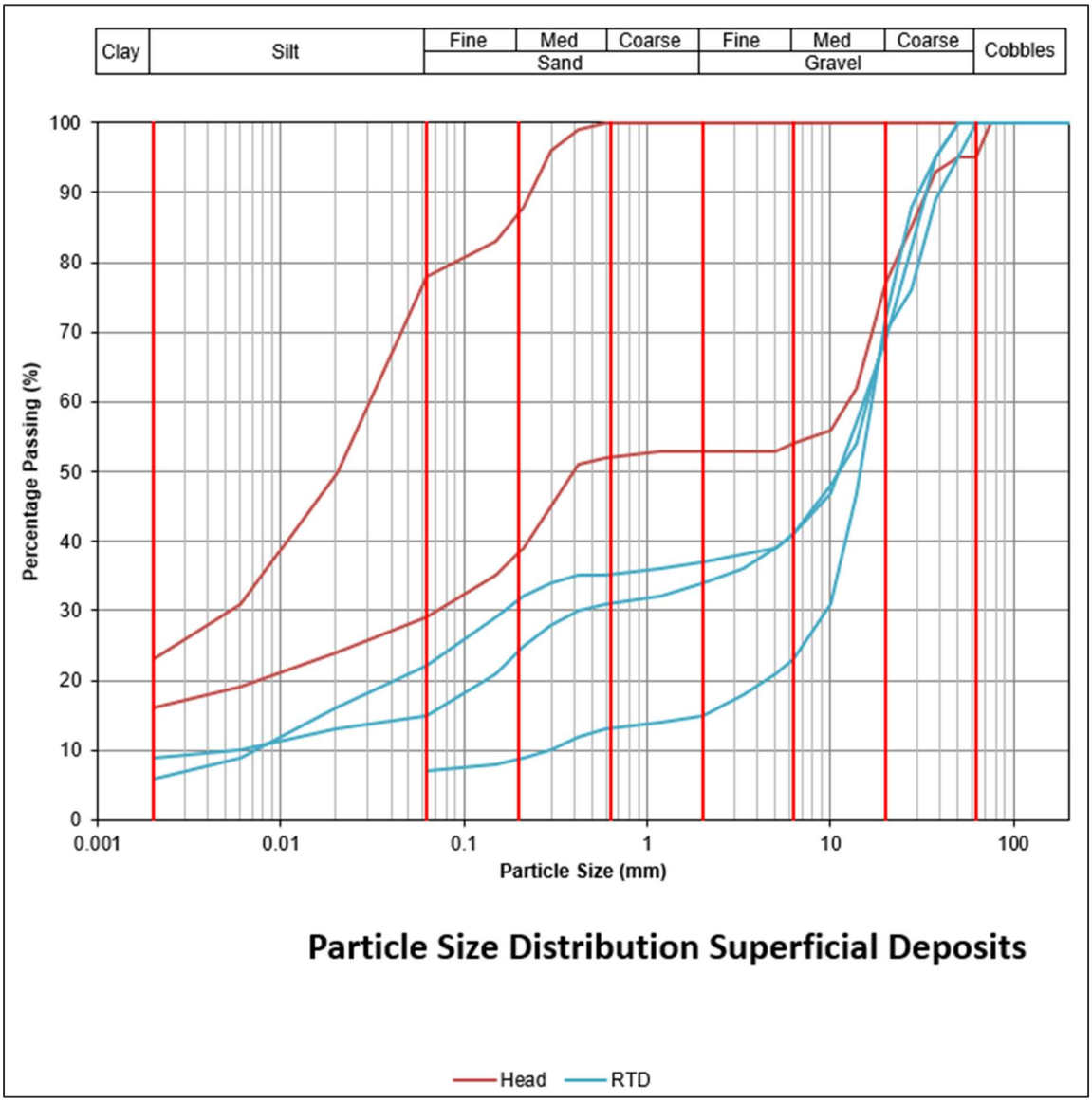


After Stroud (1975) where cu = f_1 x N60 where f_1 = 4.5

7.4 Particle Size Distribution for Section H boreholes

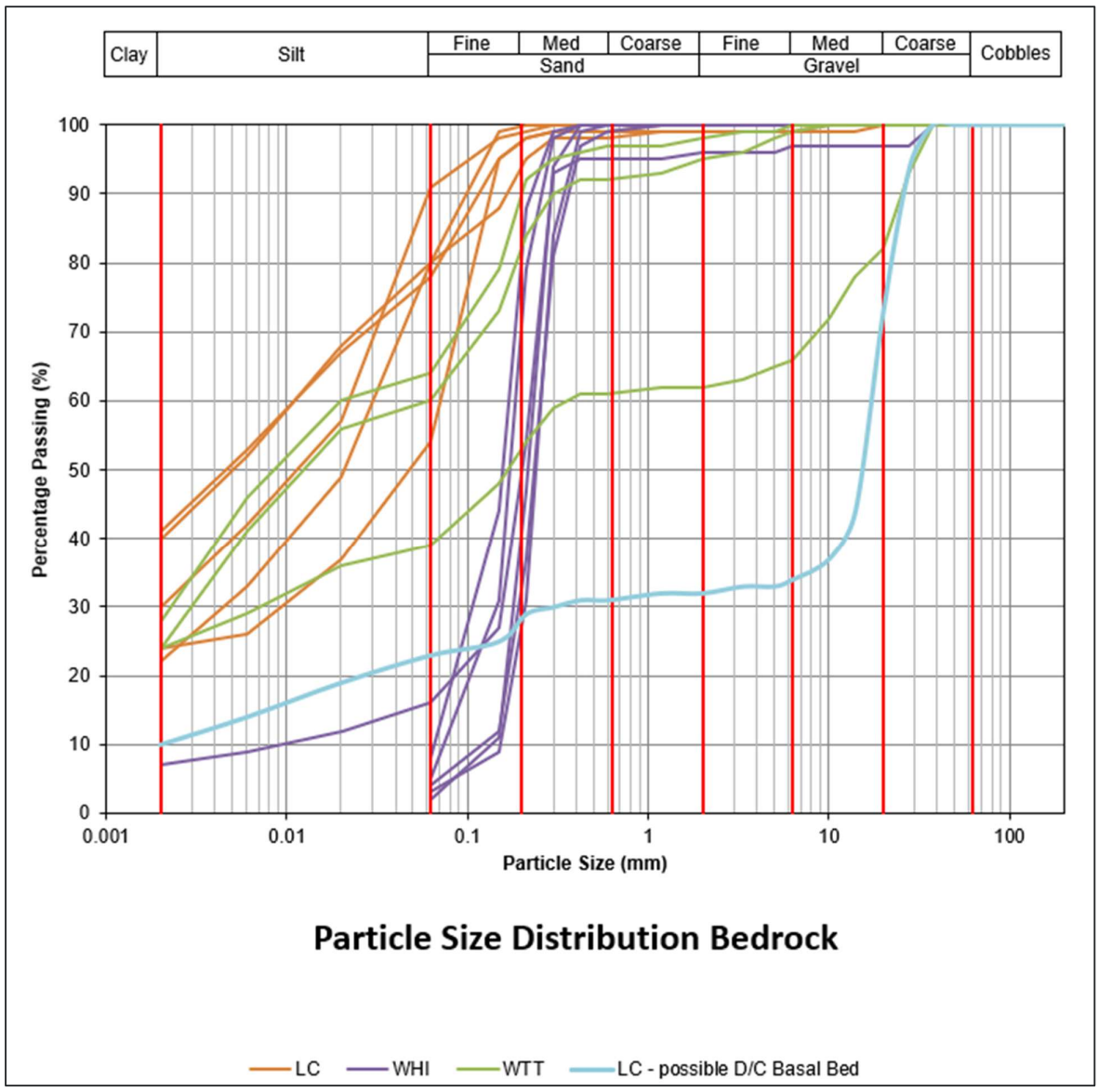
Graph 7.4 shows Head Deposits (HEAD) to be a sandy silt and gravelly silt, similar to the sandy gravelly clay description listed in **Table 4.1.** River Terrace Deposit descriptions partly align with descriptions in **Table 4.1**, with PSD testing not identifying gravelly clay material as described but presenting a sandy gravel distribution.

Graph 7.4 Particle Size Distribution (PSD) for Superficial Deposits across Section H Boreholes



The London Clay Formation - Whitecliff Sand Member (WHI) within the London Clay Formation is a well graded sand. London Clay – possible D/C basal bed is a well graded gravel, though this result is only of a single sample at 18.6 m bgl and is not likely to be representative of the whole pipeline route. The London Clay Formation and Wittering Formation are shown to be a clay and silt dominated material.

Graph 7.5 Particle Size Distribution (PSD) for Superficial Deposits across Section H Boreholes

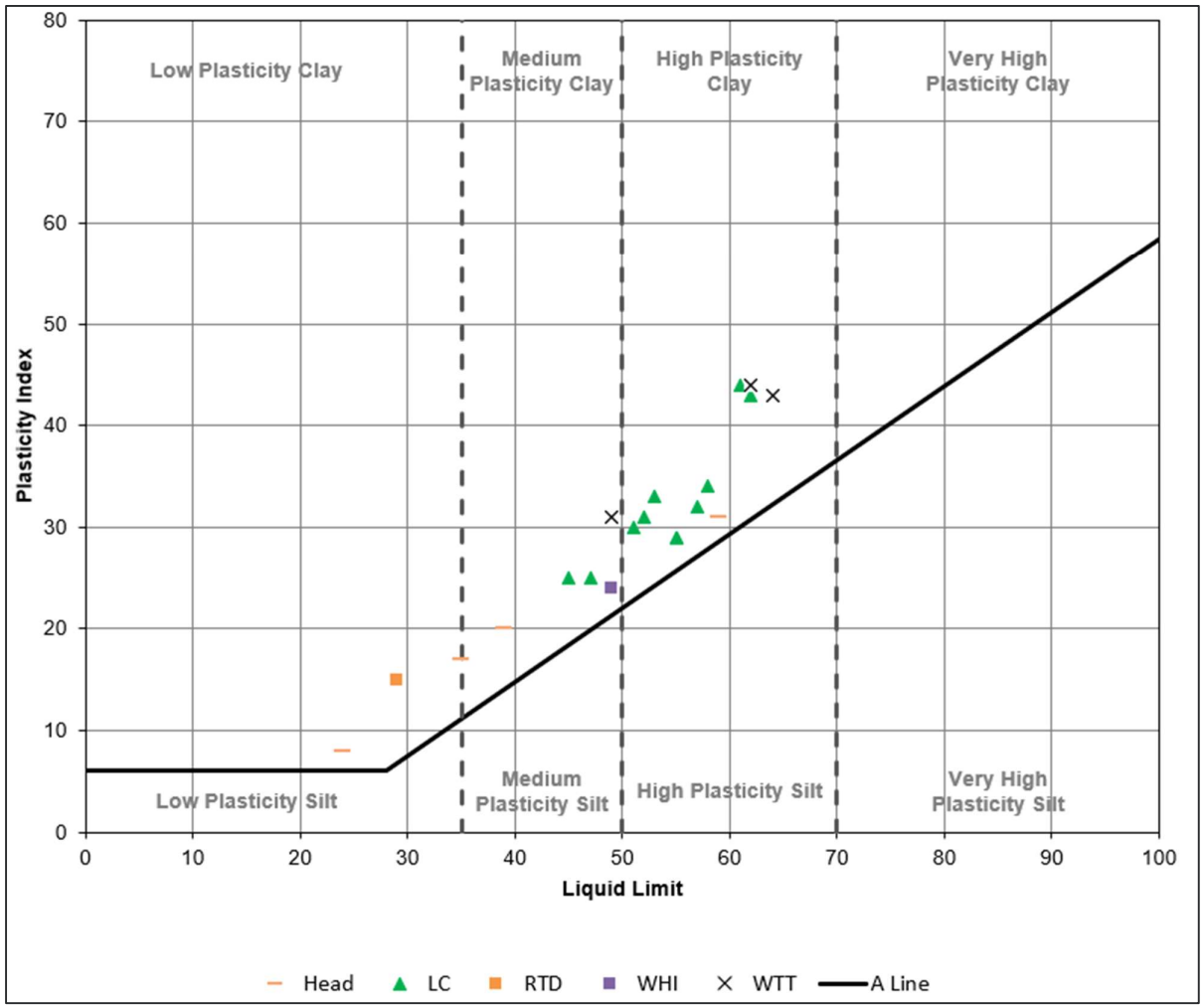


More PSD tests are required for the London Clay – Possible D/C basal bed and Head Deposits to provide a better confirmation of soil grading. Further PSDs should be scheduled in order to fully ascertain soil grading for all these strata where they are considered to impact the potential construction.

7.5 Plasticity for Section H boreholes

Graph 7.6 shows Head Deposits as most variable, recording low to high plasticity clay, River Terrace Deposits has one result; low plasticity clay. London Clay Formation is consistently medium to high plasticity clay. London Clay Formation - Whitecliff Sand Member, where encountered as cohesive, shows one result of intermediate plasticity clay. Wittering Formation testing shows it to be medium to high plasticity clay.

Graph 7.6 Plasticity across Section H Boreholes



7.6 Preliminary Geotechnical Design Parameters for Section H boreholes

Based on the soil descriptions and results obtained from the in-situ and laboratory tests, the characteristic values for each stratum have been derived and are shown in **Table 7.3.**

Table 7.3: Preliminary Geotechnical Design Parameters for Section H Boreholes

	Geotechnical Design Parameter									
Strata	**Native Soil Modulus, E'_3 (MN/m^2) [a]**	**Elastic Modulus E_u [b2]**	**Bulk weight density, γ (kN/m^3) [c]**	**Constant volume angle of shearing resistance, φ (°) [c]**	**Undrained Shear Strength, C_u (kPa) [b1]**	**Coefficient of Volume Compressibility, m_v (m^2/MN) [b1]**	**Uniaxial Compressive Strength (MPa)**	**Concrete Aggressivity [d]**	**Earthworks [b2]**	**From PSD results Embedment corresponding From Table A.3 WIS 4-08-02**
Made Ground (MGR)	Loose sand: 2 - 4	Loose sand: 3 - 10	16 - 17	Loose sand: 30º	N/A	N/A	Not Applicable	No test results available	1 V : 2.5 H	Potentially selected material suitable for S3 (Sand and coarse-grained soil with less than or equal to 12% fines) or S4 (Coarse-grained soil with more than 12% fines) bedding.
Head Deposits (HEAD)	Soft to firm clay: 3	Short Term: 2 MPa Long Term: 1 MPa	15 – 18	Based on average plasticity index result of 19%, φ = 26°	20	0.3	Not Applicable	DS-1 AC-1	1 V : 2H	Potentially selected material suitable for S4 bedding (fine grained soil some of medium to low plasticity and containing more than 25% coarse grained particles). Note however it is a variable deposit with some material being unsuitable as S4 due to having less than 25% granular material, and some material not being suitable for bedding at all due to high plasticity (liquid limit >50%). Due to the variability this material would be difficult to re-use in practice.
River Terrace Deposits (RTD)	Soft clay: 1.5 Loose gravel: 5	Soft clay Short Term: 2 MPa Long Term: 1 MPa Loose gravel 25 MPa	15 - 21	Soft clay φ = 27° Loose gravel φ = 30°	20 - 40	0.3	Not Applicable	DS-1 AC-1	1 V : 1.5 – 2 H	Potentially selected material suitable for S3 (Gravel graded) or S4 (Fine-grained soil, liquid limit <50%, medium-to-no plasticity and >25% coarse-grained material). Note however it is a variable deposit.
Wittering Formation (WTT)	Firm to stiff clay: 3 Dense sand: 9	Firm to stiff clay Short Term: 5 MPa Long Term: 4 MPa Dense sand: 25 MPa	16 - 21	Firm to stiff Clay Based on average plasticity index result of 39%, φ = 22° Dense sand φ = 35°	75 - 100	0.1	Not Applicable	DS-4 AC-4	1 V : 2 – 2.5 H	Not suitable for structural reuse as fine-grained soil, liquid limit >50% and high plasticity. Some sand beds potentially suitable as S3 bedding (if <12% fines), however further classification testing would be required.
London Clay Formation - Whitecliff Sand Member (WHI)	Medium dense to very dense sand: 4	Dense to very dense sand: 25MPa	16 - 22	φ = 29°	N / A	N / A	N / A	DS-1 AC-1	1 V : 2 H	Suitable as S3 bedding. Sand and coarse-grained soil with less than 12% fines.

	Geotechnical Design Parameter									
Strata	**Native Soil Modulus, E'_3 (MN/m^2) [a]**	**Elastic Modulus E_u [b2]**	**Bulk weight density, γ (kN/m^3) [c]**	**Constant volume angle of shearing resistance, φ (°) [c]**	**Undrained Shear Strength, C_u (kPa) [b1]**	**Coefficient of Volume Compressibility, m_v (m^2/MN) [b1]**	**Uniaxial Compressive Strength (MPa)**	**Concrete Aggressivity [d]**	**Earthworks [b2]**	**From PSD results Embedment corresponding From Table A.3 WIS 4-08-02**
London Clay Formation (LC)	Stiff to very stiff clay: 6	Short Term: 400Cu [b1] Long Term: 240Cu [b1] (most detrimental value to be used for design)	18 – 23	Based on average plasticity result of 33%, φ = 23°	75	0.1	0.09 – 0.30	DS-4 AC-4	1 V: 2.5 H	Unsuitable for structural reuse. Fine grained soil with high plasticity, containing less than 25% coarse grained particles and liquid limit >50%.
London Clay – possible D/C basal bed	Dense gravel: 15	Dense gravel 100 MPa	19 – 23	Based on soil description and density index I_D for dense gravel, φ_{dil} of 6° φ = 36°	N / A	N / A	N /A	No test results available though assume worst case value of DS-4 AC-4 with more testing required if constructing within the stratum	1 V : 1.5 H	Potentially suitable as S4 bedding. Coarse grained soil with more than 12% fines. Further classification testing including liquid limit and PSD required.

[a] (BSI, 2020) Table 13, [b1] (Tomlinson, 2001) Table 2.5,Table 2.11, Figure 2.33, Section 2.6.6, [b2] (Look, 2007) Table 11.7, Table 11.8, Figure 14.1, Table 14.10, [c] (BSI, 2015b) Figure 2 and Table 1 , [d] (BRE, 2005) Table C1, [e] (BSI, 2020) Table 24
Table 24 of BS9295:2020 corresponds to Table A.3 from the Water Industry Specification for Bedding and Side fill Materials for buried pipelines WIS 4-08-02 February 1994: Issue 1 document.

7.7 Resistivity Testing

In situ apparent resistivity testing was undertaken at two locations, the results are presented in **Table 7.4** Characteristic apparent resistivity value of 10 Ωm

Table 7.4: Electrical Resistivity Results for Section H

BH ID	Electrode Spacing (m)			
	4.0	3.0	2.0	1.0
	Apparent Resistivity (mean) (Ω.m)			
3H4513HP	43	160	70	210
3H4515HP	61	55	53	62
3H4602HP	120	120	130	140
3H4606HP	48	40	34	21

A characteristic apparent resistivity value of 21 Ωm should be taken, which indicates that the ground is highly aggressive towards ferrous metals.

7.8 Permeability Testing

Falling head permeability testing was undertaken at two locations across Section H. The results are presented in **Table 7.5.**

Table 7.5: Falling Head Permeability Testing Results

BH ID	Depth of Test (m bgl)	Test Type	Borehole / Standpipe	Test	Result (m/s)	Strata
2H4501DR	5.20 – 5.70	Falling head permeability test	Borehole	**1**	5.1×10^{-7}	London Clay Formation and London Clay Formation - Whitecliff Sand member
2H4502DS	1.00 – 4.00		Standpipe	**1**	2.6×10^{-7}	London Clay Formation - Whitecliff Sand Member

8 Geotechnical Considerations

8.1 Ground Conditions

The ground conditions recorded within the boreholes are generally in line with those anticipated from the geological mapping across the proposed section. 3H4600SA and 3H4602HP aligns with mapping with River Terrace Deposits overlying Wittering Formation. 3H4507HP and 3H4511HP aligns with mapping with Wittering Formation at ground level. 2H4501DR, 2H4502DS, 3H4515HP and 3H4603HP aligns with mapping with London Clay Formation - Whitecliff Sand Member at ground level. 3H4513HP and 3H4514HP aligns with mapping with Head Deposits at ground level.

However, several locations did not align with the BGS mapping; 2H4503DS had London Clay Formation - Whitecliff Sand Member mapped at ground level but Head Deposits was encountered overlying it at ground level. 2H4500DR does not align with mapping, London Clay Formation was mapped at ground level, however, Head Deposits overlying London Clay Formation - Whitecliff Sand Member was encountered. At 3H4517SA and 3H4606HP Made Ground was found at the ground surface overlying the mapped London Clay Formation - Whitecliff Sand Member.

- Made Ground (MGR), comprising gravelly silty sand, was encountered in two locations within Section H.
- Head Deposits (HEAD), comprising soft to firm orangish brown sandy gravelly clay, are locally encountered within the top approximate 4 m bgl.
- River Terrace Deposits (RTD), comprising soft to firm / loose gravelly clay and clayey gravel, is encountered in the south of Section H up to 4 m bgl.
- Wittering Formation (WTT), comprising firm to stiff sandy clay up to 9.45 m bgl and dense to very dense glauconitic sand, to 13.10 m bgl.
- London Clay Formation - Whitecliff Sand Member (WHI), comprising medium dense to very dense brown sand, is encountered at various levels between 0.8 m and – 11.75 m bgl.
- London Clay Formation (LC) bedrock, comprising stiff to very stiff brown and dark grey clay, is encountered between 0.4 m – 18.5 m bgl.
- London Clay – Possible D/C basal bed, comprises dense black well-rounded gravel, between 18.5 and 20.0 m bgl.

Superficial deposits and bedrock are likely to be founding strata for 1200mm diameter ductile iron (DI) open-cut pipeline sections within 3 – 6 m bgl. Near the southern end of Section H, RTD and WTT are likely to be encountered within the top 3m bgl within the first 800 m of the pipeline route from the A334 (Winchester Road) at the beginning of Section H to Pricketts Hill Road.

8.2 Foundation Design

Open-cut pipeline sections are expected to be founded with all strata within Section H described above and the ground is expected to be capable of supporting the required plant. Where cohesive superficial deposits are encountered, prior to pipeline construction, any very soft superficial deposits could potentially be removed and granular imported fill placed. For the approximate 2.7 km length of pipeline proposed across Section H; bearing resistance or settlement issues are not anticipated – the pipeline is expected to result in a net reduction in ground bearing pressure at formation level.

8.3 Shallow Excavation

8.3.1 Excavation

Shallow excavations for the proposed open-cut pipeline route are expected to be constructed between 3 m – 6 m bgl, all within Head Deposits, River Terrace Deposits, Wittering Formation, London Clay Formation -

Whitecliff Sand Member and London Clay Formation LC. Excavations are expected to be within the capability of conventional plant.

For excavations within superficial deposits full excavation support would likely be required as groundwater levels encountered suggest high groundwater levels across Section H boreholes. Where space permits (e.g. in open land), it may be possible to construct the shallow pipework within unsupported battered trenches. This is generally applicable to clays and with excavations open for a long time; supported battered trenches would be beneficial to prevent excavation collapse from occurring (CIRIA, 1992). Where fine sands are encountered within the Wittering Formation and London Clay Formation - Whitecliff Sand Member, these materials may be highly mobile below the water table.

8.3.2 Groundwater Control

Based on the ground investigation records, significant groundwater entries are likely to be encountered in shallow and deep excavations as groundwater was encountered during drilling and within monthly monitoring between 0.61 m - 9.70 m bgl (65.56 m - 56.46 m OD) within Head Deposits, Wittering Formation, London Clay Formation - Whitecliff Sand Member and London Clay Formation. Sump pumping will work within Head Deposits, cohesive River Terrace Deposits and cohesive Wittering Formation and London Clay by ponding and pumping from the base. London Clay Formation - Whitecliff Sand Member and granular Wittering Formation (likely to be encountered) that contain a large amount of fines may be controlled by ejector wells. Granular River Terrace Deposits is expected to be controlled by well pointing.

High water levels have been encountered during monitoring, which should be taken into account prior to construction.

There are a number of exploratory hole locations that did not encounter groundwater during excavation and / or drilling works including: 2H4500DR, 2H4502DS, 3H4507HP, 3H4511HP, 3H4513HP, 3H4514HP, 3H4515HP, 3H4602HP, 3H4603HP and 3H4606HP.

8.4 Flotation

There were no instances of artesian groundwater conditions above ground level during investigation.

The structures should be designed to resist flotation in all stages of temporary and permanent works.

8.5 Trenchless Construction

The Applicant have confirmed the current trenchless crossing pipeline, shaft dimensions and depths. Launch shaft dimensions will range between 9.0 m – 9.5 m diameter and reception shafts range between 5.0 m – 5.4 m diameter with a 700 mm – 800 mm diameter DI pipe within a 1200 mm internal diameter pipe jack. Trenchless crossings are presumed to be driven west to east so the launch shafts are always the most westerly shafts.

Trenchless construction depths are not currently known. However, crossing must be a minimum of 2.5 m under the lowest point of the riverbed or road. Geology at the shaft locations is summarised in **Table 8.1.**

Table 8.1: Shaft Construction Geology

Trenchless Hole Location (Launch Pit)	Base of Shaft Construction Depth m bgl (m OD)	Shaft Strata	Trenchless Hole Location (Reception Pit)	Base of Shaft Construction Depth m bgl (m OD)	Reception Pit Shaft Strata
3H4600SA	12 (+42.21)	River Terrace Deposits, Wittering Formation and London Clay Formation	3G4102SA	12 (+43.20)	River Terrace Deposits and Wittering Formation
2H4501DR	9.83 (+56.33)	London Clay Formation and London Clay Formation - Whitecliff Sand Member	2H4500DR	5 (+56.33)	Head Deposits and London Clay Formation - Whitecliff Sand Member
3J5002A	6 (+44.56)	London Clay Formation – Whitecliff Sand Group	3H4517SA	10 (+44.62)	Made Ground, London Clay Formation - Whitecliff Sand Member and London Clay Formation

All section H shafts are below the groundwater level during monitoring. Trenchless construction in Wittering Formation (within sand horizons), and Whitecliff Sand Member below the water table will need a machine with full face support (e.g. slurry // EPBM system).

Where Wittering Formation and Whitecliff Sand Member (WHI) is expected at the various trenchless construction depths, it is recommended to align the pipejack tooling deeper to target potential deeper stiff/very stiff clay. If tunnelling in stiff/very stiff clay, considered optimum material for soft-ground tunnelling as it is generally self-supporting, of low permeability, and homogenous. Both open-face and closed face tunnelling methods are likely to be suitable.

Ground investigations have not been undertaken for proposed trenchless crossings at Pricketts Hill and Blind Lane. It is not confirmed if a trenchless crossing will be required here.

8.6 Ground Aggressivity

8.6.1 Concrete

The results of the pH and sulphate tests (SO_4) undertaken on Head Deposits, River Terrace Deposits, and Whitecliff Sand Member, indicate that worst case design sulphate class is DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-1. For Wittering Formation and London Clay Formation, the worst-case design sulphate class is DS-4 and the worst case aggressive chemical environment for concrete (ACEC) class AC4. London Clay - Possible D/C basal bed was not tested for concrete aggressivity; however a worst case design sulphate class is DS-4 and the worst case aggressive chemical environment for concrete (ACEC) class AC4 should be applied.

8.6.2 Ferrous Metals

Strata across the proposed pipeline route has the potential to be aggressive towards ferrous metals.

Following guidance published by TRL (Eyre, D., & Lewis, D.A., 1987) if clay (within Superficial deposits and London Clay Formation) and sand (Whitecliff Sand Member) are encountered with the below characteristics, it is considered aggressive towards ferrous metals with:

- Characteristic apparent resistivity value of 10 Ωm
- Organic content greater than 0.2 %
- Plasticity index greater than 15
- Poorly drained area or groundwater above pipework level
- Moisture content greater than 20 %
- pH greater than 6
- Soluble sulphate 500 to 1000 mg/l
- Aggressive compounds in Made Ground (e.g. cinder or coke)

Eyre and Lewis' (1987) Contractor Report has two soil corrosivity assessment methods; Table A1 and B1. Using worst case scenario, these two assessments class Section H as highly aggressive (Table A1) and very aggressive (Table B1) respectively (Eyre, D., & Lewis, D.A., 1987).

8.7 Geotechnical Hazard Assessment

Table 8.2 summarises potential geotechnical hazards associated with the Site during and post construction.

Table 8.2: Potential Hazards

Hazard	Source of information/comment	Mitigation method
Unforeseen Ground Conditions	Project specific ground investigation undertaken in 2023 and 2024 to inform outline design. Trenchless bore collapse and uncontrolled ground settlement, very soft / loose material present that is inadequate for founding of pipework / chambers. No ground investigations at proposed trenchless crossings at Pricketts Hill and Blind Lane.	Exploratory holes, to include investigation at around 200m intervals and at trenchless crossings, have been undertaken. Considering the current pipe jacking depth is likely within WHI (the distinct sand horizon within LC), consideration may be given to deepen of the pipejack so that it is only within LC, not at its current proposed depth within WHI. Further ground investigation would be recommended to better profile the WHI/LC boundary between these two locations.
Groundwater/Flotation.	Lack of knowledge of groundwater conditions. Potentially result inappropriate/inadequate choice of dewatering techniques, excessive sump pumping causing settlement, unstable ground, inappropriate bore support and flotation.	Groundwater results should be reviewed over a minimum period of 6 months. At trenchless crossing locations, the groundwater levels should be reviewed over a 12 month period to estimate any potential dewatering requirements prior to construction. Continued monitoring or groundwater at boreholes with installations.
Bore / trench Collapse	Fracture indices during rotary coring highlighting areas of assumed zones of core loss. Inadequately defining the superficial deposits / London Clay Formation interface or from encountering sand horizons and within Whitecliff Sand Member is an issue to consider. It is important to define the interface with the underlying/overlying strata to ensure a suitable bore is designed.	When excavating, assess the degree of fracturing and structure as the excavation progresses in depth and lateral extent. Check to see if the excavation remains intact or blocky. If the ground becomes increasingly laminated and irregular, excavate in reduced thicknesses rather than larger blocks at a time to prevent the likelihood of collapse. Superficial deposits such as Head Deposits have relic shear surfaces, which may be encountered above WHI and LC bedrock deposits. Use vertical sided trench support: trench sheets or boxes, as required. Trenchless construction within the Whitecliff Sand Member, part of London Clay Formation, would require full face support (e.g. slurry / EPBM).
Excessive settlement, pipe failure / bursts.	Geological logs displaying strata to a maximum of 20.45 m bgl.	Ensure that proposed pipework avoids areas of unsuitable ground and buried structures where possible. If structures are within the route alignment, arrange with the Applicant and appropriate asset landowners

Hazard	Source of information/comment	Mitigation method
	Subsidence and hidden soft areas of ground previously not identified during the GI.	that the impact of the proposed construction is reviewed and appropriate mitigation undertaken. Ensure that the design includes for the use of appropriate groundwater control and excavation support methods, to be employed for the encountered ground, to minimise any impacts.
Existing buried services - strike, injury	Utility drawings provided to the Principal Contractor / Ground Investigation Contractor may not reveal all services underground and may differ.	Ensure that utility providers are contacted in advance of excavation works with any uncertainty proven on site by those providers having engineers present. They should be in attendance, where necessary, such as near high risk locations. For further confirmation, Ground Penetrating Radar (GPR) and/or PAS128 surveys may also be performed.
Unknown buried structures / Southern Water assets /	Geological logs displaying strata to a maximum of 20 m bgl. Subsidence and hidden soft areas of ground previously not identified during the GI.	Ensure that proposed pipework avoids these areas of unsuitable ground and buried structures where possible. If structures are within the route alignment, arrange with the Applicant and appropriate landowners for these to be investigated/removed as early as practicable consulting all records available to the Applicant.
Striking unexploded ordnance (UXO), triggering an explosion	The Site was impacted by bombing in WWII.	Preliminary Risk Assessments were conducted specific to each exploratory hole location to reduce the section-wide greater UXO risk. Detailed UXO assessment undertaken with the following findings (Zetica, 2024): ■ No significant sources of UXO hazard have been identified. ■ Proceed with works. An UXO awareness briefing is prudent for staff involved in excavations. LOW UXO hazard level is applied to Section H
Aggressive Chemical Environment for Concrete / Failure of new assets due to degradation	The results of the pH and sulphate tests (SO4) undertaken on Head Deposits, River Terrace Deposits, and Whitecliff Sand Member, indicate that worst case design sulphate class is DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-1. For Wittering Formation and London Clay Formation the worst-case design sulphate class is DS-4 and the worst case aggressive chemical environment for concrete (ACEC) class AC4.	Ensure that additional testing is carried out for Made Ground and London Clay Formation D/C Basal Bed. Resistivity testing should be undertaken at 3H4515HP and 3H4606HP.

9 Conclusions

9.1 Geotechnical

The GI data for Section H comprises 14 No. exploratory holes for the selected areas of trenchless crossings, potential sources of contamination and along the linear pipeline route.

Made Ground, Head Deposits, River Terrace Deposits, Wittering Formation, Whitecliff Sand Member and London Clay Formation bedrock are likely to be encountered during open-cut construction. Made Ground, Head Deposits, River Terrace Deposits, Whitecliff Sand Member and London Clay Formation bedrock are likely to be encountered at the proposed trenchless crossings and their reception and launch shafts.

High water levels across the borehole locations may require conventional sump pumping, well pointing and ejector wells to control the groundwater.

Pipejacking has been decided, by the Applicant, as the trenchless crossing technique due to passing under multiple sensitive land-uses. Proposed open-cut construction is to be between 3 – 6 m bgl, trenchless construction depths are currently unknown.

Head Deposits, River Terrace Deposits, and Whitecliff Sand Member indicate that worst case design sulphate class is DS-1 and the worst case aggressive chemical environment for concrete (ACEC) class AC-1. For Wittering Formation and London Clay Formation the worst-case design sulphate class is DS-4 and the worst case aggressive chemical environment for concrete (ACEC) class AC4.

Wittering Formation and London Clay Formation are unsuitable for structural reuse along the pipeline route. Made Ground, Head Deposits, River Terrace Deposits, Whitecliff Sand Member and are potentially suitable for reuse as S3 or S4 embedment material.

All ground in Section H (superficial and bedrock) are highly / very aggressive towards ferrous metals.

9.2 Geo-environmental

The Phase 2 GI completed in Section H focused on one PSC, Shirrel Heath Sand Pit Landfill (PSC 90). The current proposed DoL is within 30 m of this PSC. The Phase 2 GI locations were drilled approximately 20 m southwest of this PSC and 10 m northeast of the proposed DoL. Two GI locations at the proposed trenchless crossing at Shirrell Heath High Street were also completed during the Phase 2 works.

The Phase 3B/3C GI in Section H primarily comprised GI locations to collect ground conditions data for the linear route. Two trenchless crossing locations at proposed road crossings were also investigated. Several PSCs within a 50m buffer zone of the DoL were in proximity to the GI locations, however these have not been fully delineated. These included Pit-Sand (PSC 103), Pit-Gravel (PSC 45), Infilled Land – Disturbed Ground (PSC 78), Worked Ground (PSC 445) and Pig Farm (PSC 512).

The revised risk assessment for the PSCs, updated from the desk study with Phase 2 and Phase 3B/3C GI data, identified the following risks:

- A Moderate risk rating was identified for groundwater at locations advanced to investigate the DoL closest to Shirrell Heath Landfill - PSC 90 (2H4502DS and 2H4503DS**)** and at 3H4517SA due to the presence of TPH in groundwater sampling.
- Moderate/Low risk to groundwater due at 3H4600SA to multiple PCOC exceedances of the adopted GAC.

- A Moderate/Low risk classification has been identified for impact to construction, maintenance workers and future site users via direct contact and inhalation pathways at trenchless crossings, based on the findings of presence of TPHs in groundwater and gas concentrations. Ground gas monitoring showed carbon dioxide exceedances for short and long-term WELs and depleted oxygen levels. Though in light of the flooded well within 3H4517SA this assessment is very conservative. It should also be noted that gas risk has been reduced to a low risk for the trenchless crossing beneath Winchester Road, at the boundary between Section G and H, due to the age of the gravel pit approximately 45 m south (PSC 45).
- Risk ratings for the possible former pig farm (PSC 512) have been carried forward from the Desk Study, version 4 (SSP, 2024) due to limited GI data across the PSC footprint (one hand pit location). Moderate/Low risk ratings identified for impact to construction, maintenance workers and future site users, adjacent site users and groundwater during construction.
- Very Low/Low risk for on Site existing and future property, there are no AGP compounds within Section H, therefore the potential contaminant linkages for this receptor are not considered to require further assessment.

Ground gas is unlikely to pose a risk within areas of GI undergoing open cut excavations as any gas accumulated should quickly dissipate. At the trenchless crossings, although there are no permanent building structures proposed for this area of the scheme, the ground gas data recorded at locations should be considered at the preconstruction phase, as temporary deep excavations may be planned as reception pits.

Data Gaps

Although several exploratory holes were completed during the GIs (Phase 2 and Phase 3B/3C) in proximity to the PSCs listed below, none were advanced (except PSC 512) within the footprint of the identified PSCs (SSP, 2024). Therefore, the CSM and risk classification presented in the desk study Version 4 (SSP, 2024) for these PSCs remains current until further information is obtained.

- Infilled Land – Disturbed Ground (PSC 78)
- Pit – Sand (PSC 103)
- Worked Ground (PSC 445)
- Pig Farm (PSC 512)
- Pit-Gravel (PSC 45)

10 Recommendations

10.1 Geotechnical

Further Ground Investigation is recommended.
Section H locations are representative of a majority of the approximate 2.7 km length of pipeline.

It is recommended that

- Further GI along the route is performed to fully understand and characterise the soil required to be excavated / removed / reused and at other potential trenchless crossing locations.
- Additional groundwater monitoring takes place due to high groundwater levels present along the route.
- BRE concrete aggressivity testing is carried out on Made Ground.

Ground preparation

It is recommended that a processing plant should be used on site to screen out and remove the particles exceeding 40 mm within fine- and coarse-grained soil across the pipeline. Only material with embedment class of S4 or less are recommended to be used for as – dug soils surrounding semi-rigid pipes or the proposed 1200 mm ductile iron pipeline across the route.

10.2 Geo-environmental

Further Ground Investigation is recommended
Further soil sampling and testing prior to construction may be necessary if material reuse is planned. This is to be determined after details in the design phase are clarified.

Further GI to investigate ground conditions including geo-environmental sampling is recommended along the route in Section H at the locations of Moderate / Low risk or higher PSCs identified following the Phase 2 and Phase 3B/3C GIs and those identified in the Desk Study (SSP, 2024).

Although several exploratory holes were completed during the GIs (Phase 2 and Phase 3B/3C) close to PSCs listed below, none were advanced (except PSC 512) within the footprint of the identified PSCs (SSP, 2024):

- Infilled Land – Disturbed Ground (PSC 78)
- Pit – Sand (PSC 103)
- Worked Ground (PSC 445)
- Pig Farm (PSC 512)
- Pit-Gravel (PSC 45)

Further GI to investigate ground conditions that includes geo-environmental sampling, groundwater sampling and gas monitoring at the aforementioned PSCs is recommended due to the limited data collected thus far.

Conduct additional geo-environmental monitoring during construction
Recommendations for ground gas and groundwater monitoring / testing during construction phase should be provided within the Construction Phase Environmental Management Plan.

The ground gas data recorded at the trenchless crossing of Shirrell Heath High Street (2H4501DR), Winchester Road (A334) (3H4600SA) and Winchester Road (B2177) (3H4517SA) should be considered at the pre-construction phase in terms of risks to groundworkers in the planned launch/reception pits.

Watching Briefs

Watching briefs should be in place during construction. Groundworkers should remain vigilant throughout construction, particularly within the vicinity of PSCs, and should visual and/or olfactory indicators of contamination (including asbestos) be encountered, works should cease in that area and advice be sought from a suitably qualified geo-environmental professional. Further testing and specialist advice may be required. This is particularly applicable to parts of Section H being constructed using open-cut excavation.

Stockpile Management

Stockpile material must be well managed and kept on an area of hardstanding located down gradient of surface water drainage that may potentially discharge to a watercourse. It is recommended that any stockpiled material is covered to prevent rainfall infiltration, run off, and leachate and dust generation. Stockpiles should be secured when not in use to prevent third party access.

References

BRE. (2005). Concrete in aggressive ground BRE Construction Division Special Digest 1 : 2005. BRE.
BSI. (2007). Eurocode 7 - Geotechnical Design Part 2: Ground Investigation and testing BS EN 1997-2: 2007. BSI.
BSI. (2015a). BS8485:2015+A1:2019: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. British Standards Institute.
BSI. (2015b). BS8002:2015 Code of practice for earth retaining structures. London: Figure 2, BSI.
BSI. (2019). BS6164:2019 - Heath and Safety in Tunnelling in the Construction Industry - Code of Practice. London: British Standards Institute. Retrieved from BS 6164:2019 Health and safety in tunnelling in the construction industry. Code of practice: https://knowledge.bsigroup.com/products/health-and-safety-in-tunnelling-in-the-construction-industry-code-of-practice/tracked-changes
BSI. (2020). BS9295: 2020 Guide to the structural design of buried pipes. London: BSI.
CIRIA. (1992). Trenching Practice CIRIA Report 97. CIRIA.
CIRIA C552. (2001). Contaminated land risk assessment. A guide to good practice (C552).
Defra. (2014). SP1010 Defra. (2014). Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. Final Project Report (Version2). Contaminated Land: Applications in Real Environments. .
Drinking Water Inspectorate. (2025). Drinking Water Standards and Regulations. Retrieved from Drinking Water Inspectorate: https://www.dwi.gov.uk/drinking-water-standards-and-regulations/
Environment Agency. (2021). Waste Classification Technical Guidance . Retrieved from GOV.UK: https://www.gov.uk/government/publications/waste-classification-technical-guidance
Environment Agency. (2023, July 08). Guidance - Land contamination risk (LCRM). Retrieved from www.gov.uk: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm
Environment Agency. (2023a, July 08). Guidance - Land contamination risk (LCRM). Retrieved from www.gov.uk: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm
Eyre, D., & Lewis, D.A. (1987). TRL Contractor Report 51: Soil corrosivity assessment. Crowthorne. Transport Research Laboratory.
HazWasteOnline. (2023). Waste Classification Report; Ref: LRK8M-RCW8N-JMPPY.
HazWasteOnline. (2024). HazWasteOnline, Report Reference W3BS4-9WHWL-2DSQB.
HSE. (2020). EH40/2005 Workplace Exposure Limits. London: HSE.
King, C. (1981). The stratigraphy of the London Clay and associated deposits. Tertiary research special paper.(6), 1-158.
Look. (2007). Handbook of Geotechnical Investigation and Design Tables. Taylor and Francis.
Nathanail et al. (2015). The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press.
NLS. (2023). National Library of Scotland. Retrieved from https://maps.nls.uk/geo/explore
Safelane Global. (2023). Detailed Unexploded Ordnance Risk Assessment. In Respect of: Water for Life Havant Thicket to Otterbourne. Safelane Global.
Society of Brownfield Risk Assessment (SoBRA). (2020). Development of Acute Generic Risk Assessment - Criteria for Assessing to Human Health from Contaminants in Soil (v.2). SoBRA.
SOCOTEC. (2023). Ground Investigation Report (Factual Account of Fieldwork Monitoring and Laboratory Testing), Issue 02 ref: G2034-22/P2, November 2023. Maidstone: SOCOTEC.
SOCOTEC. (2024). WFL Hampshire Water Transfer and Water Recycling Project (Phase 3B) Report G2034-22/P3B and (Phase 3B and Phase 3C) Ground Investigation Report (Factual Account of Fieldwork, Monitoring and Laboratory Testing). Final Report. Report No. G4011-24/P3B_3C. Maidstone.
Southern Water. (2024). Hampshire Water Transfer and Water Recycling Project Technical Document Terminology Guide 710166 - SOUTHERN WATER. Southern Water January 2024 Version 8.
SSP. (2022a). Ground Investigation Specification and Bill of Quantities Water Transfer from Havant Water Recycling Plant to Havant Reservoir, Water Transfer from Havant Thicket Reservoir to Otterbourne Water Supply Works Tunnel Locations June 2022. Falmer: SSP.
SSP. (2022b). Methodology for Identification of Ground Investigation 710166-SWS-XX-XX-MS-GE-00001. SSP.
SSP. (2023). Water Recycling Plant (WRP) to Otterbourne WSW and Havant Thicket HLPS to Otterbourne WSW Geo-technical and Geo-environmental Desk Study.
SSP. (2023a). Phase 2 Data logger monitoring till November 2023. SSP.
SSP. (2023b). Ground Investigation Specifcation and Bill of Quantities for Ground Investigation. Hampshire Water Transfer and Water Recycling Project. Phase 3B Critical Crossings, Potential Sources of Contamination (PSCs), Non-pipeline Infrastructure and Linear Route.

SSP. (2023c). Ground Investigation Specifcation and Bill of Quantities for Ground Investigation. Hampshire Water Transfer and Water Recycling Project. Phase 3C Critical Crossings, Potential Sources of Contamination (PSCs), Non-pipeline Infrastructure and Linear Route.
SSP. (2024). Hampshire Water Transfer and Water Recycling Project Geotechnical and Geo-Environmental Desk Study Version 4 710166-SWS-XX-XX-RP-GE-00004. SSP.
Tomlinson. (2001). Foundation Design and Construction 7th Edition. Pearson Educational Ltd.
Zetica. (2024). UXO Desk Study & Risk Assessment. Document Ref. P14032-24-R7. H Site.

Figures

Appendices

Appendix A: Section H Desk Study Information Specific to the GI

Table A1 summarise desk study information specific for the Phase 2 and Phase 3B/3C GI areas in Section H. The information was used to develop the preliminary conceptual site model (CSM) presented in the HWTWRP Geotechnical and Geo-environmental desk study Version 4 (SSP, 2024).

Table A1: Geo-environmental Desk Study Summary Information for Phase 2 and Phase 3B/3C GI Locations at Section H

		3H4600SA, 3H4602HP	3H4507HP	3H4511HP	3H4603HP	3H4513HP, 3H4514HP	3H4515HP	2H4500DR	2H4501DR	2H4502DS, 2H4503DS	3H4606HP	3H4517SA
Geology	**Superficial Deposits**	River Terrace Deposits	Absent			Head	Head deposits c.10 m east	Head deposits c.140 m east	Absent	Absent	Absent	
	Bedrock Geology	Whittering Formation			Whitecliff Sand Member	London Clay Formation	Whitecliff Sand Member	London Clay Formation	Whitecliff Sand Member			
	Artificial/ Made Ground [1]	Absent								BGS Infilled Ground c. 30 m northeast	BGS Infilled Ground c. 75 m northeast	Absent
Hydrogeology	**Bedrock Aquifer Classification**	Secondary A			Secondary A	Unproductive	Secondary A	Unproductive	Secondary A			
	Superficial Aquifer Classification	Secondary A	N/A			Secondary Undifferentiated	N/A					
	Source Protection Zones (SPZs)	None										
	Drinking Water Safeguard Zone (DWSgZ)	None										
	Groundwater Abstractions [1]	None										
	Groundwater Nitrate Vulnerable Zone (NVZ)	None										
Hydrology	**Surface Water Courses** [1]	No watercourses or waterbodies within 250 m.			Land drains c.200 m northwest	Land drains c.30 m east & 150 m southeast	Land drains c.220 m east	No watercourses or waterbodies within 250 m.				
	Surface Water DWSgZ	None										
	Surface Water Abstractions [1]	None										
	Surface Water NVZ	None		Eutrophic Water ET2 – Chichester, Langstone and Portsmouth Harbours Eutrophic NVZ.								
Flooding	**Risk from Rivers and the Sea**	Flood Zone 1										
Site History	**On-Site**	The earliest mapping indicated the Section was located within an undeveloped area, with the northern area of the Section within Shirrell Copse, south of Shirrell Heath, partial deforestation recorded on c.1937-61 mapping. Allotment gardens are recorded within the northern area, east of Shirrell Copse (c.1892-1914, unrecorded by c. 1937-61 and 1945-65 mapping); additional allotment gardens are recorded within the northern area of the Section (c.1892-1914, unrecorded by c. 1937-61 and 1945-65 mapping).										
	Surrounding Land	The surrounding land comprises allotment gardens, mixed woodland and the village of Shirrell Heath. Allotment gardens are no longer recorded on 1937-1961 mapping.								The surrounding land comprises allotment gardens, mixed woodland and the village of Shirrell Heath. Allotment gardens are no longer recorded on 1937-1961 mapping. A sand pit is shown on the 1949-1973 map c.60 m northeast (identified as PSC 89 in the desk study and fully overlaps with PSC 90).		
Landfill Sites		There are no historical or current landfill sites within 250 m.								Shirrell Heath Sand Pit Landfill (site ref. FW1, 5/1) (PSC 90), located approximately 20-70 m northeast, licensed from 1976 for disposal of inert and commercial waste. License surrender date is unknown.		There are no historical or current landfill sites within 250 m.
Pollution Incidents		There are no pollution incidents (category 1 or 2) within 50 m of the GI locations.										
Ecological Sensitivity (250 m radius)	**Sites of Special Scientific Interest (SSSI)**	None				None				None		
	Special Areas of Conservation (SAC)											
	Special Protection Areas (SPAs)											
	RAMSAR site											
	National Nature Reserve (NNR)											
	Ancient Woodlands					Shirell Copse c.100-230 m northwest and an unnamed woodland c.80 m east to 180 m northeast	Shirell Copse c.115 m west and an unnamed woodland c.160 m southeast	Shirell Copse c.170 m south	Shirell Copse c.100 m southwest			
Overall Risk Assessment from the Desk Study		PSC 44 & 45	PSC 512	N/A	PSC 85	PSC 546 & 547	PSC 78	N/A		**PSC 90**: potential contaminant linkages with a moderate risk were identified for construction and maintenance workers and future sites users relating to direct dermal contact, ingestion and inhalation of dusts, gases and vapours. Potential contaminant linkages with a moderate / low risk were identified for adjacent land users, on Site existing and future property and groundwater. All other receptors were classified as low risk.		PSC 103 & 445

Notes:[1] Includes active groundwater and surface water abstractions within 500 m; surface waters up to 250 m; artificial ground up to 250 m. All distances are approximate.

Appendix B: Chemical Analysis List of Suites and Geo-Environmental Testing

Table B1: Summary of Geo-Environmental Laboratory Tests

Sample ID	Analysis Suites [1]															
	Soils Suites							Soil Leachate Suites (including Suite 3.0 Soil Leachate Prep)				Groundwater Suites				
	1.1	1.3	1.7	1.8	1.10	2.1	2.16	3.1	3.6	3.7	4.15	3.1	3.6	3.7	3.9	4.15
	Made Ground	Natural [2]	Pesticides	Herbicides	Waste Acceptance Criteria (WAC)	Farms Standard	BGS Made Ground / Landfill [3]	Standard	Pesticides	Herbicides	BGS Made Ground / Landfill	Standard	Pesticides	Herbicides	Hydrogeology Suite [4]	BGS Made Ground / Landfill [4]
2H4500DR 0.1m		✓	✓	✓				R	R	R						
2H4500DR 1.0m		✓														
2H4500DR 1.75m		R						R								
2H4500DR 8.5m		✓														
2H4501DR 1.0m		✓														
2H4501DR 3.1m		✓			✓											
2H4501DR 4.0m		✓						R								
2H4502DS 0.1m		✓														
2H4502DS 0.5m							✓				R					
2H4502DS 2.7m							✓				R					
2H4503DS 0.3m		✓														
2H4503DS 1.0m		✓														
2H4503DS 2.6m		✓														
2H4503DS 4.5m							✓				R					
3H4507HP 0.2m						✓										
3H4507HP 1.0m						✓										
3H4511HP 0.2m		✓														
3H4511HP 0.5m		✓														
3H4513HP 0.2m		✓														
3H4513HP 1.0m		✓														
3H4514HP 0.5m		✓														
3H4514HP 1.0m		✓														
3H4515HP 0.2m		✓	✓	✓												
3H4515HP 1.0m		✓														
3H4517SA 0.2m	✓ [5]															
3H4517SA 1.0m	✓ [5]															
3H4517SA 8.0m		✓			✓											
3H4600SA 1.1m		✓			✓											
3H4600SA 3.3m		✓						✓								
3H4600SA 9.45m		✓														
3H4602HP 0.5m		✓														
3H4602HP 1.0m		✓														
3H4603HP 0.2m		✓	✓	✓												
3H4603HP 1.0m		✓														

Sample ID	Analysis Suites [1]															
	Soils Suites							Soil Leachate Suites (including Suite 3.0 Soil Leachate Prep)				Groundwater Suites				
	1.1	1.3	1.7	1.8	1.10	2.1	2.16	3.1	3.6	3.7	4.15	3.1	3.6	3.7	3.9	4.15
	Made Ground	Natural [2]	Pesticides	Herbicides	Waste Acceptance Criteria (WAC)	Farms Standard	BGS Made Ground / Landfill [3]	Standard	Pesticides	Herbicides	BGS Made Ground / Landfill	Standard	Pesticides	Herbicides	Hydrogeology Suite [4]	BGS Made Ground / Landfill [4]
3H4606HP 0.2m	✓ [5]		✓	✓												
3H4606HP 1.0m		✓														
2H4500DR	N/A											✓ 17/07/2023	✓ 17/07/2023	✓ 17/07/2023	✓ 17/07/2023	
2H4501DR	N/A											✓ 03/05/2023 17/07/2023 12/09/2023			✓ 03/05/2023 17/07/2023 12/09/2023	
2H4502DS	N/A															✓ 03/05/2023
2H4503DS	N/A															✓ 28/02/2023 03/05/2023 17/07/2023 12/09/2023
3H4517SA	N/A											✓ 17/04/2024 01/05/2024 22/05/2024				
3H4600SA	N/A														✓ 12/08/2024 20/08/2024	✓ 12/08/2024 20/08/2024
Total completed / requested	**3 / 3**	**27 / 28**	**4 / 4**	**4 / 4**	**3 / 3**	**2 / 2**	**3 / 3**	**1 / 4**	**0 / 1**	**0 / 1**	**0 / 3**	**7 / 7**	**1 / 1**	**1 / 1**	**6 / 6**	**7 / 7**

Notes:
1 List of analytes included in each suite is presented in **Appendix B**.
2 Although requested, nickel analysis was not completed.
3 Although requested, asbestos screening was not completed.
4 Although requested, ammonia and total dissolved solids (TDS) analyses were not completed.
5 Although requested, boron results are not provided.
✓ Requested and completed.
R Requested but not received to date in either AGS format or Ground Investigation reports (SOCOTEC, 2023) (SOCOTEC, 2024).
N/A Not applicable
For groundwater samples the date shows the date of groundwater sampling from the Ground Investigation reports.

Appendix C: Deviations Reported by Analytical Laboratory

The following sample deviations have been reported by the analytical laboratory:

- The quality control (QC) associated with some results has not wholly met the QMS requirements, the accreditation has therefore been removed. However, the Laboratory has confidence in the performance of the method as a whole and that the integrity of the data has not been significantly compromised.
- Due to matrix interference, the internal standard and/or surrogate has not met the Quality Management System (QMS) requirements. This should be taken into consideration when utilising the data.
- A non-standard volume or mass has been used which has resulted in a raised detection limit.
- Acceptable (holding) time between the sampling date and laboratory analysis was exceeded. Holding times are derived based on 'stability'; the ability of a property to remain unchanged, within a stated uncertainty, under given storage conditions and a specific timeframe. If a reported result is within the holding time it is known that the degree of change (if it occurs) is not statistically meaningful. If the sample result is reported as 'deviating', the degree of change is unknown and therefore may have affected the result the result must; therefore, be treated as potentially indicative.
- Headspace was present in sample. The presence of headspace and air bubbles in volatile organic analysis sampling vials lowers the actual aqueous concentration of these compounds due to the partitioning of solutes into the gaseous phase. Due to the loss of volatile analytes, the result must be treated as potentially indicative.
- An incorrect or no preservative was used in the sample bottle.
- The sample volume or mass was insufficient to complete the analysis.

Table C1: Soil Sample Deviations

Analyte or Analytical Method	BH ID and Sample Depth (m bgl)																
	2H4500DR	2H4501DR	2H4502DS		2H4503DS		3H4507HP		3H4517SA			3H4600SA			3H4602HP		3H4606HP
	3.1	1.0	0.5	2.7	2.6	4.5	0.2	1.0	0.2	1.0	8.0-8.1	1.1	3.3	9.45	0.5	1.0	0.2
Boron (Water Soluble) by ICPOES					#	#											
Lead	C																
Mercury	C																
pH (2.5:1)		#			#	#			#	#							
Total GRO (>C6-C10)		#			#								#	#	#	#	
TPH (>C10-C40) Total with Silica Cleanup					#	#											
GRO CWG UK (C5-C10) Ali/Aro Split						#											B
TPH (CWG UK) Aliphatic Split with Carbon Banding						#											
TPH (CWG UK) Aromatic Split with Carbon Banding						#											
SOM: Soil Organic Matter (%) (Calc)					#	#											
TOC: Total Organic Carbon						#											
Cyanide (Complex, Free and Total) by SFA						#											
Sulphide by SFA						#											
Thiocyanate by SFA						#											
1,2,4-Trimethylbenzene						B											
2,4-Dinitrotoluene			B														
2,4,6-Trichlorophenol				B													
Benzo[g,h,i]perylene			B														
Benzyl alcohol			B	B													
bis(2-Chloroisopropyl)ether				B													
bis(2-Ethylhexyl)phthalate				B													
Bromomethane			B														
Butylbenzylphthalate				B													
Chloromethane			B														
Dibenzo[a,h]anthracene			B														
Hexachloroethane				B													
Indeno[1,2,3-cd]pyrene			B														
Pyrene							B	B			B						
Styrene						B											

Analyte or Analytical Method	BH ID and Sample Depth (m bgl)																
	2H4500DR	2H4501DR	2H4502DS		2H4503DS		3H4507HP		3H4517SA			3H4600SA			3H4602HP		3H4606HP
	3.1	1.0	0.5	2.7	2.6	4.5	0.2	1.0	0.2	1.0	8.0-8.1	1.1	3.3	9.45	0.5	1.0	0.2
Toluene			B	B													B
Trichlorofluoromethane			B														
p-Isopropyltoluene						B											
Vinyl Chloride						B											
Basic Solid Description, DW35 - CLand Prep and Dry Weight Correction to 35°C, Stone Content					#	#											
BTEX by GCFID						#											
SVOCs (Target List and TICs) by GCMS						#											
VOCs (Target List and TICs) by GCMS						#											
PCB 28												B					

Notes:
B – The QC associated with this result has not wholly met the QMS requirements, the accreditation has therefore been removed.
C – Due to matrix interference, the internal standard and/or surrogate has not met the QMS requirements.
– Acceptable (holding) time between the sampling date and laboratory analysis was exceeded

Table C2: WAC (10:1 Soil Leachate) Sample Deviations

Analyte or Analytical Method	BH ID and Sample Depth (m bgl)		
	2H4500DR	2H4501DR	2H4503DS
	3.1	3.1	4.5
Lead	C	C	
Mercury	C	C	
17 PAHs (inc. Coronene) for WAC by GCMS			#

Notes:
C – Due to matrix interference, the internal standard and/or surrogate has not met the QMS requirements.
– Acceptable (holding) time between the sampling date and laboratory analysis was exceeded.

GROUNDWATER

Table C3: Groundwater Sample Deviations

Analyte or Analytical Method	BH ID and Sampling Date												
	2H4500DR	2H4501DR			2H4502DS	2H4503DS				3H4517SA			3H4600SA
	17/7/23	17/7/23	3/5/23	12/9/23	3/5/23	28/2/23	17/7/23	3/5/23	12/9/23	17/4/24	01/5/24	22/5/24	12/8/24 & 20/8/24: Lab reports not provided
Electrical Conductivity @ 25°C	#	#	#	#		#	#	#	#		#	#	
pH	#	#	#	#		#	#	#	#		#	#	
>C10-C12 (Aromatic)					B	B	D		#				
>C12-C16 (Aromatic)					B	B	D		#				
>C16-C21 (Aromatic)							D		D, #				
>C21-C35 (Aromatic)							D		#				
>C35-C44 (Aromatic)									D, #				
>C10-C12 (Aliphatic)							D		#				
>C12-C16 (Aliphatic)							D		#				
>C16-C21 (Aliphatic)							D		#				
>C21-C35 (Aliphatic)							D		#				
>C35-C44 (Aliphatic)							D		#				
Total GRO (>C6-C10)				^									
>C6-C40	IS	D								D		#	
>C10-C40	IS	D											
Bromoform						B							
Chloroethane						B							

Analyte or Analytical Method	BH ID and Sampling Date												
	2H4500DR	2H4501DR			2H4502DS	2H4503DS				3H4517SA			3H4600SA
	17/7/23	17/7/23	3/5/23	12/9/23	3/5/23	28/2/23	17/7/23	3/5/23	12/9/23	17/4/24	01/5/24	22/5/24	12/8/24 & 20/8/24: Lab reports not provided
Chloromethane							B						
1,2,3-Trichlorobenzene							B						
2-Chlorotoluene					B			B					
4-Chlorotoluene					B			B					
Vinyl Chloride							B						
BTEX by GCFID				^			#						
BTEX & MTBE by GCMS	#	#											
VOCs (Target List and TICs) by GCMS							#						
m and p-Xylene										B			
OCP: Organochlorine Pesticides by GCMS	IS												
17 PAHs (inc. Coronene) by GCMS	IS								D	D		D, #	
Benzo[a]anthracene											B		
Benzo[g,h,i]perylene											B		
PCBs, ICES 7 Congeners							D						
SFAPI											#, ~		

Notes:
B – The QC associated with this result has not wholly met the QMS requirements, the accreditation has therefore been removed.
D – A non-standard volume or mass has been used for this test which has resulted in a raised detection limit.
IS – Insufficient Sample to complete analysis.
– Acceptable (holding) time between the sampling date and laboratory analysis was exceeded.
^ – Headspace was present in sample.
~ - Incorrect / No preservative

Table C4: Groundwater Sample MDL Exceedances of the DWS

BH ID	Sampling Date	Analyte and Analytical Method	LOD (µg/l)	Generic Assessment Criteria (µg/l)
2H4502DS	03/05/2023	Benzene (BTEX by GCFID method)	**5 ***	1
2H4503DS	28/02/2023 03/05/2023 17/07/2023 12/09/2023	Benzene (BTEX by GCFID method)	**5 ***	1
	12/09/2023	Benzo(a)pyrene	**0.04**	0.01
		Sum (benzo b, k, ghi & indeno123cd)	**0.16**	0.1
3H4517SA	17/04/2024	Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(g,h,i)perylene Indeno(1,2,3-c,d)pyrene	**0.2**	0.1
		Benzo(a)pyrene	**0.2**	0.01
		TPH >C6-40	**2,200**	10
	22/05/2024	TPH >C6-40	**1,100**	10
3H4600SA	12/08/2024 20/08/2024	Benzene (BTEX by GCFID method)	**5**	1
		GRO CWG UK (C5-C10) Aliphatic Split	**100**	10
		GRO CWG UK (C5-C10) >C8 to C10 Aromatic Split	**20**	10
		TPH (CWG UK) Aliphatic and Aromatic Split with Carbon Banding	**100 to 200**	10
	20/08/2024	Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(g,h,i)perylene Indeno(1,2,3-c,d)pyrene	**0.2**	0.1
		Benzo(a)pyrene	**0.2**	0.01

*Benzene also analysed as part of the VOC suite, which has a MDL of 1 µg/l.

Appendix D: Geo-Environmental Laboratory Analysis Summary Screening Tables

Appendix E: HazWasteOnline™ Reports

Appendix F: Gas Monitoring Results

Table F1: Ground Gas Monitoring Results Summary for 2H4501DR

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
4 May 2023	<0.1	0.4	20.8	6	<1	0	<0.1
24 May 2023	<0.1	0.6	20.2	4	1	0	<0.1
19 June 2023	<0.1	1.1	20.1	5	1	0	<0.1
17 July 2023	<0.1	1.2	19.9	5	1	0.4	<0.1
15 August 2023	0.1	1.3	19.7	1	1	0.4	<0.1
12 September 2023	<0.1	0.8	20.9	<1	<1	0	<0.1
10 October 2023	<0.1	6.2	14.8	<1	<1	0	<0.1
13 November 2023	0.1	6.0	12.8	<1	<1	0	0.5
11 December 2023	0.1	5.9	9.8	<1	<1	<0.1	-1.4
10 January 2024	0.1	6.7	8.4	<1	<1	0.6	-5.9
8 February 2024	0.2	7.5	7.5	<1	<1	2.0	0.2
6 March 2024	0.2	6.3	6.9	<1	<1	<0.1	-4.5
9 April 2024	1.8	0.5	18.9	0	<10	0.9	-33.2

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F2: Ground Gas Monitoring Results Summary for 2H4502DS

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
4 May 2023	0.1	4.9	16.1	<1	<1	0	<0.1
24 May 2023	<0.1	6.5	13.9	<1	1	0	<0.1
19 June 2023	<0.1	4.0	18.4	1	<1	0	<0.1
15 August 2023	<0.1	5.8	12.9	1	1	0.8	<0.1
12 September 2023	<0.1	6.9	13.1	<1	<1	0.1	<0.1

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume

Table F3: Ground Gas Monitoring Results Summary for 2H4503DS

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
19 April 2023*	<0.1	0.4	20.4	<1	<1	0.4	<0.1
4 May 2023*	<0.1	<0.1	21.1	<1	<1	0	<0.1
24 May 2023*	<0.1	1.5	19.2	<1	1	0	<0.1
19 June 2023	<0.1	6.8	15.5	1	<1	0	<0.1
17 July 2023	<0.1	6.3	15.1	<1	<1	0.2	<0.1
15 August 2023	<0.1	7.2	10.3	1	<1	0.6	<0.1
12 September 2023	<0.1	10.2	10.2	1	<1	0	<0.1

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume
* Well response zone was fully flooded on these occasions; therefore ground gas measurements are not considered representative and have been excluded from the risk assessment.

Table F4: Ground Gas Monitoring Results Summary for 3H4517SA

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
03 April 2024*	<0.1	<0.1	19.3	0	<10	1.0	29.6
17 April 2024*	<0.1	<0.1	19.3	0	<10	<0.1	0
01 May 2024*	<0.1	<0.1	20.1	0	<10	<0.1	0
08 May 2024*	<0.1	0.9	20.0	0	<10	Not reported	Not reported
22 May 2024*	<0.1	0.9	20.0	0	<10	Not reported	Not reported
29 May 2024*	<0.1	1.0	20.5	27	Not reported	1.3	-4.0
17 June 2024*	<0.1	0.7	20.3	0	<10	<0.1	-67.9
03 July 2024*	<0.1	0.7	20.4	0	10	Not reported	-21.8

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume
* Well response zone was fully flooded on these occasions; therefore ground gas measurements are not considered representative and have been excluded from the risk assessment.

Table F5: Ground Gas Monitoring Results Summary for 3H4600SA

Monitoring Date	Peak Gas Concentrations (minimum for Oxygen)						Max Gas Flow Rate (pk) l/hr
	CH_4 %vol	CO_2 %vol	O_2 %vol	CO ppm	H_2S ppm	VOC ppmv	
29 July 2024*	<0.1	4.2	8.9	0	<10	0	-20
12 August 2024*	<0.1	3.3	11.5	0	<10	0	-7.7
20 August 2024*	<0.1	2.3	15.1	0	<10	<0.1	0
28 August 2024*	<0.1	2.4	15.6	0	<10	0	-50.1
2 September 2024*	<0.1	2.7	14.5	0	<10	40.0	-34
30 September 2024*	<0.1	4.4	19.9	0	<10	0	-14.8

Notes:
CH_4 - Methane, CO_2 – Carbon Dioxide, O_2 – Oxygen, CO – Carbon Monoxide, H_2S – Hydrogen Sulphide, VOC – Volatile Organic Compounds.
ppmv - Part per Million Volume
* Well response zone was fully flooded on these occasions; therefore ground gas measurements are not considered representative and have been excluded from the risk assessment.

Appendix G: Guidance for the Assessment of Land Contamination

Selection of Soil Assessment Criteria Protective of Human Health

Generic Assessment Criteria (GAC)

To evaluate potential risks to human health receptors, including future Site users, the soil analytical results have been assessed against the following Generic Assessment Criteria (GAC):

- Suitable for Use Values (S4ULs) for commercial land use (Nathanail et al, 2015) adopting a 1% soil organic matter (SOM) value.
- Lead was compared against the Defra Category 4 Screening Level (C4SL) for a commercial end use, (Defra, 2014) because a S4UL for lead has not been published, also adopting a 1% SOM value.
- Cyanide (free) was compared to the Society of Brownfield Risk Assessment (SoBRA) Acute Generic Risk Assessment criteria for assessing risks to human health from contaminants in soil (Society of Brownfield Risk Assessment (SoBRA), 2020) since there are currently no C4SLs or S4ULs for cyanide. The assessment criterion used evaluates potential for acute harm to a child by inhalation of free cyanide. This is a conservative assessment criterion used as generic assessment criteria as allows the criteria to be adjusted if the site-specific conditions are suitable.

The GAC for a Commercial/industrial end-use have been selected as these are considered to be the most appropriate for the protection of construction workers undertaking the development and the Applicant's workers who may undertake maintenance/operational work at these locations. The GAC have been generated assuming short exposure periods over a long timescale.

The GAC have been generated using assumptions regarding soil characteristics. Where the published GAC are dependent upon Soil Organic Matter (SOM), a value of 1% has been used to provide a conservative assessment. Consideration of the default soil properties used to generate the soil GAC for protection of human health is important as these influence the fate, transport and behaviour of contaminants.

- Soil type – the model default is set as Sandy Loam and assumes a dry and relatively porous soil. The default is considered sufficiently similar to the cover/restoration soils which are variably clayey/ sandy.
- pH – pH influences the cation exchange capacity and the portioning behaviour of a chemical between soil and water. The default is pH 7. The ground encountered have been found to have a pH between 4.8 and 8.9.

Selection of Water Assessment Criteria Protective of Human Health

Generic Assessment Criteria

The Site is located over a bedrock Secondary A Aquifer (Whitecliff Sand Member). To evaluate potential risks to human health via ingestion of drinking water from the underlying aquifer, the leachate analysis results (2:1) and groundwater analysis results were assessed against the following GAC:

- UK Drinking Water Standards (DWS). These have been used to provide a very conservative assessment.

- In the absence of a TPH threshold within the Water Supply [1](Water Quality) Regs 2021, the value of 10 µg/l as presented within the withdrawn Water Supply (Water Quality) Regs 1989 has been used for reference purposes. These thresholds are considered protective of human health.

Groundwater beneath the Site is under protection for potable abstraction and on this basis an assessment of these aquifers as a drinking water resource has been undertaken.

Limit of Detection vs. Generic Assessment Criteria

Where the concentration of a determinand is below the limits of detection and the limits of detection are below the relevant threshold criterion, the concentrations recorded are not considered to present a hazard to human health or controlled waters.

Where the concentration of a determinand is below the limit of detection and the limit of detection is greater than the relevant threshold criterion, ultra-low analysis or further Detailed Quantitative Risk Assessment would be required to robustly conclude that these can be eliminated as hazards.

[1] DWI (2021) Guidance on The Water Supply (Water Quality) Regulations 2016 (as amended) specific to PFOS and PFOA concentrations in drinking water DWI, January 2021.

Appendix H: Risk Assessment Tables

Table H1: Contaminated Land Risk Assessment for Section H

PSC 90	Landfill – Shirrell Heath Sand Pit (Reference EAHLD2048 Site Ref. FW1, 5/1)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Inert and commercial waste type. The depth of the waste material is unconfirmed. Landfill approximately 20 m from GI locations 2H4502DS and 2H4503DS and approximately 30 m from the DoL	Metals, inorganics, asbestos, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), semi-VOCs (including phenols), PFAS. Findings from GI: Groundwater encountered in 2H4502DS and 2H4503DS at 0.61-2.38 m bgl. No soil GAC exceedances. Soil leachate results for 2H4502DS and 2H4503DS not provided. Groundwater GAC exceedances for TPH, nitrite and iron, lead, manganese. Elevated PFOA concentration (detectable by laboratory but below GAC) recorded.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during	Direct dermal contact, ingestion and inhalation of dusts.	Medium	Low Likelihood No landfill areas or Made Ground encountered. No soil GAC exceedances.	Moderate/Low
		Adjacent land users: Farmland, closest residential properties are approximately 45-50 m east.	Direct dermal contact, ingestion and inhalation of dusts during excavation works and stockpiling.	Mild	Low Likelihood	Low
		On Site existing and future infrastructure property (buildings and buried services: No building structures as part of scheme.	Direct contact	Mild	Unlikely No structures. No landfill areas or Made Ground encountered.	Very Low
		Surface water bodies/watercourses: None within 250 m.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Mild	Unlikely	Very Low
		Groundwater Whitecliff Sand Member (Secondary A Aquifer). No superficial deposits.	Leaching through unsaturated and saturated soil.	Medium	Likely Groundwater encountered during GI and follow-up monitoring. GAC exceedances in groundwater.	Moderate
		Ecological receptors (flora and fauna): No statutory designated areas within 250 m.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low Likelihood	Low
	Landfill ground gas (methane, carbon dioxide, carbon monoxide, hydrogen sulphide) Findings from GI: Peak CO_2 concentration of 10.2% vol exceeding STL and LTL WEL. Peak CH_4 concentration of 0.1 % vol. Minimum oxygen level of 10.2 % vol Gas flow recorded <LOD on all monitoring visits.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations / construction, maintenance workers during operation.	Inhalation of gases and vapours.	Medium	Low Likelihood CO_2 exceedances for short and long-term WELs, but ground gases are expected to disperse quickly in an open-air environment. Depleted oxygen levels possible in confined spaces.	Moderate/Low
		On Site existing and future property (buildings and buried services): No building structures as part of scheme.	Gas migration / accumulation.	Medium	Unlikely Peak CH_4 concentrations are below LEL. CO_2 concentrations up to 10.2% vol but no gas flow and no proposed structures.	Very Low

Table H2: Contaminated Land Risk Assessment for Section H

Location	Trenchless Crossing Reception Shaft east of Winchester Road (B334)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
PSC 45 (Pit-Gravel) located 45 m southwest of GI location 3H4600SA. Due to the age of the gravel pit (>170 years), it is unlikely to be generating landfill gases. No GI locations closer to PSC 45 were completed. For areas of DoL close to PSC 45 refer to risk assessment in Desk study Version 4 (SSP, 2024).	No exceedances of commercial GAC protective of human health were encountered within soil samples. One leachate sample tested, and two groundwater samples collected and tested yielded exceedances of TPH C_6-C_{40}. The source of TPHs is unconfirmed and may not be an anthropogenic source. Carbon dioxide concentrations exceed STL and LTL. Low oxygen concentrations detected. Well was flooded during all monitoring rounds, results are considered as indicative.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Direct dermal contact, ingestion and inhalation of dusts	Medium	Low Likelihood	Moderate/Low
			Inhalation of gases and vapours	Medium	Unlikely	Low
		Adjacent land users: Farmland, closest residential property is adjacent to the DoL and within the PSC.	Direct dermal contact, ingestion and inhalation of dusts during excavation works and stockpiling.	Mild	Low Likelihood	Low
		On Site existing and future property (buildings and buried services): No building structures as part of scheme.	Direct contact and gas migration / accumulation.	Medium	Unlikely	Low
		Surface water bodies/watercourses: None within 250m.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Mild	Unlikely	Very Low
		Groundwater: Wittering Formation - sand silt and clay (Secondary A Aquifer). Superficial deposits of River Terrace Deposits (Secondary	Leaching through unsaturated and saturated soil.	Medium	Low Likelihood	Moderate/Low
		Ecological receptors (flora and fauna): No statutory designated areas within 250 m. Gravel Pit Copse is located 4560 m southwest of the DoL and within the PSC.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low Likelihood	Low

Table H3: Contaminated Land Risk Assessment for Section H

Location	Trenchless Crossing Reception Shaft east of Winchester Road (B2177)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Former Sand Pit (PSC 103) located approximately 20 m west of 3H4517SA. Potential for Made Ground and infill areas. Trenchless crossing through former sand pit area (PSC 103). Worked Ground (PSC 445), 3H4517SA located approximately 35 m south of PSC.	No exceedances of commercial GAC protective of human health were encountered within soil samples. Groundwater sampling yielded exceedances of lead, nickel, ammonium, nitrite and TPH (C_6-C_{40}). Carbon dioxide concentrations were recorded above the long term WELs. High carbon monoxide and hydrogen sulphide concentrations were recorded once during the 6-month monitoring period. These readings are unexplained. Negative gas flow readings recorded, Well was flooded during all monitoring rounds, results are considered as indicative. No GI data has been obtained from within the assumed footprint of these PSCs. Refer to the risk assessments in the desk study (SSP, 2024) for assessment of PSC 103 and PSC 445.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Direct dermal contact, ingestion and inhalation of dusts	Medium	Low Likelihood	Moderate/Low
			Inhalation of gases and vapours	Medium	Likely	Moderate/Low
		Adjacent land users: Wooded area, residential property approximately 50 m northeast**.**	Direct dermal contact, ingestion and inhalation of dusts, gases and vapours during excavation works and stockpiling.	Medium	Unlikely	Low
		On Site existing and future property (buildings and buried services): No building structures as part of scheme.	Direct contact and gas migration / accumulation.	Medium	Unlikely	Low
		Surface water bodies/watercourses: None within 250 m.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Mild	Unlikely	Very Low
		Groundwater: Whitecliff Sand Member – Sand (Secondary A Aquifer). Head deposits (Secondary undifferentiated aquifer) to the south (approximately 30m).	Leaching through unsaturated and saturated soil.	Medium	Likely	Moderate
		Ecological receptors (flora and fauna): No statutory designated areas within 250m.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low likelihood	Low

Table H4: Contaminated Land Risk Assessment for Section H

PSC 512	Farm – Pig Farm (potential)					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Possible former pig farm within the DoL (circa 2005). The land use activity shown on 2005 aerial photography is not confirmed, however, a possible pig farm has been included as a PSC for completeness. There is no further information to confirm this.	3H4507HP advanced within the footprint of the PSC. No Made Ground encountered. No exceedances of the adopted soil GAC. No soil leachate testing completed. No groundwater sampling or ground gas monitoring completed. As only one hand pit has been advanced within the PSC footprint, the nature and extent of ground conditions and potential contaminants across other areas is unconfirmed. PCOCs include metals, parasites, pathogens and pesticides/herbicides.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Direct dermal contact, ingestion and inhalation of dusts.	Medium	Low Likelihood	Moderate/Low
		Adjacent land users: Arable farming	Direct dermal contact, ingestion and inhalation of dusts during excavation works and stockpiling.	Medium	Low Likelihood	Moderate/Low
		On Site future property (buildings and buried services): No building structures on DoL route.	Direct contact with materials	Medium	Unlikely	Low
		Surface water bodies/watercourses: Land drain is approximately 50 m southeast of DoL.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Mild	Low Likelihood	Low
		Groundwater: Superficial deposits are River Terrace Deposits (Secondary A Aquifer). Bedrock is Wittering Formation, sand, silt, clay (Secondary A Aquifer).	Leaching through unsaturated and saturated soil.	Medium	Low Likelihood	Moderate/Low
		Ecological receptors (flora and fauna): no statutory designated sites within 250m	Plant uptake, direct contact, ingestion and inhalation of dusts by animals.	Mild	Unlikely	Very Low

Table H5: Contaminated Land Risk Assessment for Section H

Location	Trenchless Crossing Reception Shafts Shirrell Health High Street					
Potential Source of Contamination	**Potential Contaminants of Concern**	**Potential Receptors**	**Potential Pathways**	**Potential Consequence of Pollutant Linkage**	**Probability of Pollutant Linkage**	**Risk (without mitigation measures)**
Trenchless Crossing, no PSCs targeted at GI locations 2H4500DR and 2H4501DR. Farm building (PSC 545) located approximately 30 m southwest of 2H4501DR.	No exceedances of commercial GAC protective of human health were encountered within soil samples. Groundwater samples collected and tested yielded TPH exceedances of GAC at both locations. The source of TPHs is unconfirmed and may not be an anthropogenic source. Carbon dioxide concentrations exceed the short- and long-term WELs. Oxygen-depleted conditions were also detected, with minimum oxygen concentration at 6.9 %. Negative gas flow readings recorded.	**Construction, maintenance workers and future site users:** Construction workers during open cut excavations/construction, maintenance workers during operation.	Direct dermal contact, ingestion and inhalation of dusts	Medium	Low Likelihood	Moderate/Low
			Inhalation of gases and vapours	Medium	Low Likelihood	Moderate/Low
		Adjacent land users: Wooded area, residential property approximately 50 m northeast.	Direct dermal contact, ingestion and inhalation of dusts, gases and vapours during excavation works and stockpiling.	Medium	Unlikely	Low
		On Site existing and future property (buildings and buried services): No building structures as part of scheme.	Direct contact and gas migration / accumulation.	Medium	Unlikely	Low
		Surface water bodies/watercourses: Unnamed watercourse approximately 220 m.	Surface water runoff from stockpiles and migration through groundwater and underground utilities.	Mild	Low Likelihood	Low
		Groundwater: No superficial deposits. London Clay (unproductive stratum). Whitecliff Sand Member – Sand (Secondary A Aquifer) approximately 20m west of proposed shaft location	Leaching through unsaturated and saturated soil.	Mild	Low Likelihood	Low
		Ecological receptors (flora and fauna): No statutory designated areas within 250m.	Plant uptake, direct contact, ingestion and inhalation of dusts, gases and vapours by animals.	Mild	Low likelihood	Low

Appendix I: Risk Assessment Methodology