A30 Chiverton to Carland Cross
Environmental Statement

Volume 6 Document Ref 6.4 ES Appendix 9.4 Baseline conditions

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C01 | A3

22/08/18

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended)
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highways england

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Notice

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9.4 Baseline Conditions

Topography and geomorphology

9.4.1 The findings of the PSSR [1] (see **WSP Preliminary sources study report** (Volume 6 Document Ref 6.4 ES Appendix 9.1)), **WSP Ground Investigation Report (GIR)** [2] (see Volume 6 Document Ref 6.4 ES Appendix 9.2) and a review of aerial photography [3] have been used to describe the topography and geomorphology. Volume 6 Document Ref 6.3 ES Figure 9-1 presents a digital terrain model (DTIf soM) derived from the publicly available Environment Agency LiDAR data. Details of the level changes are summarised within Table 9-1 below.

Table 9-1 Summary of significant level changes along the scheme alignment.

Chainage (m)	Existing elevation (mOD)	General Description
0+000 to 0+900	122 to 147	Gradual uphill slope with minor gentle undulations.
0+900 to 1+800	147 to 131	Very gentle downhill slope with minor gentle undulations.
1+800 to 2+700	131 to 143	Gentle uphill slope with minor gentle undulations.
2+700 to 4+200	143 to 96	Gradual downhill slope with minor gentle undulations
4+200 to 5+200	96 to 121	Gentle uphill slope with minor undulations
5+200 to 6+100	121 to 79	Gradual becoming steep downhill slope with minor gentle undulations. Fluvial valley
6+100 to 6+600	79 to 100	Gradual uphill slope with minor gentle undulations.
6+600 to 7+200	101 to 78	Steep becoming gradual downhill slope with slight gentle undulations.
7+200 to 7+800	78 to 101	Gradual uphill slope with gentle minor undulations.
7+800 to 8+500	101 to 107	Flat becoming steep uphill slope with moderate undulations
8+500 to 9+000	107 to 69	Steep downhill slope with minor undulations.
9+000 to 13+400	69 to 144	Steep becoming gentle uphill slope with minor stepped undulations becoming minor gentle undulations.
13+400 to 14+400	144 to 118	Gentle becoming steep uphill slope with minor gentle undulations.

9.4.2 Volume 6 Document Ref 6.3 ES Figure 9-1 shows that the scheme alignment follows a south-west to north-east striking ridge, which falls away on both sides to form a relative high in comparison with the surrounding topography. The landscape surrounding the route comprises numerous steep sided valleys, which have been cut by the fluvial action of watercourses. These watercourses are sourced from springs proximal to the scheme alignment that flow outwards. Watercourses create an undulating landscape, most notably towards the middle section of the route.

9.4.3 Generally, no evidence of unstable slope forms was observed, other than features of shallow slope movement within a steep wooded slope adjacent to observed seepage north of Carland Cross junction (Ch. 13+700 to 13+800) (see Volume 6 Document Ref 6.3 ES Figure 9-7).

Published geology

9.4.4 The published geology is presented within Volume 6 Document Ref 6.3 ES Figure 9-2. Information on the ground conditions is provided within the **WSP Ground Investigation Report (GIR)** [2] (see Volume 6 Document Ref 6.4 ES Appendix 9.2) and the **Arup GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3) and is summarised within Paragraph 9.4.69 to Paragraph 9.4.71 of this report.

Artificial ground

9.4.5 Artificial ground is indicated to be present underlying the scheme between chainage 12+675m and 12+775. This aligns with the location of a flooded quarry. No other areas of artificial ground are indicated within the scheme Study Area.

Superficial geology

9.4.6 Head deposits are present within the base of fluvial valleys, which record the active periglacial[1] weathering, solifluction[2] and deposition during the last phase of the Quaternary glaciation [5]. This stratum is largely heterogeneous comprising sandy clay with quartz pebbles and small angular local rock fragments with dispersed blocks [5]. Cryoturbation[3] has affected the upper layers of head deposits due to the freeze-thaw action during and proceeding the last phase of glaciation.

9.4.7 More recently, active fluvial deposition by streams has resulted in the presence of Alluvium at valley bottoms, although this is generally thin. The published geological maps [6] [7] indicate Alluvium to be generally absent within the study area.

9.4.8 The location of superficial deposits along the scheme alignment are summarised in Table 9-2.

Table 9-2 Summary of the location of superficial deposits along the scheme alignment.

Strata	Chainage (m)	Approximate location in relation to the scheme
Head	8+900 to 8+930	Minor tributary of the River Allen; Culvert proposed
Head	9+210 to 9+290	Minor tributary of the River Allen; Culvert proposed
Head	11+030 to 11+080	Penny-Come-Quick underbridge; Minor tributary of the River Allen
Head	13+040 to 13+110	North-west of Carland Cross Junction; Newlyn Downs
Head	13+550 to 13+640	North-east of Carland Cross Junction; Minor tributary of the River Gannet

Bedrock geology

9.4.9 The scheme alignment is predominantly underlain by Devonian bedrock of the Gramscatho Basin Succession, comprising predominantly clastic sedimentary rocks formed from mud and sand produced by erosion and deposited in a deep marine environment [5].

[1] Periglacial = relating to an area affected by repeated freezing and thawing.
[2] Solifluction = the slow or gradual movement of soil down slope relating to freeze-thaw activity.
[3] Cryoturbation = refers to the mixing of materials from various horizons of the soil down to bedrock due to freezing and thawing.

9.4.10 The scheme alignment transects the thrust fault separating the Gramscatho Basin Succession and the Looe Basin Succession to the north. The Looe Basin Succession, comprising a shallow water facies of variable siliciclastic mudstones, siltstone and sandstones with internal structures representing strong water movements. The stratigraphy is summarised within Table 9-3, from youngest to oldest.

Table 9-3 Summary of the stratigraphy beneath the scheme alignment.

Period		Succession[1]	Group	Formation	Description[2]
Devonian	Middle to Upper	Looe Basin Succession	Meadfoot Group	Trendrean Mudstone Formation	Dark grey to black mudstone with upward-fining siltstone laminae and some beds of pale grey fine-grained sandstone.
		Gramscatho Basin Succession	Gramscatho Group	Porthtowan Formation	Interbedded slaty mudstone, grey and grey-green, and sandstone. Subordinate sandstone beds are up to 2m thick, typical turbidites.
	Middle			Grampound Formation	Thinly interlaminated grey slaty mudstone and mid-grey siltstone, weathering yellowish green, with sporadic thin beds of sandstone and sparse lenticular limestone.

Notes
[1] Approximately synchronous deposition of Looe Basin and Gramscatho Basin Successions
[2] Description based on the British Geological Survey (BGS) lexicon [8]

9.4.11 The distribution of the various Formations along the scheme alignment based on the published geology is summarised in Table 9-4 and presented within Volume 6 Document Ref 6.3 ES Figure 9-2.

Table 9-4 Summary of the bedrock geology along the scheme alignment.

Formation	Chainage (m)	
	From	To
Porthtowan Formation	0+000	8+050
Grampound Formation	8+050	13+720
Trendrean Mudstone	13+720	14+490

9.4.12 Metalliferous rich mineral veins (lodes) are present within the area originating from the emplacement of the St Austell and Carnmenellis Granite and the associated circulation of hydrothermal fluids and subsequent mineral precipitation. According to the BGS (1994) [9] the scheme alignment lies within the St Agnes Mining District. Locally these lodes contain mainly tin, copper, zinc, lead, with arsenic, sulphur, silver. Mining is discussed in more detail within Paragraph 9.4.23 to Paragraph 9.4.37.

Structural geology

9.4.13 The bedrock geology has been affected by numerous phases of tectonic deformation, most significantly the late Palaeozoic mountain building period known as the Variscan Orogeny [9]. This has resulted in approximately east-north-east trending structures, resulting in cleavage and bedding dipping generally to the south-east. Rocks are also locally folded and faulted.

9.4.14 A regionally persistent north-west to south-east trending thrust fault separates the Gramscatho Basin Succession and the Looe Basin Succession to the north. This thrust fault is also cross cut by regular locally persistent approximately north-south trending faults, creating a step like boundary. These faults are also indicated to affect the geological boundary between the Grampound Formation and the overlying Porthtowan Formation.

9.4.15 A zone of degraded rock quality and a significantly deep weathering zone was encountered within BH-220 and BH-306 at approximate chainage 9+250m. This is interpreted to be due to the presence of a fault and it expect to have shaped the broad, low relief valley across the area between approximate chainage 8+600m to 9+600m.

9.4.16 As shown in Volume 6 Document Ref 6.3 ES Figure 9-2, the scheme alignment transects faults at the locations summarised within Table 9-5.

Table 9-5 Summary of the presence of faults along the scheme alignment

Chainage (m)	Location relative to scheme alignment	Comments
8+190	Online	Locally persistent fault trending approximately north-south downthrowing the Porthtowan Formation to the west
9+250	Online	Zone of deep weathering and degraded rock quality, possible due to the presence of a fault zone.
12+130	Online	Locally persistent fault trending approximately north-south and crossing the Trendrean Formation, Grampound Formation and the Porthtowan Formation. This fault downthrows to the east and intersects the east-west trending regional thrust fault.
11+200 and 12+300	200m north	East-west trending regional thrust fault within 200m of scheme alignment. It forms a hanging wall of the Grampound Formation to the south of the Trendrean Mudstone Formation.
13+720	Online	Locally persistent fault downthrows to the west and forms the boundary between the Grampound Formation to the west and the Trendrean Formation to the east.

9.4.17 The review of aerial photography [3] states that the faults interpreted in the BGS 1:50,000 maps are not strongly expressed in the aerial imagery. However, it suggests that short lengths of ravines and small valleys are controlled by minor unmapped faults.

Site history

9.4.18 The history of the study area has been interpreted through review of various editions of the Ordnance Survey mapping as presented in the PSSR [1] (see **WSP Preliminary sources study report** (Volume 6 Document Ref 6.4 ES Appendix 9.1)) for the site.

9.4.19 The main industrial activity in the study area are numerous mines, associated spoil tips/heaps, shafts, pits and workings. These are typically present on the

earliest maps and many are noted as disused in by 1879. By the late 1800's and early 1900's all are labelled as disused. In addition to the mines, numerous quarries are located throughout the study area, many of these are initially indicated as 'old' on the 1879 mapping and by later editions are either being used as tips or are no longer shown. Mining and mineral resource features are discussed within Paragraph 9.4.23 to Paragraph 9.4.39 and presented within Volume 6 Document Ref 6.3 ES Figure 9-3.

9.4.20 Aside from the industrial land uses, the historic mapping also indicates numerous tumuli along the study area in addition to other features of archaeological and heritage interest. These are discussed further and assessed within **Cultural heritage** (Volume 6 Document Ref 6.2 ES Chapter 6).

9.4.21 Review of the historic mapping has indicated that the previous mining use and associated mine waste, infilled quarries and tips, and the potential use of made ground materials in previous A30 route upgrades, and the existing use of the A30 are the most likely sources of anthropogenic contamination across the study area. Smaller industrial uses such as blacksmiths and mills are also considered to be potential contamination sources, however it is considered likely that their influence would have been more localised. These features are presented within Volume 6 Document Ref 6.3 ES Figure 9-6.

Unexploded ordnance (UXO)

9.4.22 Based on the findings of a preliminary assessment within the PSSR [1] (see **WSP Ground investigation report** (Volume 6 Document Ref 6.4 ES Appendix 9.1)), the UXO risk is considered to be low. Given the generally rural nature of the site it is not expected that significant targets would have been present on or in the vicinity of the study area. Similarly, the lack of sensitive or military assets near the study area is considered to preclude the likely presence of defensive installations that may also provide a UXO source. Aerial photographs taken during the war (1942 to 1946) [3] do not indicate evidence of military installations, potential bombing targets or evidence of bomb strikes within the scheme study area.

Mining and mineral resources

Introduction

9.4.23 The 1:100,000 scale Mineral Resources map of Cornwall [10] indicates the scheme alignment to be underlain by a sandstone resource (of interbedded sandstone and shale/slate). This map is intended to be used to inform planning decisions, with the aim of protecting mineral resources.

9.4.24 The Cornwall Council (CC) Interactive Map [11] does not indicate the presence of any Mineral Safeguarding Areas within the scheme study area. The policy for the safeguarding of minerals is discussed within the CC Draft Minerals Safeguarding Development Plan Document [12].

9.4.25 The Air Photo Interpretation Report [3] indicates the presence of areas of extensive mottled soil without distinct boundaries between chainage 1+320m and 2+830m. This indicates poor drainage and may relate to ancient shallow surface workings.

9.4.26 All mining features described within this section, including recorded and suspected shafts, adits, mines, quarries, and lode outcrops are presented within Volume 6 Document Ref 6.3 ES Figure 9-3.

9.4.27 The mining risk zones, as defined by the Cornwall Consultant Ltd mining search (described in Paragraph 9.4.30 to Paragraph 9.4.37), are presented in Volume 6 Document Ref 6.3 ES Figure 9-7. This figure also shows the pertinent features discovered during the Phase 2 Additional GI and the updated risk level for each mining risk zone.

Historical mining and methods

9.4.28 Metalliferous minerals have been extracted across the South West for thousands of years, throughout which shallow prospecting was widespread. Costean (trial) pits were dug to in order to discover the mineral lodes, then often mined by openworks (linear excavations) along the outcrop and later by means of shafts, adits and levels driven away from the shafts. The ore was extracted from between the levels to leave narrow chasms. Steam pumping engines introduced in the 19th century enabled deeper workings. Industrial decline by the end of the century led to the closure of most mines, often left abandoned without being secured due to a lack of funding and regulations. Most old and shallow mine workings are poorly recorded due to an historical lack of legal requirements.

PSSR [1] and GIR [2] summary

9.4.29 The study area lies on the two mining districts of Chacewater to the south-west and St Agnes to the northeast. The district was historically prospected by means of pits excavated to bedrock to uncover lodes not visible at the surface. Resources mined are generally metalliferous, with historical maps showing a number of disused lead, silver, copper, zinc, iron and tin mining sites throughout the study area. No evidence of mining was observed beneath the proposed alignment. However, in areas of workable deposit, it is prudent to assume the presence of potential unrecorded workings. The below discussion provides a summary of the recent desk based studies and non-intrusive geophysical investigations that have been undertaken to refine the assessment of the mining hazard and the risks to the scheme.

Cornwall Consultants Ltd (2017) mining search [13]

9.4.30 Cornwall Consultants Ltd were appointed in August 2017 to carry out a mining search and mining risk assessment with the aim of predicting the existence, location and severity of the risk from recorded and unrecorded mine workings. This covered a buffer area of 500m either side of the scheme alignment.

9.4.31 Six named mines sites and four unnamed trial workings were identified within the search area. A further four trial sites or mines lie on the search area boundary and may have associated unrecorded workings that enter the search area.

9.4.32 Inferred or recorded lode outcrops traverse the roadway at six locations and there is the potential for unrecorded prospective mine workings to exist on these outcrops. Unrecorded workings on lode outcrops are the most widespread adverse features in the region and give rise to the greatest number of problems for land development. Such workings can comprise partially filled and/or voided stope workings that extend from surface to adit level and on to much deeper levels of the mine.

9.4.33 In addition to the outcrop of lodes that traverse the alignment, an elvan (quartz porphyry) dyke traverses the alignment at approximately chainage 14+000m. Elvan has the potential to contain metalliferous ores and therefore unrecorded working might exist here in addition to the known surface quarries and opencast workings.

9.4.34 There are no recorded or suspected shafts, adits or deep workings beneath the scheme alignment, although it is interpreted that an adit exists beneath the scheme at approximately chainage 0+450m. This is based on the assumption the major shafts associated with the Burra Burra Mine were drained by an adit and discharged in the valley to the south-east or connected to the former Prince Coburg Mine to the west.

9.4.35 The Engine Shaft (closest to the road on the eastern side) intercepted the inclined lode at a depth of 18 fathoms (33 metres). This might be the depth of the adit, because it would have been reasonable for the engine shaft to connect to it vertically. The adit would be a near-horizontal tunnel with approximate dimensions 1.0 m wide by 1.8 m high.

9.4.36 The evidence for the presence of mine workings and mine entrances within the scheme study area are presented within Volume 6 Document Ref 6.3 ES Figure 9-3. These have been separated into areas based on the most proximal mining sett name.

9.4.37 The Cornwall Consultants Ltd (2017) [13] report concludes that the interpreted land instability risk to the scheme arising from past extractive metalliferous mining is low. Risk zones derived by Cornwall Consultants Ltd are presented within Volume 6 Document Ref 6.3 ES Figure 9-7. Moderate risk zones have been assigned to those features that are indirectly related to extractive metalliferous mining activity, whereas a high risk zone has been applied to all features directly related to extractive metalliferous mining activity, irrespective of their proximity to the roadway.

Mining geophysical investigation

9.4.38 The high risk zones defined by the Cornwall Consultants Ltd report were targeted for surface geophysical investigations and the findings have been used to inform a reassessment of the level of risk associated with land stability in these areas (see Table 9-6).

9.4.39 Investigations were carried out by TerraDat in May 2018 and included a mixture of surface techniques, including magnetic, electromagnetic, microgravity and resistivity. The results are presented within the SOCOTEC Factual Report [14] and are also summarised within Table 9-6 with reference to features presented within Volume 6 Document Ref 6.3 ES Figure 9-7. The results are also described in more detail within the **Arup GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3). Further studies are required to investigate a number of the anomalies.

Table 9-6 Summary of the findings of the mining geophysical investigations and subsequent risk assessment

Geophysical investigation area	Aim of investigation	Relative level of risk[1] according to Cornwall Consultants [13]	Summary of findings of geophysical surveys[2]	Concluding remarks and residual relative level of risk following geophysics[1]
Chiverton Cross Junction	Investigate features associated with potential prospective working of the surface outcrop of an unnamed load.	Mineral lode directly related to extractive metalliferous mining activity, therefore **high risk** 20m buffer surrounding unnamed lode.	Small scattered magnetic anomalies (F1.2, F1.4 and F1.8) encountered. Sub vertical zone of low resistivity (F3.1 and F3.4), possibly representing the location of the mineral lode.	Evidence of mineral lode traversing the scheme, however no clear evidence of mine entrances or shallow mine workings. Mineral lode identified to be 35m south of mapped zone, therefore a **medium risk** has been applied.
Chiverton Cross North	Investigate features associated with possible quarry	Quarry directly related to extractive metalliferous mining, therefore **high risk** 20m buffer surrounding quarry.	Small scattered magnetic anomalies (F1.1). Several low resistivity zones (F3.2, F3.4, F3.5 and F3.6) that are probably unrelated to mining, but possibly related to weathering.	No clear evidence of quarry, therefore the level of risk has been reduced to **low risk**.
Callestick Vean	Investigate features associated with potential prospective working of the surface outcrop of two Perran Virgin lodes	Mineral lodes directly related to extractive metalliferous mining activity, therefore **high risk** 20m buffer surrounding two Perran Virgin lodes.	Increased magnetic response (F1.8 and F1.9) along the alignment of the Perran Virgin lode (west) may indicate shallow worked/disturbed ground. Scattered magnetic dipole features (F1.1 to F1.5) will require ground truthing to confirm feature. Sub-vertical zone of decreased resistivity (F3.1 to F3.6) indicates the location of mineral lodes. Bowl shaped depressions of resistivity within bedrock (F3.7) may indicate worked ground. Features coincide with magnetic dipole features F1.4 and F.5.	Evidence of mineral lodes traversing the scheme and some evidence of worked/disturbed ground. Single feature associated with the Perran Virgin lode (east) close to development therefore a **high risk** has been applied. Perran Virgin lode (west) identified to be a broader zone than previously thought, possibly up to 50m wide. Some features close to the development need further confirmation/ground truthing, therefore a **high risk** has been applied.
Nanteague Farm	Investigate features associated with potential prospective working of the surface outcrop of	Mineral lodes associated with fault directly related to extractive metalliferous mining	Presence of services and metal gates affects the signal across much of the site. Parallel linear magnetic feature (F1.2) extends across the inferred outcrop of the Great South Chiverton lode. Sub vertical low resistivity zone (F3.2) corresponding to	Evidence of mineral lode and fault potentially traversing the scheme along the approximate mapped location. No clear evidence of mine entrances or shallow mine workings, however the

Geophysical investigation area	Aim of investigation	Relative level of risk[1] according to Cornwall Consultants [13]	Summary of findings of geophysical surveys[2]	Concluding remarks and residual relative level of risk following geophysics[1]
	the Great South Chiverton lode and two possible shafts associated with the Great South Chiverton mine	activity, therefore **high risk** 20m buffer surrounding the Great South Chiverton lode.	broad, low density feature (F3.1) to the west of the suggested fault zone. Likely caused by fracturing of the rock in the fault zone.	quality of the survey was impacted by surface features, therefore a **medium risk** has been applied.
Twoburrows Junction	Investigate features associated with potential prospective working of possible mineralisation along north-south trending fault	Fault indirectly related to extractive metalliferous mining activity, therefore **medium risk** 20m buffer surrounding fault.	Single larger area of increased magnetic response (F1.2) and several scattered magnetic anomalies (F1.3 and F1.4) indicating buried ferrous object. Significant, sub-vertical decreases in resistivity indicating the presence of a fault zone or mineral lode, within the bedrock.	Evidence of fault zone traversing the scheme, possibly orientated north-south as opposed to the mapped north-west to south-east orientation. Evidence of a magnetic feature that needs confirmation/ground truthing, therefore **medium risk** has been applied.
Boxheater Junction South	Investigate the location of a possible trial shaft	Shaft directly related to extractive metalliferous mining, therefore **high risk** 20m buffer surrounding shaft.	Numerous magnetic anomalies (F1.1 to F1.3). Microgravity survey indicates an isolated low density feature (F1.2) thought to represent the location of the shaft.	Evidence of shaft location with below ground void, therefore **high risk** remains.
Journey's End	Investigate features associated with potential prospective working of the surface outcrop of an unnamed lode and two shafts associated with Wheal Ennis	Mineral lodes associated with fault directly related to extractive metalliferous mining activity, therefore **high risk** 20m buffer surrounding the unnamed lode and two shafts associated with Wheal Ennis.	Large isolated magnetic anomaly (F1.2) and smaller, but still significant isolated magnetic anomaly (F1.3), both of which could be associated with mine shafts. Various linear magnetic anomalies (F1.4a to F1.4d and F1.5) possibly associated with costean pitting and/or an old tramway serving the shaft. Ground truthing will be required to confirm all features. Sub vertical low resistivity zone (40m wide) (F3.1 to F3.3), representing fractured rock in the fault zone and/or mineral lodes. This zone is located approximately 20m to the west of the mapped location.	Confirmation of northern shaft location and confirmation of the absence of a shaft to the south. Possible worked/disturbed ground associated with linear anomalies and fault zone/mineral lode approximately 20m to west, therefore **high risk** remains.
Carland cross	Investigate features associated with	Elvan indirectly related to extractive	Large zone of increased magnetic response (F1,1) correlates with expected location of quarry and the	Confirmation of the presence of backfilled quarries. Some features need

Geophysical investigation area	Aim of investigation	Relative level of risk[1] according to Cornwall Consultants [13]	Summary of findings of geophysical surveys[2]	Concluding remarks and residual relative level of risk following geophysics[1]
	surface workings associated with Wheal Mitchell	metalliferous mining activity, therefore **medium risk** 20m buffer surrounding elvan outcrop.	presence of a depression observed within the field. Strong magnetic anomalies (F2.2) and lineations (F2.1) are coincident with conjectured backfilled quarry. Broad and subtle decrease in ground conductivity and magnetic anomaly may indicate the presence of disturbed ground or spoil.	further confirmation/ground truthing, however a **medium risk** has been applied.

Notes

1) Low = no evidence of features related to mining. Medium = confirmation of position of mineral lode/fault, which does not extend beyond the limits of the survey area; and/or confirmation of the location of possible mining features greater than 20m away from scheme (that need more detailed studies) - High = confirmation of the location of possible mining features that directly impact the scheme (that need more detailed studies).
2) Refer to Volume 6 Document Ref 6.3 ES Figure 9-7 for feature locations indicated by FX.X.

Hydrology and hydrogeology

Introduction

9.4.40 The hydrological and hydrogeological baseline conditions have been determined based on a review of the PSSR [1] (see (**WSP Preliminary sources report** (Volume 6 Document Ref 6.4 ES Appendix 9.1)), GIR [2] (see **WSP Ground investigation report** (Volume 6 Document Ref 6.4 ES Appendix 9.2)) and **GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3). Where necessary other relevant resources have been used and referenced throughout. The location of all hydrological and hydrogeological features are presented in Volume 6 Document Ref 6.3 ES Figure 9-4. A review of historical and more recent aerial photography has identified a number of hydrological and hydrogeological features, including springs, seepages and poorly drained ground, which are also presented within Volume 6 Document Ref 6.3 ES Figure 9-4. Where possible these have been corroborated on site by visual inspection or anecdotally through discussions with landowners.

Surface water

9.4.41 The scheme alignment generally traverses a boundary between two watersheds. Several springs emerge along the flanks of this watershed boundary, flowing to the north and south. The River Gannel and its tributaries flow to the north, and Rivers Kenwyn, Tresillian and Allen and tributaries flow to the south [1]. All surface water features, including streams, springs, seepages and poorly drained ground are presented in Volume 6 Document Ref 6.3 ES Figure 9-4. A summary of the hydrological features within the study area are presented in Table 9-7 and Table 9-8.

Table 9-7 Summary of watercourse features.

Watercourse Feature	Chainage (m)	Approx. distance from scheme centreline (m)	Comments
Headwater stream[3]	0+180	30m east	Both merge 250m east of the scheme before eventually joining the Truro River to the east.
Headwater stream[3]	0+250	160m east	
Headwater stream[3]	1+210	150m north-west	Flows north.
Headwater stream[3]	1+500	150m east	Flows east before meeting a pond 700m east of the scheme.
Headwater stream[3]	3+700	130m south	Flows south eventually merging with the River Kenwyn.
Headwater stream[3]	4+500	240m north	Flows north before forming a pond 320m north of the scheme.
Headwater stream[3]	6+060	80m south-east	Flows south-east as tertiary river, then secondary river 180m from scheme. Merges with a pond 220m south-east of the scheme. Eventually merging with the River Allen.
Headwater stream[3] (Pond[2])	7+210	150m south-east	Flows east from a pond, eventually merging with the River Allen. The pond dries out seasonally but is topped up by pumping from a borehole.
Headwater stream[3]	8+850	135m north-west	

Watercourse Feature	Chainage (m)	Approx. distance from scheme centreline (m)	Comments
Headwater stream[3]	8+910	80m north-west	Both merge together at Ch 8+900 45m north-west of the scheme before crossing beneath at Ch 8+910. River flows east before joining a river network eventually merging with the River Allen.
Headwater stream[3]	9+250	Beneath scheme	Flows south-east crossing under the Scheme at Ch 9+250. River flows south-east before joining a river network eventually merging with the River Allen.
Headwater stream[3]	9+980	190m north	Flows north as tertiary river till 270m from scheme, river is then culverted flowing north-west
Headwater stream[3]	11+030	150m north-west	Flows south-east, crossing scheme at Ch 11+040. Continues to flow south-east.
Headwater stream[3]	11+920	190m south-east	Flows south-west away from scheme.
Headwater stream[3]	12+890	220m north-west	Flows north-west away from scheme.
Headwater stream[3]	13+500	185m south-east	Flows south as tertiary river before being culverted 250m south of the scheme, flowing south-east
Headwater stream[3] (Spring[3])	13+600	180m south-east	Flows south before merging with culvert 400m south-east of scheme.
Headwater stream[3]	13+680	55m north-west	Flows north-east

Source:
[1] Cornwall Consultants metalliferous minerals mining search [13].
[2] PSSR [1]
[3] Groundsure Report [15] [16]

Table 9-8 Summary of springs and ponds.

Hydrological feature	Chainage (m)	Approx. distance from scheme centreline (m)
Spring[1]	1+760	250m north-east
Spring[1]	3+710	135m south
Spring[1]	6+200	200m south-east
Pond[2]	6+200 to 6+250	210m, extending to 300m south-east
Pond[2] (group of two)	7+100 to 7+120	145m, extending to 205m south-east
Spring[1]	7+700	160m north-west
Spring[1]	7+770	165m north-west
Pond[2]	10+450 to 10+490	40m, extending to 80m north-west
Pond[2] (group of two)	11+000 to 11+080	25m, extending to 40m north
Pond[2]	12+700 to 12+260	Along alignment, extending 30m north
Spring[3]	13+600	180m south-east
Spring[3]	13+680	55m north-west
Spring[1]	14+496	150m north

Source:
[1] Cornwall Consultants metalliferous minerals mining search [13].
[2] PSSR [1]

Hydrological feature	Chainage (m)	Approx. distance from scheme centreline (m)
[3] Groundsure Report [15] [16]		

9.4.42 The Water Framework Directive status of the surface waters are discussed in detail within **Road drainage and water environment** (Volume 6 Document Ref 6.2 ES Chapter 13).

Groundwater flooding

9.4.43 BGS data contained with the Groundsure report [15] [16] indicate the scheme alignment to traverse areas having a moderate to high susceptibility to groundwater flooding within superficial deposits. High potential areas are defined as having the potential for groundwater flooding at the surface and moderate potential areas have the potential for groundwater flooding to affect structures below ground level.

9.4.44 The flood risk assessment, which considers groundwater flooding, is included in **Road drainage and water environment** (Volume 6 Document Ref 6.2 ES Chapter 13). Groundwater flooding areas within the 250m scoping area are summarised within Table 9-9.

Table 9-9 Summary of groundwater flooding areas within the scheme study area

Groundwater flooding susceptibility	Chainage extents (m)	Approx. distance from scheme alignment (m)	Association
Very high[1]	1+280 to 1+360	200m to 300m north-west	Tertiary River[1]
Moderate to high[1]	5+990 to 6+100	Crosses scheme between Ch 5+990 to 6+080. Extends south-east	Seepage[2]
Very High[1]	6+000 to 6+210	30m to 145m south-east	Tertiary River[1], Seepage[2]
Very High[1]	6+110 to 6+220	190m to 290m south-east	Secondary River[1], Seepage[2], Pond[3]
Very High[1]	8+900 to 9+500	80m to >300m south-east	Tertiary River, Seepage
Very High[1]	10+940 to 11+150	Crosses scheme at ch 10+960 to 11+060. Extends 80m north and >250m south	Tertiary River[1], Seepage[2], 2No. Pond[3]
Source: [1] Groundsure Report [15] [16] [2] Air Photo Interpretation Consultancy [3] [3] PSSR [1]			

Hydrogeology

9.4.45 Environmental Agency hydrogeological mapping [17] provides information on annual average rainfall, groundwater flows in aquifers, surface water, and groundwater features in England. The entire site is classed as a ‘Secondary A’ aquifer for bedrock geology. These aquifers consist of permeable layers that store water at a local rather than strategic scale, in some cases forming an important base flow to rivers.

9.4.46 The location of aquifers in superficial geology generally corresponds to the position of Head and Alluvium. Superficial deposit aquifers in this area are all either 'Secondary A' or 'Secondary undifferentiated' aquifers. This indicates that they comprise permeable layers capable of supporting water supplies at local rather than strategic scale and in some cases, form an important source of base flow to rivers.

9.4.47 The Environmental Agency Groundwater Vulnerability Map [17] identifies the vulnerability of groundwater to contamination in England and Wales. It is based on the soil leaching class, drainage properties, drift properties, and groundwater flow regime in the area. It indicates the risk posed to groundwater from surface activities by categorising ground conditions into six vulnerability classes. These maps indicate that the majority of the scheme lies within minor aquifer low and minor aquifer intermediate Groundwater Vulnerability Zones. A high minor aquifer groundwater vulnerability zone overlaps the scheme approximately 500m south-west of Two Barrows Junction.

9.4.48 Approximately 600m of the current A30 northeast of Carland Cross lies within a 'Zone 2' groundwater source protection zone. Furthermore, two 'Zone 1' groundwater source protection zones directly underlie the scheme alignment (see Volume 6 Document Ref 6.3 ES Figure 9-4). Zones 1 and 2 are defined as the 50 and 400-day travel time from any point below the water table to the source respectively. It is understood that these source protection zones are for domestic and agricultural use at West Nancemere Farm and Grove Farm.

9.4.49 It is known that a large number of springs are exploited for both domestic and agricultural uses. Consultation with CC and publicly available Groundsure data has confirmed the presence of a number of private abstraction licence within the scheme study area as presented on Volume 6 Document Ref 6.3 ES Figure 9-4. Records indicate there are numerous historical abstraction licenses relating to farms within the area.

Significant Services

9.4.50 The **WSP Ground investigation report** [2] (see Volume 6 Document Ref 6.4 ES Appendix 9.2) indicates the presence of a high pressure gas main located beneath the footprint of the proposed alignment at various locations between Ch. 5+100m to Ch. 6+300m and between Ch. 12+920m to Ch.13+450m. The gas main is presented on Volume 6 Document Ref 6.3 ES Figure 9-6.

9.4.51 An abandoned oil pipeline is located between Ch. 11+700m and Ch.12+200m running approximately parallel beneath the footprint of the proposed alignment. During fieldworks undertaken as part of the Phase 1 investigations it was confirmed, via verbal communications with St Mawgan's airbase, that the pipeline was no longer in use and had since been flushed with sections removed [2]. The oil pipeline is presented on Volume 6 Document Ref 6.3 ES Figure 9-6.

9.4.52 These services are considered a source of contamination to geology and soils should a leak occur. The presence of the pipelines will need to be confirmed and then will need to be protected/removed before works commence. Should any localised contamination be encountered, this will be treated in line with current best practice and guidance as detailed in **Geology and soils** (Volume 6 Document Ref 6.2 ES Chapter 9) and in accordance with an outline Construction Environmental Management Plan (**Outline CEMP** (Volume 6 Document Ref 6.4 ES Appendix 16.1)).

Ground hazards

9.4.53 The geological risks potentially affecting the scheme alignment, as defined by the BGS, are described below:

- Potential for collapsible ground stability hazards (Very Low);
- Potential for compressible ground stability hazards (Moderate (Alluvium) – Negligible);
- Potential for ground dissolution stability hazards (Negligible);
- Potential for landslide ground stability hazards (Low (Meadfoot beds & Porthtowan Formation) - Negligible);
- Potential for running sand ground stability hazards (Low (Alluvium), Very Low (Head) Negligible (bedrock);
- Potential for shrinking or swelling clay ground stability hazards (Very Low - Negligible); and
- Potential for Karstic features (Negligible).

9.4.54 This does not include the risks associated with man-made activities such as mining.

9.4.55 A land stability assessment plan is illustrated in Volume 6 Document Ref 6.3 ES Figure 9-7.

Geological designated sites

9.4.56 There are no statutory or non-statutory designated geological sites within the Geology & Soils Study Area. The nearest RIGS is located approximately 2.8km north-west of Chybucca Junction (Ch 4830m).

Environmental setting

9.4.57 A review of the current industrial land uses in the Groundsure report included in the PSSR [1] (see **WSP Preliminary sources study report** (Volume 6 Document Ref 6.4 ES Appendix 9.1)) indicates that fuel stations are present at both Carland Cross at approximate chainage 13+500m, and Chiverton Cross at approximate chainage 0+600m. In addition, a vehicle servicing centre is present at Chiverton Cross and new vehicle sales units are also present at Chiverton and Carland Cross at similar chainages to the petrol filling stations. Another new vehicle sales property is present at approximate chainage 6+300m to the north of the existing A30. Aside from these, many of the entries within 250m of the route alignment relate to electrical infrastructure such as pylons, turbines, sub-stations, and solar electricity generation. Numerous tanks have been noted throughout the study area, little information is provided in the Groundsure entries for these, however, review of the current OS mapping and aerial imagery indicates that many, if not all of these are likely to be in relation to agricultural irrigation, private water supply, or livestock/farm use. Some quarries and mine shafts are also listed; however, these are not considered to be currently in use. A contaminated land features plan is presented within Volume 6 Document Ref 6.3 ES Figure 9-6.

9.4.58 Review of the historic land uses listed in the Groundsure report [1] indicate that the majority of features within the study area are in relation to previous mining history and comprise mines, mineshafts, wheel and pump houses, pit wheels and other mining infrastructure. Numerous spoil heaps are noted across the study

area, mostly in relation to areas of mining activity but also in areas between these features too. In addition to mining, a number of former quarries are noted across the study area, with many of these no longer indicated on current OS mapping suggesting their subsequent in-filling. Aside from mining and quarrying, an area at approximate chainage 0+000m and an area at approximate chainage 8+050 to 8+150m and immediately to the north of the existing A30 were noted as former nurseries. Numerous smithies were noted in the local villages. Lastly a former garage was indicated just within the north-eastern extent of the study area beyond chainage 14+496m.

9.4.59 Metalliferous minerals are present within the bedrock beneath the scheme. Where minerals are concentrated along lodes or disseminated within the country rock it is expected that the ground will be locally enriched in heavy metals.

9.4.60 Review of records of Environment Agency Recorded Pollution Incidents indicate that a total of 3No. incidents have occurred within the study area. Two are located in the south west of the study area, the first relates to release of lubricating oils on the existing A30 at the far southern point of the proposed alignment which resulted in a category 3 minor land impact. The second relates to the commercial waste immediately to the north of the A30/A390 junction which resulted in a category 4 (no) impact. The third pollution incident relates to the presence of asbestos containing wastes located in woodland to the east of the village of Zelah, approximately 250m from the proposed route alignment which was recorded as a category 3 minor land impact.

9.4.61 Numerous Environment Agency Discharge Consents are noted within the study area. Many of these relates to domestic soakaway drainage, or direct discharge of surface water to surface water systems from both domestic and farm properties. A soakway for the Shell filling station at Carland Cross is also noted as this may have a higher risk of potential contamination from possible petroleum substances spills and leaks, it is considered highly likely that a fuel interceptor will be in place at this location, however this may have defects which would result in potential contaminants being released.

9.4.62 Review of Part A2 and Part B Local Authority Pollution Prevention Controls indicates that the only entries relate to the filling stations located at Carland Cross, Chiverton Cross and a waste oil burner located at Town and Country Motor Centre approximately half way along the route near Little Tresawsen to the north of the existing A30.

9.4.63 No current or historic landfills or waste treatment facilities lie within the study area.

9.4.64 Review of Designated Environmentally Sensitive Sites indicates that much of the scheme lies within a DEFRA designated Nitrate Vulnerable Zone. The far south west of the scheme (south of Chiverton Cross) is situated within the Cornwall and West Devon Mining Landscape World Heritage Site. The Newlyn Downs Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI) is located approximately 230m north east of the scheme alignment at the closest edge of carriageway.

9.4.65 The study area lies within the St Agnes Mining District and has been affected by mining of metalliferous ores through below ground and above ground workings. Building stone quarries are also present throughout the study area and have largely been infilled. A detailed description of the mining features is provided

within paragraph 9.4.23 to paragraph 9.4.37 and mining features presented within Volume 6 Document Ref 6.3 ES Figure 9-3.

9.4.66 Review of the records of groundwater abstractions within 1km of the scheme indicate that the majority of records relate to historical licenses. An assessment of the impacts of the scheme on water supplies is presented within **Road drainage and the water environment** (Volume 6 Document Ref 6.2 ES Chapter 13)).

Ground investigations

9.4.67 A number of ground investigations have been completed within the study area. These are listed below. The factual results from the ground investigation including exploratory holes logs and in-situ and laboratory test results are contained within the respective factual reports referenced throughout. The previous ground investigations include:

- Department for Transport (1988), London to Penzance Trunk Road A30 Penhale to Carland Cross Improvement Site Investigation Report [18];
- Soil Mechanics (2004), A30 Chiverton to Carland Cross Preliminary Ground Investigation Factual Report [19];
- Parsons Brinckerhoff (2005), A30 Chiverton Cross Roundabout Improvement, Geotechnical Report (including factual information) [20];
- Accord (2008), A30 Chiverton Cross CCTV Mast, Geotechnical Report [21];
- Structural Soils Ltd (2017). A30 – Chiverton to Carland Cross. Factual Report on Ground Investigation [22]
- Structural Soils Ltd (2017). A30 – Chiverton to Carland Cross Phase 2. Factual Report on Ground Investigation [23]
- SOCOTEC (2018). A30 Chiverton to Carland Cross Phase 2 Additional Ground Investigation Factual Report.

9.4.68 All exploratory hole positions and the locations of geophysical surveys are shown on Volume 6 Document Ref 6.3 ES Figure 9-5, the ground investigation location plan.

Ground conditions

9.4.69 The baseline ground conditions within the scheme study area have been determined on the basis of a review of available published geological maps and memoirs, and available ground investigation information. The ground conditions are discussed in detail within the **WSP Ground investigation report** [2] (see Volume 6 Document Ref 6.4 ES Appendix 9.2) and **GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3).

9.4.70 Table 9-10 and typically comprise topsoil, limited localised areas of Made Ground and Alluvium or Head or both within valley bottoms. Generally, from Chiverton Cross to Marazanvose the bedrock comprises Porthtowan Formation (interbedded slates and turbidite sandstones), from Marazanvose to Carland Cross the bedrock is Grampound Formation (interbedded sandstone and subordinate siltstones), and east of Carland Cross the bedrock is the Trendrean Mudstone Formation (mudstone with siltstone laminations and occasional sandstone beds).

Table 9-10 Summary of encountered ground conditions.

Material	Thickness (m)
Topsoil	Absent to 0.9
Made Ground	Absent to >4.65
Alluvium	Absent to 7.2
Porthtowan Formation	Maximum proven thickness of 16.0
Grampound Formation	Maximum proven thickness of 24.6
Trendrean Mudstone Formation	Maximum proven thickness of 6.4

Made ground

9.4.71 The study area generally comprises agricultural land, with rare occurrences of Made Ground. Previous ground investigations have encountered Made Ground in 17 No. exploratory holes, the details of which have been summarised in Table 9-11, and the locations presented in Volume 6 Document Ref 6.3 ES Figure 9-6. Most Made Ground has been encountered near access roads or embankments, but there is more than one instance of Made Ground being encountered in potential mining areas.

Table 9-11 Summary of locations and origins of Made Ground

GI	Hole	Chainage (m)	Distance (m)	Thickness (m)	Description and (*origin where known*)
SSL 2017 Phase 1	TP-P-009	6+060	55m SE	0.45	Slightly gravelly clayey sand with a low cobble content. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse phyllite, quartz and brick. Cobbles are subangular phyllite. (*Possible landowner access track*)
SSL 2017 Phase 1	TP-R-088A	13+280	Along scheme	0.80	0.50m of white slightly sandy gravel overlain by 0.30m of dark brown very gravelly sand. Sand is fine to coarse. Gravel is subangular fine to coarse of mixed lithologies, possibly including concrete. (*Possibly associated with nearby backfilled quarry*)
SSL 2017 Phase 1	BH-R-030	12+080	Along scheme	0.55	Firm brown slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is angular to subangular fine to coarse weathered weak slate and rare fine concrete and brick fragments. (*Possibly associated with nearby mine workings*)
SSL 2017 Phase 1	BH-R-040C	13+850		0.45	Light brown slightly clayey slightly gravelly fine to coarse sand (possible Made Ground). Gravel is angular to subangular fine to coarse slate and mudstone. Part of access track construction. (*Possibly associated with nearby backfilled Elvan quarry*)

GI	Hole	Chainage (m)	Distance (m)	Thickness (m)	Description and (*origin where known*)
SSL 2017 Phase 1	BH-R-041	14+030	Along scheme	0.90	0.10m topsoil, 0.80m of gravelly sand and sandy gravels. Gravel is angular to subangular fine to coarse slate. (*Possibly associated with backfilled Elvan quarry*)
SSL 2017 Phase 1	BH-S-019	5+995	Along scheme	0.23	Thin band of fill material containing cobbles of mudstone/shale and tarmac gravel.
SSL 2017 Phase 1	BH-S-032	8+700	25m NW	0.15	Light beige and brown clayey gravel containing low cobble and boulder content. Cobbles and boulder are tabular grey slate approx. 350mm x 180mm.
Accord 2008	TP1	0+700	10m E	Unproven, at least 1.30	Soft to firm, dark orange red silty gravelly clay, and medium dense to firm moist dark orange red to dark brown clayey gravel. (*Possibly associated with embankment for the existing A30*).
Soil Mechanics 2006	BH17	9+770	Along scheme	1.30	Brown and black very sandy angular fine to coarse gravel of tarmac and slate, and black tarmac. (*Possibly associated with embankment for the existing A30*).
Soil Mechanics 2006	WS1	9+320	15m NW	4.35	Gravelly fine to coarse sand, with gravel of various lithologies including slate and mudstone. This overlays 0.10m of hard dark brown sandy slightly gravelly clay, followed by 3.45m of medium dense to dense light brown clayey sandy angular to subangular fine to coarse gravel of slate and mudstone. (*Possibly associated with embankment for the existing A30*).
Soil Mechanics 2006	WS2	9+320	30m NW	Unproven, at least 4.65	0.9m of very clayey very gravelly fine to coarse sand, and 3.75m medium dense red brown very clayey sandy angular to subangular, fine to coarse gravel of slate and mudstone. Finally, an unproven depth of moderately strong white medium grained quartzite was encountered at the bottom of the sample, to an unproven depth. (*Possibly associated with embankment for the existing A30*).
Parsons Brinckerhoff 2005	TP1	0+640	140m NW	Unproven, at least 0.80	0.3m of reddish brown clayey silty gravel followed by 0.2m sandy gravel, 0.1m of black hard road pavement and 0.8m of very stiff sandy gravel, to an unproven depth. (*Possibly associated with embankment for the existing A30*).
Parsons Brinckerhoff 2005	TP6	0+710	10m E	Unproven, at least 1.40	Firm silty clay with gravel of mudstone and slate. Fragments of wood, plastic bags and paper were also found.

GI	Hole	Chainage (m)	Distance (m)	Thickness (m)	Description and (*origin where known*)
					(*Possibly associated with embankment for the existing A30*).
SSL 2018 Phase 2	BH-212	7+320	20m S	0.15	Grass over brown clayey sandy gravel. Sand is fine to coarse. Gravel is angular to subangular fine to coarse phyllite. Occasional coal and ceramic.
SSL 2018 Phase 2	TP-201	0+420	50m NW	0.90	0.7m of firm dark greyish brown locally dark brown and light greyish brown slightly sandy gravelly clay with a low cobble content and low rootlets and root content. Sand is fine to coarse. Gravel is angular to subrounded fine to course of vein quarts, mudstone, plastic, wood, brick and asphalt. Cobbles are subangular of vein quartz. 0.2m of soft dark blackish brown mottled white slightly sandy slightly gravelly clay with a low cobble content.
SSL 2018 Phase 2	TP-219	4+080	5m N	Unproven, at least 1.00	0.1m of grass over soft brown sandy gravelly clay with rare pieces of plastic. 0.6m of firm to stiff firm to stiff light greyish brown mottled orangish brown slightly sandy gravelly clay. Gravel is angular to subrounded vein quartz, phyllite, psammite and tarmac. 0.3m of soft to firm blackish brown slightly gravelly clay. At 0.90m, pockets of 300m diameter dark brownish black organic silt with low root content. *(Possibly associated with a drainage system below location)*
SSL 2018 Phase 2	TP-363B	13+390	160m S	1.00, possible MG a further 2.00	1.0m of soft brown slightly sandy gravelly clay with a low cobble content and medium root content. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of platey phyllite and Vein quartz. Cobbles are subangular being quartz (Reworked natural material). At 0.05m depth, continuous black plastic membrane. At 0.50m depth, 200mm piece of asphalt. 2.0m of possible Made Ground comprising very stiff light grey and orange locally mottled red gravelly silt with a low cobble content. (*Possibly associated with embankment for the existing A30*).

Groundwater levels

9.4.72 During the most recent ground investigations by Structural Soils [22] [23], groundwater monitoring installations were installed in 19 No. boreholes across site. Data logging ‘divers’ were installed and data logs have been and are planned to be downloaded every two months up until construction and during works. The results presented within the **WSP Ground investigation report** [2] (see Volume 6 Document Ref 6.4 ES Appendix 9.2) and **GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3) are summarised in Table 9-12.

Table 9-12 Summary of the results of groundwater monitoring within the Structural Soils 2017 Phase 1 and 2018 Phase 2 boreholes.

Borehole	Chainage (m)	Response zone (m bgl)	Bedrock Formation	Ground Level (mOD)	Design groundwater level		Groundwater monitoring data				
							Minimum from level logger		Maximum from level logger		Seasonal fluctuation (m)
					Depth (mbgl)	Level (mOD)	Depth (mbgl)	Level (mOD)	Depth (mbgl)	Level (mOD)	
BH-S-005	1+000	3.0 to 15.0	Porthtowan	143.7	2.2	137.5	No level logger data available				
BH-R-004	2+900	3.0 to 5.0	Porthtowan	143.6	2.8	140.8	5.0	138.6	2.8	140.8	2.2
BH-R-010	3+950	2.0 to 5.6	Porthtowan	107.1	2.1	105.0	5.6	101.5	2.1	105.0	3.5
BH-S-012	4+850	1.0 to 7.0	Porthtowan	116.7	5.0	111.8	7.0	109.7	4.7	112.0	2.3
BH-R-013	5+800	3.0 to 6.0	Porthtowan	98.7	6.2	92.5*	Dry	Dry	Dry	Dry	-
BH-S-019	6+000	0.8 to 6.5	Porthtowan	81.8	2.8	79.0	5.5	76.3	2.7	79.1	2.9
BH-R-017	7+100	4.5 to 7.5	Porthtowan	79.3	1.1	78.3	6.1	73.2	0.9	78.4	5.2
BH-S-032	8+700	1.5 to 5.5	Grampound	80.3	5.6	74.8*	Dry	Dry	Dry	Dry	-
BH-S-036	11+000	8.0 to 24.6	Grampound	111.3	4.6	106.8	5.5	105.8	4.7	106.6	0.8
BH-R-027	11+400	4.4 to 7.4	Grampound	120.4	2.9	117.5	6.9	113.5	2.8	117.7	4.1
BH-S-042	12+900	3.0 to 9.0	Grampound	146.8	5.8	141.0	9.0	137.8	5.6	141.2	3.4
BH-S-049	13+350	5.5 to 9.0	Grampound	143.7	3.3	140.5	8.9	134.8	3.0	140.8	6.0
BH-R-041	14+050	1.0 to 7.3	Trendrean	135.9	4.7	131.3	7.2	128.6	4.6	131.3	2.7
BH-201	1+400	1.90 to 7.90	Porthtowan	139.67	2.2	137.5	1.4	132.2	7.4	138.3	6.1
BH-207	1+540	1.00 to 7.00	Porthtowan	135.22	4.5	130.8	7.4	127.8	2.1	133.1	5.3
BH-213	7+310	2.70 to 8.70	Porthtowan	101.91	2.9	99.0	8.7	93.2	2.8	99.1	5.9
BH-216	8+310	2.00 to 8.00	Grampound	106.84	3.6	103.3	8.0	98.8	3.2	103.6	4.8
BH-303	7+310	2.80 to 8.80	Porthtowan	84.29	3.0	81.3	5.2	79.1	2.78	81.5	2.4
BH-309	11+510	2.70 to 5.70	Grampound	122.49	2.0	120.5	4.6	117.9	1.9	120.6	2.7

*Standpipe piezometers were dry throughout the monitoring period, a conservatively high groundwater level approximately 0.25m below the base of the response zone has been assumed.

9.4.73 Design groundwater levels are based upon the higher groundwater levels experienced in the winter with consideration given to the extent and persistency of short-term response to rainfall.

9.4.74 The design groundwater levels vary from 1.10m to over 6m below existing ground level. Generally, lower ground levels corresponded to slightly higher groundwater levels, and vice versa. Therefore, shallow groundwater may be encountered within excavations within the central third of the site, as it is at a lower elevation on average than the east and west of the route.

Permeability

9.4.75 Soakaway infiltration tests carried out in the Porthtowan Formation during the Structural Soils (2017) Phase 1 [22] and Phase 2 [23] GI recorded infiltration rates of $2.3x10^{-3}$ to $1.95x10^{-6}$ m/s. Two in-situ rising head permeability tests undertaken in borehole BH-S-036 in the Grampound Formation (response zones of 2.7m and 19.3m) recorded permeability of between $2.3x10^{-5}$ and $3.1x10^{-7}$ m/s respectively.

Conceptual site model

9.4.76 The following paragraphs detail the Conceptual Site Model for the existing baseline condition. The Conceptual model presents the potential sources, pathways, and receptors (potential pollution linkages) identified from the review of the baseline conditions within the study area. The conceptual model identifies potential current impacts from contamination in the existing baseline conditions.

9.4.77 The sources are split into those on, and those off site. For the purpose of the conceptual model those sources listed as on site relate to locations within the boundaries of the scheme. Sources identified outside this area but within the boundaries of the study area are deemed to be off site sources.

9.4.78 The potential sources of contamination identified during review of the baseline conditions are presented in Table 9-13 and Volume 6 Document Ref 6.3 ES Figure 9-6.

Table 9-13 Identified potential sources of contamination.

Potential Source	Potential Contaminants
On site	
Made Ground soils	
Possible made ground associated with existing road infrastructure (A30 and other routes crossing the scheme): • 0-1+600m A3075 and A30 • 1+800m B road • 1+950m to 2+100m A30 • 3+650m to 5+000m A30 and B3284 • 5+500m farm track • 5+800m B road • 6+400m to 6+600m A30 adjacent • 7+100m B road • 7+300m to 8+600m farm track, A30 and B road • 9+300m B road	Metals, hydrocarbons, asbestos in soils and groundwater, ground gas

• 9+500m to 9+800m A30 adjacent and B road • 10+950m B road • 11+400m B road • 12+850m to 12+950m A30 • 13+300m to 14+496m A30	
Made ground identified during intrusive investigations with elevated soil concentrations and leachable concentrations of contaminants: • BH-R-030 • BH-R-040C • BH-R-041 • TP-P-009 • TP-R-088A • BH-212 • TP-201 • TP-219 (oil sheen noted on groundwater)	Metals in soils including arsenic and lead. Leachable levels of metals, PAH, TPH
Made ground associated with private development/farmland crossing the scheme. There is a potential risk in all areas of the scheme however attention is drawn to the following locations: • 5+500m two small outbuildings along alignment • 6+200m private access track to a Farm • 7+100m Private dwellings and land.	Metals, hydrocarbons, asbestos, in soils ground gas
Historic mining and infilled quarries	
Historic mining areas with associated mine waste, backfilled mining areas, backfilled quarries. In particular, those identified as part of historic and environmental searches, however there is a risk of un-recorded features being encountered along the scheme. • See Volume 6 Document Ref 6.3 ES Figure 9-3 for locations where mine workings are on site.	Metals, hydrocarbons, asbestos, ground gas.
Current or Historic Activities	
Activities associated with the operation of the existing road infrastructure (A30 and other routes crossing the scheme). These activities may have resulted in accidental spillages or leakages of fuels or oils, the gradual discharge of fuel/oil contaminated run off into defective drainage networks and release to the surrounding ground. It may also include fly tipped materials on more minor roads and tracks.	Metals, hydrocarbons, asbestos.
Current or historic land uses (excluding mining): • 0+600m Petrol filling station • 1+700m electrical repair premises • 5+100m to 6+300m and 12+920m to 13+450m high pressure gas main • 7+650m electricity pylon • 7+900m electricity pylon • 8+100m to 8+150m former nursery on 1993 mapping • 11+700m to 12+200m abandoned oil pipeline • 13+500m filling station It should be considered that the main historic and current land use in the location of the scheme is for agricultural purposes. On this basis there is potential for the accumulation of herbicides and	Metals, hydrocarbons, asbestos, herbicides and pesticides, ground gas

pesticides in the site soils along the scheme alignment. These have been taregeted during laboratory testing.	
Environment Agency Recorded pollution incidents: • 0+050m Lubricating Oils – Minor 3 Land • 0+850m Commercial Wastes – No impact	Hydrocarbons
Contaminated Groundwater	
Impact of the above listed sources on the groundwater in the vicinity of the sources through leaching of soil contaminants	Metals, hydrocarbons, herbicides, PCBs
Impact of the above listed source on the groundwater through leaks/spills etc (Petrol stations, vehicle servicing etc)	Hydrocarbons
Off Site	
Potential Made Ground soils	
Made ground associated with existing road infrastructure such as the A30 and other routes in close proximity to the proposed alignment that may have impacted on or be impacting on the scheme via, dust migration, leaching and migration of contamination or migration of ground gas. Given the scheme location, there are numerous areas where this scenario is possible over much of the route and as such individual locations are not listed for the purpose of brevity.	Metals, hydrocarbons, herbicides in soils, ground gas.
Made ground associated with private development/farmland in close proximity to the scheme. There is a potential risk in all areas of the proposed route.	Metals, hydrocarbons, asbestos, herbicides in soils, ground gas.
Historic mining and infilled quarries	
Historic mining areas with associated mine waste, backfilled mining areas, backfilled quarries in close proximity to the scheme. In particular, those identified as part of historic and environmental searches, however there is a risk of un-recorded features being encountered in the study area. • See Volume 6 Document Ref 6.3 ES Figure 9-3 for off site locations.	Metals, hydrocarbons, asbestos, ground gas.
Current or historic activities	
Activities associated with the operation of the existing road infrastructure (A30 and other routes in close proximity to the scheme). These activities may have resulted in accidental spillages or leakages of fuels or oils, the gradual discharge of fuel/oil contaminated run off into defective drainage networks and release to the surrounding ground. It may also include fly tipped materials on more minor roads and tracks.	Metals, hydrocarbons, asbestos.
Current or historic land uses (excluding mining/quarries): • 0+600m Petrol filling station. vehicle sales, vehicle servicing. • 0+900m to 1+000m grave yard. • 1+700m electrical repair premises, construction services • 1+800 wind turbine • 3+500m electricity sub station. • 4+250m wind turbine • 4+600m wind turbine • 6+200m Civil engineering/sewerage premises. • 6+350m vehicle sales garage and waste oil burner. • 6+600m solar farm	Metals, hydrocarbons, asbestos, herbicides, PCBs (old electricity sub stations)

• 7+200m infilled pond on 1879 mapping • 7+400m to 8+500m electricity pylons • 8+100m to 8+150m former nursery on 1993 mapping • 8+400 to 8+600m four disused quarries on 1879 mapping • 9+200m smithy noted on 1879 mapping • 10+450m infilled pond on 1906 mapping • 11+000m refuse heap noted on 1958 mapping • 11+200m potentially infilled pond on 1879 mapping • 11+900m potentially infilled pond on 1879 mapping • 13+000m power turbine • 13+500m power turbine • 13+500m filling station It should be considered that the main historic and current land use in the location of the scheme is for agricultural purposes. On this basis there is potential for the accumulation of herbicides and pesticides within site soils in areas in proximity to the scheme.	
Numerous soakaway discharge consents are present in proximity to the scheme alignment. Whilst these should be for infiltration of surface water (rain) they have potential to be conduits for contamination release to the local groundwater.	Metals, hydrocarbons.
Contaminated Groundwater	
Impact of the above listed sources on the groundwater in the vicinity of the sources through leaching of soil contaminants	Impact of the above listed sources on the groundwater in the vicinity of the sources through leaching of soil contaminants
Impact of the above listed source on the groundwater through leaks/spills etc. (Petrol stations, vehicle servicing etc.)	Impact of the above listed source on the groundwater through leaks/spills etc. (Petrol stations, vehicle servicing etc.)

9.4.79 An oily sheen was noted on the water within TP-219 during the Phase 2 investigations presented in Volume 6 Document Ref 6.3 ES Figure 9-6. No other visual or olfactory evidence of contamination was noted during the intrusive works on site.

9.4.80 Review of the investigations undertaken on site to date have generally confirmed the site is predominately underlain by natural soils, with minor areas of made ground identified, as detailed in Table 9-13.

9.4.81 Soil analysis, leachate analysis and groundwater analysis has been obtained as part of the baseline information. Should a plausible pathway be identified between the sources identified in Table 9-13 the results of this testing can be used to assess the impact further.

9.4.82 Ground gas monitoring was not undertaken as part of intrusive works on site, however, given the natural geology and other potential contaminant sources present across the majority of the scheme it is not considered that a significant source of ground gas is present. Made Ground has generally been encountered in isolated locations and typically less than 1m thick so not considered to pose a significant risk of lateral gas migration. The alluvial soils may present some potential for ground gas generation, however these are generally located in

discrete areas across the scheme area, freely venting to atmosphere and therefore not considered to present a risk in the baseline scenario.

9.4.83 The potential receptors to the identified sources of potential contamination are presented in Table 9-14.

Table 9-14 Identified potential baseline Receptors.

Receptors	Discussion
Human:	
Residents and workers of nearby villages, hamlets, and farms in the scheme and study area.	Residents and workers in the scheme and study area are considered to be sensitive receptors which may be impacted by long term exposure to the potential contamination sources identified in the previous section.
Users of agricultural land and countryside (ramblers etc) in the scheme and study area.	Due to shorter term exposure durations, it is considered that these receptors are less likely to be impacted.
Maintenance workers on the existing A30 (which form part of the scheme) and other highways crossing the scheme and study area.	Regular and possible long term (albeit intermittent) exposure to the potential contamination sources identified in the previous section.
Users of the existing A30 road at tie in points with the scheme and other highways crossing the scheme, including motorists, cyclists, pedestrians, horse riders etc.	These receptors are considered to be at a low risk due to the transient nature of their likely exposure to the potential contamination sources.
Environmental:	
Groundwater beneath the scheme and study area (Secondary A Aquifers)	Impact from contamination within the scheme, or study area and migration into the scheme
Surface water features identified in Table 9-7 and Table 9-8	
Water abstraction points identified in Volume 6 Document Ref 6.3 ES Figure 9-4	

9.4.84 The pathways identified between potential sources of contamination and the potential receptors are presented in the Table 9-15.

Table 9-15 Identified potential baseline pathways.

Pathway	Discussion
Human Health:	
Ingestion of soil and dust	Exposed soils in temporary excavations e.g. road works/farmland in the immediate vicinity, during cutting of verges etc
Inhalation of soil dust	Generation of dust during temporary excavations (e.g. roadworks) or other works such as farming, grass cutting etc.
Inhalation of gases and volatile organic contamination	Inhalation on gasses or vapours from sources such as spills/leaks, ground gas generated from made ground or natural deposits of alluvium.
Dermal contact with soils and dust.	Contact with temporarily exposed site soils (road works / farming) /groundwater in

Pathway	Discussion
	excavations or from dust created. Considered unlikely that contact with groundwater will occur.
Controlled Waters:	
Direct release of contaminants from leaks or spills into controlled waters (groundwater, streams, springs, rivers etc.).	Leaks or spills near controlled waters, or into drainage which discharges to controlled waters etc.
Release of contaminants from leaks or spills into the sub-surface and subsequent vertical and lateral migration through unsaturated and saturated zones.	Migration through pore space/fractures in rocks and soils, along preferential pathways such as service corridors or higher permeability strata. Impact on aquifers within subsurface, surface waters through springs/issues.
Leaching of contamination from soils into surface waters, or into the sub-surface and subsequent vertical and lateral migration through unsaturated and saturated zones.	

9.4.85 Review of the above potential pollution linkages indicate that in the current baseline conditions, nearby residents and workers are unlikely to be exposed to potential sources of contamination through ingestion, inhalation and to groundwater and soils through dermal contact on a frequent basis, if at all, for the following reasons:

- The ground investigations to date have generally encountered natural soils across the study site.
- Where made ground soils have been encountered these have been generally isolated to small areas and did not display visual or olfactory signs of contamination.
- The most likely source for contamination is either made ground associated with the existing road infrastructure or possible mining waste. In the current baseline, the former is likely to be largely isolated from these receptors by road surfacing/topsoil with vegetation, while the latter is considered likely to be isolated to some degree by vegetation and or topsoil layers.

9.4.86 Review of the above potential SPR linkages in relation to recreational users of the study area indicate that they are unlikely to be impacted in the current baseline for the following reasons:

- The ground investigations to date have generally encountered natural soils across the study area.
- Where made ground soils have been encountered these have been generally isolated to small areas and did not display visual or olfactory signs of contamination.
- Exposure frequency is likely to be relatively sporadic, and in addition the duration is likely to be short term. For example, it is overly pessimistic to assume that an entire walking route would be over exposed contaminated soils.

9.4.87 Review of the possible impact to maintenance workers indicates that, in current baseline conditions, they are considered the most likely to be impacted by the potential sources of contamination for the following reasons:

- Maintenance workers or highways workers may be directly exposed to contaminated soils or made ground during works on the existing infrastructure on site. Exposure pathways would include dermal, ingestion and inhalation.

Exposure duration is likely to be relatively short term, however it is feasible that this could be on a regular basis, over the lifetime of the worker (e.g. grass cutting on verges).

- Due to likely location of the works (in association with highways) it is considered that there is a higher potential for made ground, or contaminated soils to be present.

9.4.88 However, as regular maintenance works are not considered likely to involve deep excavations, no direct exposure to groundwater is considered likely to occur. In addition, given the likely nature of the site soils, ground gas risk is considered to be low. Furthermore, it is considered that man entry into excavations/confined spaces would be limited and likely to be controlled with mitigation measures and risk assessment to reduce the risk to maintenance workers from ground gasses.

9.4.89 Existing users of the A30, or other highways in the study area are not considered likely to be impacted by contamination on the basis of the following:

- Relative isolation within vehicles.
- Their transient nature and likely short term duration.

9.4.90 The possible pathways in relation to controlled waters are considered to be plausible for the following reasons:

- Potential contaminants within the identified sources are considered to be freely leachable from the site soils via infiltration of rain or surface water given the absence of drainage or hard cover.
- The investigations to date have indicated the site soils to comprise a mixture of granular and cohesive materials overlying weathered bedrock. While not considered to be highly permeable strata, vertical and lateral migration is still plausible, especially in bands of higher permeability strata or in granular made ground, service runs, or old mining features.

9.4.91 On the basis of the above discussion, Table 9-16 presents the plausible pollutant linkages present in the baseline setting for the scheme.

Table 9-16 Baseline Source-Pathway-Receptor Linkages.

Sources	Pathways	Receptors	Comments
On Site **Made ground:** Existing road infrastructure Made ground identified during previous ground investigations **Historic Mining and Quarries** Mine waste used to fill/level areas. Backfilled mine workings with mine wastes (possible surface workings along lodes) Back filled quarries – unknown backfill with potential contamination. **Current or historic activities** Possible contamination associated with operation of A30 and other highways crossing the scheme alignment. Land use – filling stations, electrical distribution network, agriculture, oil and gas pipelines. Previous pollution incidents (recorded and un-recorded). **Off Site** **Made ground:** Possible made ground associated with the existing road infrastructure crossing the scheme alignment. Possible made ground associated with private developments, farm land. **Historic Mining and Quarries** Mine waste used to fill/level areas. Backfilled mine workings with mine wastes (possible surface workings along lodes) Back filled quarries – unknown backfill with potential contamination	**Human Health** Ingestion of soil and dust Inhalation of soil and dust Inhalation of gasses and volatile organic contamination Dermal contact with soils, dust.	**Human Health** Maintenance workers on highways or other land that crosses the scheme alignment.	**Human Health** Made ground, mining waste or backfilled workings, and potential current contaminative processes are considered likely to be present in locations in the study site. Maintenance workers on existing highways may be directly exposed to potential contaminated made ground.
	Controlled Waters Leaching of contaminants, vertical and horizontal migration within the subsurface. Direct discharge into ground.	**Controlled Waters** Groundwater beneath the scheme alignment (Secondary A Aquifers)	**Controlled Waters** Direct release into the groundwater is not considered likely, however migration of contaminants from spills or leaks or via leaching of soil based contamination is considered plausible. Given the distance from the scheme to surface water features it is not considered likely that direct releases will impact. However indirect migration of contamination may be considered plausible. Source protection zones related to abstractions exist beneath the scheme. These are considered likely to be impacted by any contamination present.
		Surface water features	
		Water Abstractions	

Sources	Pathways	Receptors	Comments
Current or historic activities Possible contamination associated with operation of A30 and other highways crossing the scheme alignment. Land use – filling stations, smithy's, electrical distribution network, horticulture, agriculture. Previous pollution incidents (recorded and un-recorded). Soakaway drainage as possible contamination pathways.			

Assessment of potential impact of current baseline conditions

Land contamination

9.4.92 Table 9-16 indicates that in the baseline condition the potential plausible pollution linkages are:

- Maintenance workers impacted by direct exposure to contaminants in soils/made ground.
- Controlled waters impacted by potential contamination present in made ground or mine workings, leaks and spills, and current land use (petrol filling stations).

9.4.93 On the basis of the above and in accordance with the proposed assessment methodology (see **Geology and soils** (Volume 6 Document Ref 6.2 ES Chapter 9)) a Generic Quantitative Risk Assessment (GQRA) has been carried out to assess the risk. The details are presented in the following paragraphs.

Human Health GQRA

9.4.94 The following GQRA is based on the results obtained from the intrusive ground investigations undertaken on site to date.

9.4.95 As part of the GIR [2] soil sample analysis, a total of 21No. soil samples were submitted for chemical testing. Of these samples, 5No. were from made ground soils, 4No. were from weathered bedrock, 1No. was obtained from alluvium, and 11No. were obtained from Topsoil.

9.4.96 During the Phase 2 GI works discussed in the **GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3), a further 48No. soil samples were submitted for chemical testing. Of these 7No. were from Made Ground soils, 4No. were from weathered bedrock, 1No. was obtained from alluvium, and 14No. obtained from topsoil.

9.4.97 In relation to the human health risk from contaminated soils the identified receptors are maintenance and construction workers. Published generic screening criteria for the exposure scenario associated with this type of work are not available. On this basis the assessment criteria chosen for the GQRA are for residential with plant uptake end use as they represent the most conservative land use. These criteria are considered to be conservative given the likely exposure scenario encountered by a maintenance worker, however they are likely to be suitable to establish if further discussion or detailed assessment is required.

9.4.98 The results of the screening assessment indicate that the majority of chemical concentrations fall below the applied screening criteria with the following exceptions:

- 8 No. concentrations of arsenic;
- Two concentrations of lead;
- One concentration of benzo(a)pyrene;
- One concentration of dibenzo(ah)anthracene.

9.4.99 Exceedances for arsenic were encountered in samples of made ground from 0.6m bgl in TP-P-09, samples from 0.5m above ground level (bund) and 0.2m bgl in TP-201, samples from 0.4 to 0.5m and 0.9 to 1.0m bgl in TP-219. Review of the soil descriptions for TP-P-09, TP-201, and TP-219 does not indicate a potential

source of the arsenic aside from the general description of Made Ground. The other exceedances for arsenic were noted in residual natural soils in samples from 0.4 to 0.5m bgl in TP-363, 0.7 to 0.8m bgl in TP-365, and a sample from 0.3m bgl in BH-213. It is concluded that these arsenic concentrations may be reflective of elevated background concentrations associated with the natural soils in this geography.

9.4.100 Exceedances for lead were encountered in samples of Made Ground from 0.65m bgl in BH-R-030 and 0.00 to 0.15m bgl in BH-212. Review of the soil descriptions for both exploratory holes does not indicate any potential sources for the lead aside from the general description of Ground including coal. Review of the location of BH-R-030 indicates that the borehole lies approximately 100m north of the location of an old shaft and heap (possible mine waste) shown on the historic mapping from 1879 to 1958. The mapping following 1958 no longer shows the shaft or heap, the heap may well have been re-graded across the area and it may be that this is the cause of the elevated lead in this location. BH-212 is in close proximity to an old shale quarry and as such it is conceivable that the Made Ground in this area may be backfilled waste material used to fill this feature.

9.4.101 Exceedances for both benzo(a)pyrene and dibenzon(ah)anthracene were only recorded in a single sample from 0.9 to 1.0m bgl in TP-219. Review of the soil descriptions for TP-219 indicates asphalt present within the Made Ground, potential drainage infrastructure and an oily sheen on the groundwater encountered in the trial pit. These substances are considered possible sources of these elevated levels of PAH.

9.4.102 Despite the above exceedances, in general the soils encountered during the investigation works have shown little evidence of contamination with concentrations of contaminants falling below the applied residential with plant uptake screening criteria. It is considered that the screening criteria are likely to be overly conservative in relation to assessing the risk to maintenance and construction workers, and that it is likely that much of the risk identified by the exceedances would be mitigated by the likely use of personal protective equipment (PPE). On this basis it is not considered that a significant risk to human health is present to the identified receptors.

Controlled Waters GQRA

9.4.103 In order to assess the likely impact on controlled waters a GQRA based on the results of leachate analysis and groundwater analysis obtained during the previous investigations has been undertaken.

9.4.104 The **WSP Ground investigation report** (Volume 6 Document Ref 6.4 ES Appendix 9.2) [2] included soil leachate analysis on a total of 16No. soil samples; 4No. samples were from made ground deposits, 4No. from weathered bedrock and a further 8No. from topsoil samples.

9.4.105 As part of the Phase 2 investigations included in the **GIR Addendum** [4] (see Volume 6 Document Ref 6.4 ES Appendix 9.3), a total of 12No. groundwater samples were obtained from installations in boreholes from across the scheme.

9.4.106 The study area is situated above Secondary A Aquifers, there are numerous water courses and springs within the study area, and in addition, there are abstraction licenses within the study area. On this basis leachate results have been screened against Freshwater Environmental Quality Standards (FEQS) or

UK Drinking Water Standards (UKDWS), whichever is most conservative. In addition, priority hazardous substances have been screened against their laboratory Limit of Detection (LOD). For ambient level concentrations of particular contaminants the catchment area has been defined as the Fal. Where hardness dependant FEQS values have been used, in the absence of site specific data the most conservative FEQS values have been adopted. Similarly, where particular FEQS are derived from assessment of site specific pH, calcium and dissolved organic carbon data, in the absence of this data the most conservative bioavailable FEQS values have been adopted. Impact of hazardous leachable contaminants on the underlying groundwater is assessed by comparing minimum reporting values (MRVs) against measured concentrations.

9.4.107 The results of the screening assessment indicate the following:

- The majority of heavy metals are below the applied screening criteria with the exception of copper, lead, and zinc which are discussed further below.
- Numerous concentrations of PAH compounds are recorded above the laboratory limit of detection which are discussed further below.
- Two samples indicated leachable levels of TPH fractions, this is discussed further below.

9.4.108 A single elevated level of cadmium was observed in a sample from BH-S-005 at a concentration of 0.4µg/l against the FEQS of 0.08µg/l.

9.4.109 Bioavailable assessment of the copper concentrations has indicated that 4No. bioavailable concentrations of copper ranging from 1.25µg/l to 2.54µg/l exceeded the FEQS of 1.0µg/l. These copper exceedances were recorded in samples from BH-S-005, BH-S-019, BH-S-049, and BH-R-027.

9.4.110 Two elevated concentrations of mercury were recorded, one at 15.0µg/l against the FEQS of 0.05µg/l in BH-201, and one at 7.0µg/l in BH-216.

9.4.111 Bioavailable assessment of nickel concentration has indicated a single elevated bioavailable concentration of 4.23µg/l in exceedance of the FEQS of 4.0µg/l from BH-S-042.

9.4.112 Bioavailable assessment of zinc concentrations has indicated 4No. bioavailable concentrations ranging from 20.1µg/l to 45.0µg/l exceed the FEQS of 16.7µg/l. These exceedances were recorded in samples from BH-S-005, BH-R-010a, BH-S-019, BH-R-027, BH-S-042, and BH-216.

9.4.113 Numerous PAH compounds were recorded above the laboratory limit of detection in BH-201. This was the only location in which PAH compounds were recorded in groundwater samples.

9.4.114 TPH Aliphatic fractions C5 to C6 were recorded at concentrations of between 1.0µg/l and 5.0µg/l in samples from BH-S-005, BH-201, and BH-309. Aliphatic C6 to C8 were recorded at concentrations of 5.0µg/l and 6.0µg/l in BH-201 and BH-309 respectively. Aliphatic C16 to C21 and C21 to C35 were recorded at concentrations of 41.0µg/l and 78.0µg/l respectively in a sample from BH-S-005.

9.4.115 TPH Aromatic fractions C7 to C8 and C8 to C9 were recorded at concentrations of 5.0µg/l and 1.0µg/l respectively in a sample from BH-201. Aromatic C16to C21 was recorded at a concentration of 12.0µg/l in a sample from BH-S-019.

9.4.116 Generally, the groundwater chemical analysis has indicated some exceedances of heavy metal concentrations, and generally organic contaminant concentrations below the laboratory limit of detection except for a single sample showing PAHs and TPH and three others showing TPH detections.

9.4.117 With regards to the potential sources of heavy metals, review of the locations where exceedances have occurred does not indicate an obvious spatial relationship, some occurrences are noted in boreholes near known former mining areas but at the same time other exceedances are present in boreholes not near known mining features.

9.4.118 It is suspected that the heavy metal concentrations may be reflective of typical background concentrations in this area given the past mining history and likely metalliferous mineralisation present in the local geology. In relation to the organic contaminants encountered a review of the location of the boreholes from which exceedances noted do not indicate potential sources for the hydrocarbon contaminants. BH201 showed elevated PAHs and TPH fractions, however there was no evidence of contamination within the logs, and the borehole is in an area of open agricultural land, away from likely potential sources of PAH contamination.

9.4.119 BH-S-005 showed variable levels of TPH fractions, however the borehole is in an area of open agricultural land, away from likely potential sources of PAH contamination.

9.4.120 BH-S-019, and BH-309 all showed variable levels of TPH fractions. BH-S-019 lies circa 10m south of the high pressure gas pipeline, however, TPH exceedances were not noted within the surrounding exploratory holes and no evidence of contamination was noted within the logs. BH-309 is located circa 5m north of the abandoned oil pipeline, however, the logs do not suggest any evidence of contamination and exceedances were very minimal. BH-R-028, circa 10m north-west of BH-309 did not show any leachable levels of TPH above the limit of detection.

9.4.121 In summary, generally the groundwater chemical analysis has indicated some exceedances of heavy metal concentrations, and generally organic contaminant concentrations below the laboratory limit of detection except for a single sample showing PAHs and TPH and three others showing TPH detections. With regards to the potential sources of heavy metals, review of the locations where exceedances have occurred does not indicate an obvious spatial relationship, some occurrences are noted in boreholes near known former mining areas but at the same time other exceedances are present in boreholes not near known mining features. It is suspected that the heavy metal concentrations may be reflective of typical background concentrations in this area given the past mining history and likely metalliferous mineralisation present in the local geology. In relation to the organic contaminants encountered a review of the location of the boreholes from which exceedances noted do not indicate potential sources for the hydrocarbon contaminants. BH201 showed elevated PAHs and TPH fractions, however the borehole is in an area of open agricultural land, away from likely potential sources of PAH contamination. BH-S-005, BH-S-019, and BH-309 all showed variable levels of TPH fractions, review of their locations also indicated that the exploratory holes were in agricultural areas, away from any development and likely source of hydrocarbon contamination.

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