6 Ground Conditions

6.1 Introduction

6.1.1 This chapter considers the baseline conditions present in the area of the proposed Cardiff Hendre Lakes development (and associated Cardiff Parkway railway station; 'proposed development') and identifies the potential effects that the construction and operation may have on ground conditions focusing on geology, hydrogeology and the impact of land contamination on human health and controlled waters.

6.1.2 This chapter sets out the legislative context specific to the assessment of ground conditions followed by a presentation of the baseline conditions within the proposed development site. This includes the presentation of geological, hydrological and hydrogeological setting, underlying ground conditions, site history and a conceptual site model for the assessment of impacts of land contamination. This is followed by an assessment of potential effects on ground conditions resulting from construction activities and operation.

6.1.3 The chapter includes the following appendices:

- Appendix D1 – Geotechnical desk study
- Appendix D2 - Ground gas monitoring strategy note
- Appendix D3 – 2019 Ground investigation factual report
- Appendix D4 – Ground investigation report
- Appendix D5 – Detailed UXO risk assessment report

6.1.4 The potential effects on hydrology and potential impacts on groundwater quality from construction activities are covered in Section 5 Hydrology and Flooding. The potential effects on ecological features including aquatic life are assessed in Section 7 Biodiversity.

6.2 Review of proposed development

6.2.1 The proposed development as detailed in Section 3, would include the construction of a development platform, buildings and widening of the existing railway embankment crossing the proposed development site.

6.2.2 Construction of the development platform will require placement of a large volume of fill materials raising the finished development level by between 1m and 2.5m. The existing reens in the area of the fill will be infilled. Placement of fill

will result in consolidation of soft deposits that are present within the proposed development site area. Consolidation can be a long-term process potentially taking years to be substantially complete. Therefore, in order to ensure that any ongoing settlements are reduced to acceptable limits within reasonable project development time scales, engineering measures are likely to be required. These may include 'surcharging' the ground, i.e. temporarily placing fill above proposed finished ground levels and/or the installation of band drains in the fill areas to accelerate rates of settlement to within reasonable construction timescales of say 3-6 months. The band drains comprise vertical drains (e.g. plastic hollow tubes with slotted walls allowing for water inflow) inserted into the ground that allow for water release from the compressed ground, accelerating the settlement rate. Water collected by the drains is typically discharged at surface into a drainage blanket installed beneath the fill.

6.2.3 The proposed development includes the widening of the existing rail embankment. In order to manage differential settlements between the existing and new embankments, the new embankments are likely to require piled foundations, where usually no foundations would be required. Proposed buildings and associated structures such as the new footbridges required to access the station platforms will also be supported on piled foundations. The embankment widening will also require extensions to the existing culverts.

6.2.4 The proposed development will require some shallow earthworks. These will mainly comprise excavations to allow for the construction of foundations and utilities. In addition, the existing reens will be backfilled or widened and new reens will be constructed, as detailed in Section 3. It is also proposed to lower the ground level in the south-western corner of the proposed development site and to the south of the railway land, in flood compensation areas. These works will require excavation and removal of soils. It is anticipated that the soil arisings will be reused within the development. As part of the detailed design, suitability for reuse criteria with respect to human health and controlled waters will be derived. The reuse criteria will set out minimum requirements (including concentrations of contaminants) that will be protective of human health or controlled waters. These values will be derived based on operational end use scenario and in line with the current contaminated land risk assessment framework (as set out in Section 6.5 Methodology). These will be presented within the specification derived for the earthworks. This will feed into a materials management plan adopted for the proposed development. This will set out requirements with respect to reuse, storage and handling of soil arisings. A requirement to develop a materials management plan and suitability for reuse criteria has been incorporated into the outline CEMP as presented in Appendix A2.

6.3 Legislation, policy context and guidance

6.3.1 The principal legislation and policies specifically related to the assessment of ground conditions focusing on geology and land contamination are described below.

Legislation

6.3.2 Geological sites of national importance are principally afforded protection under the Wildlife and Countryside Act 1981 (as amended) or the National Parks and Access to the Countryside Act 1949 by designation as a Site of Special Scientific Interest (SSSI) or National Nature Reserve (NNR).

6.3.3 Environmental legislation implemented as either Acts or Regulations provide separate legislative drivers to manage contamination. The main legislative drivers for managing risks to human health and the environment from land contamination are:

- Part IIA of the Environmental Protection Act 1990;
- Contaminated Land (Wales) Regulations 2006;
- Contaminated Land (Wales) (Amendment) Regulations 2012;
- Environment Act 1995; and
- Environmental Permitting Regulations 2016 (as amended).

6.3.4 In Wales, Part IIA of the Environmental Protection Act 1990, as introduced by Section 57 of the Environment Act 1995, came into effect in September 2001 with the implementation of the Contaminated Land Regulations 2000 (now superseded by The Contaminated Land Regulations 2006/2012). Under Part IIA of the Environmental Protection Act, sites are identified as 'contaminated land' if they are causing, or if there is a significant possibility of causing significant harm to human health or significant pollution of controlled waters (as defined by Section 104 of the Water Resources Act 1991).

6.3.5 The Environment (Wales) Act 2016 sets out a framework for the sustainable management of natural resources. The accompanying Natural Resources Policy (2017) focuses on the delivery of the Well-being Goals and is aimed at improving the environment and delivering economic objectives (as set out by the Well-being of Future Generation Act 2015).

6.3.6 In general terms the legislation advocates the use of a risk assessment approach to the assessment of contamination and any remedial requirements.

6.3.7 A list of additional legislation and guidance considered within this assessment and relating to contamination and water environment includes:

- Water Resources Act 1991 as amended in Wales by the Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009;
- EU Water Framework Directive (WFD) 2000/60/EC (as amended by supplementary directives and decisions);
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 which implement Water Framework Directive

(2000/60/EC), and transpose aspects of the Groundwater Directive (2006/118/EEC) and the Priority Substances Directive (2008/105/EC).

- The Environmental Permitting Regulations 2016 (as amended in 2018 and 2019), which amend the Environmental Permitting (England and Wales) Regulations SI 2010/675. The 2010 Regulations revoked the Groundwater Regulations (England and Wales) 2009, which originally implemented in the Groundwater Directive;
- Groundwater Daughter Directive (GWDD) (2006/118/EC);
- The Water Framework Directive (Standards & Classification) Directions (England and Wales) 2015;
- The Groundwater (Water Framework Directive) (Wales) Direction 2016;
- The Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009; and
- Flood and Water Management Act 2010.

Policy context

6.3.8 Planning Policy Wales Edition 10 (2018) (PPW10), Section 6.3 highlights the importance that geological features have in the natural environment. Specific reference is made to the protection, conservation and enhancement of:

- UNESCO Global Geoparks;
- Regionally Important Geological and Geomorphological Sites (RIGS); and
- Sites of Special Scientific Interest (SSSIs).

6.3.9 In addition, PPW10 encourages planning authorities to promote opportunities for the incorporation of geological features within the design of development.

6.3.10 PPW10, Section 6.9 covers both development on contaminated land and developments which may pose risks to health and the environment. Physical ground conditions and land instability are also considered within this section.

Local planning policy

6.3.11 The Cardiff Local Development Plan (Cardiff LDP) 2006 – 2026, was adopted in January 2016. In the interest of sustainable development, the Key Policy KP18: Natural Resources requires development proposals to take full account of the need to minimise impacts on the natural resources and minimise pollution, including the requirement to protect the water resources and remediate land contamination. Developments will only be allowed where there would not be unacceptable harm to the quality or quantity of water resources and these water resources are

safeguarded. Land impacted by contamination would require remediation to ensure it is suitable for the proposed development.

6.3.12 The Cardiff LDP provides a range of Detailed Policies focusing on Designated Sites (EN5), Protection of Water Resources (EN11) and Air, Noise, Light Pollution and Land Contamination (EN13):

- The EN5 protects statutory and non-statutory geological and geomorphological sites of importance. Where the development may affect such a site in cases, the need for the development needs to outweigh the conservation importance and it must be shown that there is no alternative location and compensation measures would need to be provided.
- No development will be allowed if it poses an unacceptable risk to water resources unless appropriate measures to prevent pollution can be incorporated into the development proposals.
- Any development proposals likely to impact the water resources will be consulted with Natural Resources Wales and Caldicot and Wentloog Levels Internal Drainage Board, where necessary. Permission for development may be refused if it may adversely affect the quality, quantity or supply of surface or groundwater.
- Where significant contamination is likely to be present, the local planning authority will require evidence of a detailed investigation and risk assessment prior to determination of the application to enable beneficial use of land. Where necessary, remedial measures will be required.
- Developer need to ensure that the development of the site will not result in designation as a site with land contamination under Part 2A of the Environmental Protection Act 1990 and ensure the land is suitable for development.

6.3.13 The Newport Local Development Plan (Newport LDP, 2011-2026) adopted in January 2015 sets out the vision, strategy and objectives with respect to sustainable land use and conservation of the natural environment. The Newport LDP provides a series of strategic policies, which are underpinned by policies. Three strategic policies SP1 Sustainability, SP4 Water Resources and SP9 Conservation of the Natural, Historic and Built Environment, are considered relevant to the proposed development. These policies state:

- Proposed development will be required to make a positive contribution to sustainable development with respect to efficient use of land, development of brownfield land, and protecting and enhancing the natural environment.
- Proposed development should protect water quality during and after construction. Natural Resources Wales will be consulted on proposals likely to affect the supply or quality of water.

- Conservation, enhancement and management of recognised sites within the natural environment will be required in all proposals.

6.3.14 The Newport LDP provides General Development Principles with respect to Natural Environment (GP5) and Environmental Protection and Public Health (GP7). These require:

- Proposals do not result in unacceptable impact on water quality. Developments are expected to comply with the Water Framework Directive.
- Developments do not result in unacceptable harm to health because of land contamination, water pollution or any other risk to the environment or public health and safety. A Construction Management Plan may be required to demonstrate how the impacts on community and amenity during the construction phase will be minimised and managed.

6.3.15 Detailed policies focus on Locally Designated Nature Conservation and Geological Sites (CE8). Proposals affecting locally designated sites (including SINC and RIGS) will only be permitted if there would be no significant adverse effect on the geological interest of the site and appropriate mitigation or compensatory measures can be achieved.

Relevant guidance

6.3.16 The assessment will be undertaken with due consideration of the following topic specific guidance:

- Model Procedures for the Management of Land Contamination (CLR11)[1]. The guidance is currently under review and will be withdrawn in the early 2020 and replaced by the updated online guidance called 'Land contamination: risk management'[2];
- Development of Land Affected by Contamination: A Guide for Developers[3]
- Construction Industry Research and Information Association (CIRIA) R132: A Guide for Safe Working on Contaminated Sites[4];
- CIRIA SP73: Roles and Responsibility in Site Investigations[5];
- BS5930: 2015: Code of Practice for Site Investigations including Amendment 2[6];

[1] Model Procedures for the Management of Land Contamination (CLR11), Environment Agency and Defra, 2004.
[2] Environment Agency, Land contamination: risk management, https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks
[3] Development of Land Affected by Contamination: A Guide for Developers, Welsh Local Government Association and Natural Resources Wales, Version 3, May 2017
[4] A Guide for Safe Working on Contaminated Sites (R132), Construction Industry Research and Information Association (CIRIA), 1996.
[5] Roles and Responsibility in Site Investigations (SP73), Construction Industry Research and Information Association (CIRIA), 1991.
[6] BS5930:2015 Code of Practice for Site Investigations including Amendment 2, British Standards Institution, 2015.

- BS10175:2011 + A1 2013: Code of Practice for Investigation of Potentially Contaminated Sites[7];
- Groundwater protection guidance[8], including the Environment Agency's approach to groundwater protection[9];
- CIRIA 552: Contaminated Land Risk Assessment, A guide to good practice[10];
- CIRIA 681: Unexploded ordnance (UXO) A guide for the construction industry[11];
- CIRIA 733: Asbestos in soil and made ground: a guide to understanding and managing risks[12];
- CIRIA 765: Asbestos in soil and made ground: good practice site guide[13];
- Definition of Waste: Development Industry Code of Practice[14] sets out a framework for management of materials during construction. This is currently not obligatory for use in Wales, and therefore has not been referenced as a requirement that will be followed. Refer to Section 16: Material Assets for more details;
- Eurocode 7 (BS EN 1997-1[15] & EN 1997-2[16]) and all relevant normatives; and
- NRW Guidance for Pollution Prevention (these replace the withdrawn Pollution Prevention Guidance (PPG)) of relevance in relation to protection of soils and waters.

6.4 Scoping and consultation

Scoping

6.4.1 The Scoping opinion response with respect to ground conditions assessment from Cardiff Council (CC) and Natural Resources Wales (NRW) is presented in

[7] BS10175:2011+A1 2013 Code of Practice for Investigation of Potentially Contaminated Sites British Standards Institution, 2011.
[8] Department for Environment and Rural Affairs, "Groundwater Protection," 14 March 2017. [Online]. Available: https://www.gov.uk/government/collections/groundwater-protection. [Accessed 17 June 2019].
[9] Environment Agency, "The Environment Agency's approach to groundwater protection," February 2018. [Online]. Available: https://www.gov.uk/government/publications/groundwater-protection-position-statements. [Accessed 17 June 2019].
[10] Contaminated Land Risk Assessment, A guide to good practice (C552), Construction Industry Research and Information Association (CIRIA), 2001
[11] Unexploded ordnance (UXO) A guide for the construction industry (C681), Construction Industry Research and Information Association (CIRIA), 2009
[12] Asbestos in soil and made ground: a guide to understanding and managing risks (C733), Construction Industry Research and Information Association (CIRIA), 2014
[13] Asbestos in soil and made ground: good practice site guide (C765), Construction Industry Research and Information Association (CIRIA), 2017
[14] Definition of Waste Development Industry Code of Practice. Version 2. In association with the Homes and Communities Agency, DEC UK and Hydrock. Contaminated Land: Applications in Real Environments (CL:AIRE), 2011.
[15] BS EN 1997-1: 2004 and Amendment 1: 2013: Eurocode 7 Geotechnical Design. General Rules British Standards Institution, 2013.
[16] BS EN 1997-2: 2007 UK National Annex to Eurocode 7 Geotechnical Design. Ground Investigation and Testing, British Standards Institution, 2007.

Appendix A1 and responses specific to the ground conditions assessment are detailed in Table 6.1 below.

Table 6.1: Response to scoping opinion

Scoping opinion clause	Response
CCC dated 13/07/2019	CCC acknowledge the completion of a preliminary contamination risk assessment as presented in the Geotechnical Desk Study, Arup 2017 (refer to Appendix D1). The proposed ground investigations to assess the presence of contamination and ground gases and to determine any appropriate measures to be undertaken in line with the WLGA / WG / NRW guidance document, 'Land Contamination: A guide for Developers' (2017).
NRW dated 02/08/2018	NRW noted and welcomed the proposed scoping of the ground conditions assessments.

Consultation

6.4.2 Consultation with CC has been undertaken with respect to approach to ground gas monitoring as part of the intrusive investigations. The Ground Gas Monitoring Strategy note dated 19 July 2018 (enclosed in Appendix D2) was issued to CC for comments, which was subsequently agreed by the council. This is documented in their email dated 7 August 2018, presented in Appendix A1.

6.4.3 In order to inform baseline conditions study, information on records of private water supplies and land contamination was requested from CC and Newport City Council (NCC). Responses are presented in Appendix A1.

6.4.4 A similar request was sent to NRW, which included data records of water abstractions, source protection zones, water quality data, pollution incidents, industrial processes, discharge consents and historical and licenced landfill sites. The requested data is presented in Appendix A1.

Table 6.2: Response to representations from stakeholders on scope of ground conditions assessment

Stakeholder	Comment	Response
CC	Proposed ground gas monitoring strategy (enclosed in Appendix D2)	Agreement has been reached (response enclosed in Appendix A1)
NRW	Request for information (via email) 06/09/2018	Information received (via email) 08/10/2018
NCC	Request for information (via email) 04/09/2018	Information received (via email) 08/10/2018
CC	Request for information (via email) 20/01/2020	Information received (via email) 21/01/2020

6.5 Methodology

Overview

6.5.1 The methodology includes a review of the existing baseline conditions which are used to assess the potential impacts due to the construction and operation of the proposed development.

Methodology for establishing baseline conditions

6.5.2 The identification of baseline conditions has included:

- Published geological maps and memoirs;
- Topographic maps and information;
- Current and historical land use information;
- Available ground investigations information;
- Information gathered from the relevant statutory bodies and the local planning authorities, as detailed in Section 1.4; and
- Proposed development site walkover survey completed on the 20th of November 2017.

6.5.3 A desk study review[17] of the above has been completed to support the design of the proposed development. This is presented in Appendix D1 of the ES. This was followed by the 2019 intrusive investigations. The results and assessments of the encountered ground conditions are presented in the factual report[18] and ground investigation report[19], enclosed in Appendix D3 and Appendix D4, respectively.

6.5.4 The above information has been used to develop Conceptual Site Models (CSMs) for the proposed development in accordance with the Model Procedures for the Management of Land Contamination (CLR 11). This is to be replaced by new guidance 'Land contamination: risk management' in 2020, however no significant changes to the guidance is anticipated.

[17] Cardiff Hendre Lakes Development Ltd, Cardiff Hendre Lakes, Geotechnical Desk Study, ref. 252199, December 2017 (Arup)
[18] Cardiff Hendre Lakes Initial Ground Investigation, Factual report on ground Investigation prepared for Cardiff Hendre Lakes Development Limited, report ref. 35338, dated 15/10/2019 (Geotechnical Engineering Limited)
[19] Cardiff Hendre Lakes Development Ltd, Cardiff Hendre Lakes, Ground Investigation Report, ref. 252199, November 2019 (Arup)

Study Area

6.5.5 The study area that has been used for this assessment includes an area shown on Figure 6.1 extending:

- up to 250m away from the boundary of the proposed development area to allow for identification of potential pollution linkages, and
- up to 1km – for identification of sensitive receptors to any potential contamination originating within the proposed development, for example source protection zones, water abstraction points or private water supplies..

6.5.6 The 250m distance is considered to be appropriate in order to establish the current baseline for the ground conditions at the proposed development site and includes sites that have plausible pollutant linkages. Notwithstanding this, potential pollutant linkages have been considered on a case by case basis, for example, if sources of contamination are identified outside the study area but there is potential for that contamination to migrate towards the proposed development, for instance via groundwater.

6.5.7 The geology study area has been determined on the basis of the regional geology of the area, however it is considered that the proposed development would have an impact on geology only within the footprint of the development.

Assessment methodology

6.5.8 The assessment of risks associated with contaminated land has been based on the risk management framework provided in the Model Procedures for the Management of Land Contamination (CLR 11) to be replaced by new guidance 'Land contamination: risk management' in 2020. This has involved preparation of a CSM for the baseline conditions, which has formed the basis for preliminary followed by generic and, if required, detailed risk assessments.

6.5.9 The impacts and effects on the geology/geomorphology/hydrogeology and land contamination arising from construction has been assessed by review of baseline conditions in the context of the extent, method and programme of the proposed construction activities that will be required. These have been outlined in Section 3 and an outline CEMP as presented in Appendix A2.

6.5.10 Assessment of the likely impact on the geology/geomorphology/hydrogeology and land contamination arising from the operation has been undertaken by a review of baseline conditions in the context of the final end use.

6.5.11 Potential interrelationships have been identified between the ES chapters concerned with water resources, air quality (dust) and climate change. The assessment of effects has taken into account these interrelationships.

Significance criteria

6.5.12 The significance of impacts has been assessed by attributing a value or sensitivity to each receptor impacted, in combination with the magnitude of impact that will occur to it. The sensitivity of each receptor has been assessed in line with Table 6.3, and the magnitude of impact in accordance with Table 6.4.

6.5.13 The significance of impact has then been assessed by considering the sensitivity of the receptors in combination with the magnitude of impact in accordance with Table 6.5.

6.5.14 The criteria of sensitivity, magnitude of impact and evaluation of effects have been adopted from the Design Manual for Roads and Bridges (DMRB) guidance for the assessment of potential impacts on Soils and Geology (LA109).

6.5.15 The level of significance that merits further consideration / mitigation has been determined following the procedures set out in Section 2. Significant effects are those where the significance of the effect is 'moderate' or greater.

Table 6.3: Criteria and EIA Definitions of Sensitivity or Value

Value (sensitivity)	Typical Descriptors
Very high	**Geology:** Very rare and of international importance with no potential for replacement (e.g. UNESCO World Heritage Sites, UNESCO Global Geoparks, Site of Special Scientific Interest (SSSI) and Geological Conservation Review sites where citations indicate features of international importance). Geology meeting international designation citation criteria which is not designated as such. **Land Contamination:** Human health: High sensitivity land use scenario such as residential and allotments. Controlled waters (Groundwater/ Surface water): as per sensitivity value assigned in Section 5.
High	**Geology:** Rare and of national importance with little potential for replacement (e.g. geological SSSI). Geology meeting national designation citation criteria which is not designated as such. **Land Contamination:** Human health: High sensitivity land use scenario such as public open space. Controlled waters (Groundwater/ Surface water): as per sensitivity value assigned in Section 5.
Medium	**Geology:** Of regional importance with little potential for replacement (e.g. Regionally Important Geological Sites). Geology meeting national designation citation criteria which is not designated as such. **Land Contamination:** Human health: Medium sensitivity land use scenario such as commercial or industrial

Value (sensitivity)	Typical Descriptors
	Controlled waters (Groundwater/ Surface water): as per sensitivity value assigned in Section 5.
Low	**Geology:** Of local importance/interest with potential for replacement (e.g. non designated geological exposures, former quarry/mining site). **Land Contamination:** Human health: Medium sensitivity land use scenario such as construction site, highways or rail Controlled waters (Groundwater/ Surface water): as per sensitivity value assigned in Section 5.
Negligible	**Geology:** No geological exposures, little/no local interest. **Land Contamination:** Human health: undeveloped surplus land/ no sensitive land use proposed. Controlled waters (Groundwater/ Surface water): as per sensitivity value assigned in Section 5.

Table 6.4: Criteria and EIA Definitions of Impact Magnitude

Magnitude of Impact	Typical Criteria Descriptors
Major	**Geology:** Loss of geological feature/designation and/or quality and integrity, severe damage to key characteristics, features or elements. **Land Contamination:** Human health: Significant contamination identified. Contamination levels significantly exceed background levels and relevant screening criteria with potential for significant harm to human health. Controlled waters (Groundwater/ Surface water): Reduction of water quality rendering groundwater or surface water unfit to drink and/or substantial adverse impact on groundwater dependent environmental receptors. Discharge of hazardous substances to groundwater.
Moderate	**Geology:** Partial loss of geological feature/designation and/or quality, potentially affecting integrity, partial loss of/ damage to key characteristics, features or elements. **Land Contamination:** Human health: Contamination levels exceed background levels and are in line with relevant screening criteria. Significant contamination can be present. Control/remediation measures are required to reduce risks to human health/ make land suitable for intended use. Controlled waters (Groundwater/ Surface water): Reduced reliability of a supply at a groundwater or surface water abstraction source. Discharge of non-hazardous substances to groundwater and surface water resulting in pollution (i.e. contaminants present above the Environmental Quality Standard (EQS)).
Minor	**Geology:** Minor measurable change in geological feature/designation, quality or vulnerability; minor loss of, or alteration to one (or maybe more) key characteristics, features or elements. **Land Contamination:** Human health: Contamination levels are below relevant screening criteria. Significant contamination is unlikely with a low risk to human health. Best practice measures can be required to minimise risks to human health. Controlled waters (Groundwater/ Surface water): Marginal reduced reliability of a supply at a groundwater or surface water abstraction source. Discharge of non-hazardous substances to groundwater and surface water not resulting in pollution (i.e. contaminants present below the EQS).
Negligible	**Geology:** Very minor loss or detrimental alteration to one or more characteristics, features or elements of geological feature/designation. Overall integrity of resource not affected.

Magnitude of Impact	Typical Criteria Descriptors
	Land Contamination: Human health: Contamination concentrations substantially below levels outlined in relevant screening criteria. No requirement for control measures to reduce risks to human health/ make land suitable for intended use. Controlled waters (Groundwater/ Surface water): Non-measurable change to quality.
No change	**Geology:** No temporary or permanent loss/ disturbance of characteristics, features or elements of geological feature/designation. **Land Contamination:** Human health: Reported contamination levels below background levels. Controlled waters (Groundwater/ Surface water): No change to quality.

Table 6.5: Approach to Evaluating Significance of Effect

		Magnitude of Impact				
		No Change	**Negligible**	**Minor**	**Moderate**	**Major**
Value/ Sensitivity	Very high	Neutral	Slight	Moderate or large	Large or Very large	Very large
	High	Neutral	Slight	Slight or moderate	Moderate or Large	Large or Very large
	Medium	Neutral	Neutral or slight	Slight	Moderate	Moderate or Large
	Low	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or Moderate
	Negligible	Neutral	Neutral	Neutral	Neutral or slight	Slight

6.6 Limitations and assumptions

Limitations

6.6.1 Initial intrusive ground investigations were undertaken in 2019 within the proposed development area. These initial investigations did not include the area of the railway embankment or other areas associated with the existing road network, where the presence of made ground is anticipated, and limited investigations were undertaken to the south of the railway line, where no major works are proposed. Further detailed intrusive investigations targeting specific aspects of the development may be required to inform the detailed design.

6.6.2 However, the available ground investigation information and published information is considered suitable to create a preliminary ground model and identify the required mitigation measures. This is considered sufficient at this initial design stage and to inform the environmental impact assessments.

Assumptions

6.6.3 It is assumed that during construction, or any intrusive maintenance works, good health and safety management and pollution control will be undertaken in

accordance with current legislation and published guidance. It is assumed that measures would include groundwater management during excavations and management of dust generation. These have been set out in an outline CEMP (Appendix A2).

6.6.4 It is assumed that should any materials constituting on-going sources of contamination be identified, they will be removed/remediated as part of the proposed development construction in line with current legislation. This is in line with the outline CEMP requirements with respect to encountering unexpected contamination.

6.6.5 It is assumed that any discharge into controlled water environment during construction will be undertaken in line with regulatory requirements and any relevant consents and permits.

6.6.6 Professional judgement has been applied where necessary in assignment of sensitivity and magnitude of effects in line with definitions provided in Table 6.3 and Table 6.4.

6.6.7 Notwithstanding the limitations and assumption, it is considered that sufficient information has been available for the completion of the assessment of ground conditions and issues.

6.7 Baseline Environment

6.7.1 This section presents the baseline conditions with respect to geo-environmental setting and resources within the study area. It also describes the conceptual site model in relation to potential contaminants, pathways and receptors of contamination and their linkages.

Site location and topography

6.7.2 The proposed development site location and context are detailed in Section 3 of the ES. The topography of the site is generally flat at approximately 5m AOD. The railway that bisects the site is on an embankment at approximately 7m AOD. The land to the west of the Faendre Reen rises to approximately 8m AOD. Refer to Ground Investigation Report (presented in Appendix D4) for details.

Site History

6.7.3 The detailed history of proposed development area is presented in the 2019 geotechnical desk study report prepared by Arup, a copy of which is enclosed in Appendix D1. Land reclamation work dating back to Roman times resulted in an introduction of a complex drainage system comprising a network of reens and ditches across the wider Gwent Levels, including the proposed development area. The Great Western mainline railway that bisects the proposed development site was constructed in the mid 19th Century. There is no indication of major development on the majority of the site since this time. Buildings associated with

a gas governor facility were constructed in the southeast of the northern proposed development area between 1992 and 2002. Four gas pipelines are shown to cross the proposed development site from the gas governor. Overhead electricity cables were constructed crossing the site area by 1970. The key features are shown on Figure 6.2.

Published geology

6.7.4 The detailed description of published geology is presented in the Arup geotechnical desk study report, enclosed in Appendix D1. In summary, the proposed development site is overlain by the Tidal Flat Deposits, as shown on Figure 6.3. These typically comprise clay and silt with beds of peat overlying sand and gravel. Published sources indicate the potential presence of early postglacial river channels infilled by the seaward reaches of the valleys with fluvial deposits, which consist mainly of alluvial mud, silts and sands with a little gravel. The coastal flats of the Bristol Channel are thickly covered by marine alluvium, comprising mainly mud and silt, with interbedded bands of peat. As a result of the presence of the buried river channels, both the depth of the bedrock and the thickness of the superficial deposits are anticipated to vary across the proposed development area.

6.7.5 The bedrock in the northern proposed development area is predominantly of the St Maughan's Formation, which comprises interbedded argillaceous rocks. The south eastern corner of the northern proposed development area and all of the southern area are underlain by bedrock of the Mercia Mudstone Group. Refer to Figure 6.4. The Mercia Mudstone comprises predominantly mudstone with subordinate siltstone and sandstone beds, with roughly horizontal bedding that unconformably overlies the St Maughan's Formation, which has a regional dip of approximately 40º towards the northeast.

6.7.6 The encountered ground conditions are discussed in sections below.

Geological and Geomorphological Designated Sites

6.7.7 There are no statutory geological or geomorphological designations within the proposed development site boundary.

6.7.8 The proposed development is located within the Pilldu Geological Landscape area evaluated at moderate value due to being a reclaimed marshland of Severn Terrace with a 'fair condition' as largely rural/agricultural use. The geological character of the area is mainly due to the presence of superficial deposits such as Estuarine clay and thin peats with active coastal processes still occurring and evidence of past estuarian processes. The location and extent of the Geological Landscape area is shown on Figure 6.2.

6.7.9 The Pilldu Geological Landscape area is linked with the Gwent Levels – Rumney and Peterstone Site of Special Scientific Interest (SSSI). In addition, there are two Sites of Importance for Nature Conservation (SINC) that are located within the

proposed development area, Hendre Lake and Marshfield. These areas are likely to be sensitive to changes in surface water and groundwater chemistry.

Hydrology and hydrogeology

6.7.10 The proposed development is located on low-lying land, historically reclaimed from the sea during Roman times following the introduction of an interconnected network of drainage channels and ditches, known as 'reens'. Many drainage channels or 'reens' are located within the proposed development area. The Faendre Reen drainage channel runs along the western boundary, flowing south, with other reens and ditches connecting into it. The reen network forms part of the Gwent Levels – Rumney and Peterstone SSSI. The flow within the reens is controlled by sluices and is dependent on tide conditions. The general drainage direction of surface water flow is however anticipated to be towards the Severn Channel, approximately 1.5km to the south.

6.7.11 The NRW aquifer designation classifies the Tidal Flat Deposits as unproductive. The St Maughan's Formation is classified as a secondary (A) aquifer. Whilst the Mercia Mudstone Group underlying the southern area of the proposed development site and part of the northern area is classified as a secondary (B) aquifer.

6.7.12 The Tidal Flat Deposits are generally low permeability materials but higher permeabilities can be encountered at the interface between solid geology formations and the overlying superficial deposits and where more granular or organic layers are present within the deposits. The encountered groundwater conditions are discussed in sections below.

6.7.13 There are no private water supplies within the Study Area. As detailed in Section 5 Water Resources, there are three non-potable water abstractions within the Study Area.

Mining

6.7.14 The proposed development is located outside of a Coal Authority mining reporting area and the review of historical maps and aerial images did not identify any evidence of coal or other mining within or near to the proposed development area.

Unexploded Ordnance

6.7.15 The potential for unexploded ordnance has been assessed in the Arup geotechnical desk study, enclosed in Appendix D1. In summary, it was recommended that a detailed UXO report should be carried out. This was because Newport had been heavily bombed during WWII, St Mellons had been the site of a number of military bases and decoy sites, the ground comprised soft clay and the extent of potential intrusive works required for the development was considered substantial.

6.7.16 A detailed UXO risk assessment report (presented in Appendix D5) for the proposed development area, concluded that the UXO risk is low. It concluded the most probable UXO threat was posed by WWII German High Explosive (HE)

bombs, with a residual threat present from Incendiary Bombs (IBs) and British Anti-Aircraft Ammunition (AAA). Whilst there is a residual UXO risk present within the proposed development area, it was not believed to be a significant risk pathway to warrant on site pro-active mitigation measures.

6.7.17 The report recommended the following mitigation measures for all ground works, which included:

- An operational UXO emergency response plan to be held on the proposed development site.
- UXO safety and awareness briefings for all personnel working on site.

6.7.18 Undertaking these measures was recommended to reduce the UXO risk to as low as reasonably practicable (ALARP).

Site Investigations

6.7.19 A number of ground investigations have been undertaken within the proposed development and its vicinity:

- Initial phase of ground investigation was conducted for Cardiff Parkway Developments Ltd in 2019 within the proposed development area ('2019 ground investigations'). This investigation comprised eleven boreholes, seven trial pits, six Cone Penetration Tests (CPT), groundwater and ground gas monitoring, chemical testing on soil (targeting made ground only), surface water and groundwater samples, laboratory and in-situ geotechnical testing. Factual information including exploratory hole logs, testing and monitoring results, is presented in the factual report, enclosed in Appendix D3.
- Investigations in the area of Green Lane Overbridge were completed in 2015 ('2015 Green Lane Overbridge investigations'). It was undertaken within close proximity to the proposed development site, along Heol Las. Ground investigation comprised seven boreholes monitored for ground water ingress, three trial pits and CPTs;
- Investigations to inform the Great Western Electrification Scheme (GWES) – Section M were completed in 2016 ('2016 GWES investigations'). In the proximity of the proposed development site the ground investigation comprised four boreholes monitored for groundwater ingress, eight inspection pits and eight CPTs;
- BGS online viewer[20] boreholes ('BGS boreholes'). Within and surrounding the proposed development site footprint previous ground investigations comprising six boreholes.

[20] British Geological Survey https://www.bgs.ac.uk/

6.7.20 The locations are shown on Figure 6.2. Details are provided within the Ground Investigation Report, enclosed in Appendix D4.

Encountered Ground Conditions

6.7.21 The completed ground investigations, as listed in section 6.7.19, encountered the typical ground conditions within the proposed development area as summarised in Table 6.6 below and detailed in the Ground Investigation Report, enclosed in Appendix D4, including geological long/cross sections and detailed descriptions and properties of the encountered strata.

6.7.22 The ground conditions encountered throughout the proposed development were generally consistent with the geology predicted from the published geology sources.

Table 6.6: Summary of encountered ground conditions

Material Name	Typical Description	Depth (m bgl*)	Thickness (m)
Made Ground			
Made Ground	No Made Ground was encountered across the site by exploratory holes, except for area of Green Lane Overbridge and vicinity of the railway embankment. Encountered made ground in the overbridge area comprised tarmacadam with silty sandy clays and gravels, including coarse brick, siltstone, limestone, sandstone, coal, slag and glass.	GL – 7.9	0.4 to 7.9
	The 2016 GWES investigations found embankment materials to comprise grass over silty sandy clay, with gravel subangular to sub rounded brick and mudstone. The 2019 ground investigations encountered made ground as reworked natural ground.	GL – 0.4	0.1 to 0.4
Superficial Geology			
Tidal Flat Deposit – Clay	Soft to firm slightly sandy gravelly clay with abundant wood fragments and frequent rootlets. Infrequent gravel of sandstone and mudstone. (Increasing thickness towards the East) [Desiccated Crust present across the majority of the site; locally mottled firm clay with frequent rootlets]	GL to 7.9	0.8 to 7.5 [Desiccated Crust: 0.3 – 1.6]
Tidal Flat Deposit – Peat	Bands of firm clayey fibrous peat becoming slightly sandy organic silty clay. Frequent fragments of plant material and wood fragments. Within Green Lane Overbridge it was described as spongy oxidising fibrous peat (Frequently occurring towards the east of the site's footprint)	0.4 to 11.1	0.2 to 2.0

Material Name	Typical Description	Depth (m bgl*)	Thickness (m)
Glacial Till Deposit	Firm slightly gravelly sandy silty clay. Gravel of coarse sandstone, mudstone and siltstone. Frequent pockets of fine sands. (Increasing thickness towards the west of the site) [Glaciofluvial Deposits are suggested to be present in infrequent bands towards the north of the site; typically sands or gravels]	GL to 7.5	0.4 to 5.4
Solid Geology			
Undifferentiated Bedrock of St Maughan's and Mercia Mudstone	Extremely weak to very weak mudstone and sandstone tending to very stiff clay. Sub horizontal fractures. (Increasing thickness towards the south of the site's footprint)	6.0 to 15.0	0.2 to 24.8 [Undefined thickness]

Notes: '* bgl – below ground level

Soil quality

6.7.23 Ground investigations completed to date encountered limited and isolated areas of made ground. No evidence of major contamination within the proposed development area has been encountered.

6.7.24 The known areas of made ground are associated with the Green Lane Overbridge, the railway line and access track to the gas governor. These materials were found to contain inclusions of slag, fragments of tyres, coal and demolition rubble. There may be potential sources of contaminants such as metals, hydrocarbons and/or asbestos. No chemical testing has been undertaken on these materials.

6.7.25 Fly-tipped materials (e.g. construction/demolition type of materials) have also been observed within the proposed development area. These may be a source of asbestos.

6.7.26 Organic odours were observed within the Tidal Flat Deposits, associated with the peat deposits.

Encountered Groundwater Conditions

Groundwater Strikes

6.7.27 Groundwater strikes were recorded during the completed investigations as summarised in the Ground Investigation Report enclosed in Appendix D4. The water strikes observed during the 2019 ground investigations are also shown on exploratory hole logs (refer to factual report enclosed in Appendix D3). The groundwater strikes were recorded at relatively shallow depth, between 1 and 2.2m below ground level (bgl), typically 3-4m AOD.

6.7.28 The low permeability of the Tidal Flat Deposit clays means that it is unexpected that groundwater seepages during drilling would be observed. It is likely that the

encountered water strikes are associated with bands/pockets of more permeable peat or sandy/silty layers within the Tidal Flat Deposits.

Groundwater Monitoring

6.7.29 The 2019 ground investigations included six rounds of groundwater level monitoring and three rounds of sampling and chemical testing. The results are presented in the factual report (enclosed in Appendix D3). The monitored installations and assessments of the results are detailed in the Ground Investigation Report (enclosed in Appendix D4)

6.7.30 The results of the groundwater level monitoring showed groundwater to be present typically approximately 1m bgl (on average at between 4 and 4.4 m AOD) with a slight hydraulic gradient towards the south east, with the average piezometric head difference of approximately 0.3m between the north of the proposed development site (BH01 and BH02) and the south east of the site (BH07 and BH08). No large difference has been observed in the monitored water levels between the shallow and deep response zones suggesting hydraulic continuity between the monitored strata. It is assumed that the groundwater is in continuity with the water in the reens, although due to the relatively low permeability of the Tidal Flat Deposits there may be a lag in level response between the groundwater and the reens. Groundwater monitoring results are detailed in the Ground Investigation Report enclosed in Appendix D4.

6.7.31 The assessment of the chemical testing results indicated the presence of elevated concentrations of cadmium, copper (bioavailable), phenols and petroleum hydrocarbons with respect to potential risk to aquatic environment. The assessments however concluded that considering the degree of exceedances and frequency, the identified exceedances were not of concern with respect to controlled waters, and in the case of the elevated metals were likely to be representative of a wider background water quality.

Surface Water Monitoring

6.7.32 The 2019 ground investigations included eight rounds of surface water sampling and chemical testing. The results are presented in the factual report (enclosed in Appendix D3). The assessments are detailed in the Ground Investigation Report (enclosed in Appendix D4).

6.7.33 The assessment of the chemical testing results indicated the presence of elevated concentrations of zinc (bioavailable) with respect to potential risk to aquatic environment. The assessments however concluded that considering that the identified exceedances were identified within upstream locations in relation to the proposed development, these are likely to indicate the presence of sources of zinc outside rather than within the proposed development area.

6.7.34 The baseline conditions describing ecological features including aquatic life present within the proposed development are presented in Section 7 Biodiversity.

Ground Gas Monitoring

6.7.35 The 2019 ground investigations included six rounds of ground gas monitoring undertaken in line with a strategy presented in Appendix D2. The results are presented in the factual report (enclosed in Appendix D3). The assessments are detailed in the Ground Investigation Report (enclosed in Appendix D4).

6.7.36 The assessment of the monitoring results indicated that no significant vertical ground gas migration from the peat deposits to the near ground surface and no significant migration of gas from the dissolved phase to gaseous phase was occurring.

6.7.37 The monitoring results have however indicated the presence of elevated levels of Volatile Organic Compounds (VOCs) in all monitored installations across the site. The source of the VOCs has not been identified and it is considered to be a result of either human or equipment error. Further monitoring has been recommended to obtain more data.

Land Contamination

6.7.38 The following sections set out a baseline Conceptual Site Model (CSM), which considers potential contaminants and pathways via which this contamination may impact the identified receptors. For the risk to exist all three components, contaminant – pathway – receptor, need to be in place.

Sources and Contaminants (Baseline)

6.7.39 A review of the proposed development site history showed that the site has predominantly been agricultural fields since 1898. As a result, there could be contaminants associated with the use of fertiliser and pesticides, particularly in areas of storage or loading. The levels within the fields are unlikely to be significant as the application would have been limited to acceptable levels in relation to the given crop type or agricultural land use, and therefore unlikely to be at toxic levels. No storage areas have been identified on historical mapping or during site walkovers, therefore no significant levels of contaminants associated with agricultural use are anticipated.

6.7.40 The majority of the proposed development area is underlain by topsoil over natural deposits. Isolated areas of made ground are however likely to be present within the proposed development area. Made ground has been encountered in proximity to the railway embankment and Green Lane Overbridge. The railway embankment is also likely to comprise made ground materials. Contaminants typically associated with historical and operational railway lines or road network include hydrocarbons due to spillages of fuel or lubricants, metals, sulphates and hydrocarbons within ash. Asbestos fibres may also be present, e.g. associated with former train braking systems. No evidence of hydrocarbon contamination has been observed during completed investigations.

6.7.41 Made ground may also be present in small discrete areas of the fields associated with buildings, sheds or tracks that are/have been on the proposed development

site, or land management. Completed ground investigations have not encountered such areas.

6.7.42 There is also evidence of localised waste associated with fly tipping on parts of the proposed development area. Considering the nature of these fly-tipped materials i.e. construction/demolition type of materials, there is a potential for asbestos presence.

6.7.43 Gas governors were constructed on small areas, in the east and the north of the proposed development site. The associated gas pipes are shown on Figure 6.2. Made ground may be encountered as pipe surrounds and could contain contamination.

6.7.44 Peat layers have been encountered within the Tidal Flat Deposits, which could be a source of ground gas. Peat layers/lenses have been recorded at depth with a thickness of up to 2.0m. Ground gas monitoring did not indicate a significant gas generation and migration to surface. Records provided by CC (enclosed in Appendix A1) indicate that a development located approximately 320m to the northeast was assessed to be a Characteristic Situation 1 site and therefore not requiring ground gas protection measures. The ground conditions underlying that site are unknown, however based on published geology maps, that site is primarily underlain by glacial till, where the presence of peat deposits is not anticipated. Similar ground gas conditions may be present in the proposed development areas underlain by glacial till deposits.

6.7.45 Two historical landfills are recorded by NRW near to the proposed development site. One, Swn-Y-Mor Farm No.1, is located approximately 240m southeast of the proposed development and the other, Pil-Du-Lake, is located 120m west of the proposed development, as shown on Figure 6.2. Swn-Y-Mor Farm No.1 received inert, industrial, commercial and household waste. The first input is recorded as being 1985. Pill-Du-Lake received inert waste between 1966 and 1990. Information provided by Cardiff Council (enclosed in Appendix A1) indicates that Pill-Du-Lake received inert waste and stated “Anecdotal records indicate made ground using excavation material from construction of lake; organic type soils, peat rich”.

6.7.46 Two pollution incidents are recorded by NRW within the proposed development area. One occurred in July 2016; the pollutant was unspecified and had a minor impact. The other, occurred in April 2016, had a pollutant of soil and clay, and had a minor water impact.

6.7.47 Baseline groundwater and surface water quality assessments indicated that both groundwater and surface water have been impacted by contaminant sources located outside the proposed development area and are likely to represent wider background concentrations.

Pathways (Baseline)

6.7.48 Potential pathways to human receptors include:

- Direct soil and dust ingestion;
- Dermal exposure;
- Inhalation of particulates/fibres;
- Inhalation of soil vapour; and
- Gas migration.

6.7.49 Vertical gas migration is anticipated to be restricted by the generally cohesive nature of the surrounding material but the gas could migrate laterally through sandier layers or within groundwater.

6.7.50 Pathways to Controlled Waters

- Leaching and vertical/lateral migration;
- Direct discharge; and
- Contamination migration through preferential flow paths potentially induced by existing pipe network.

Receptors (Baseline)

6.7.51 Potential receptors of contamination include:

- Current users of the proposed development site e.g. farmers;
- Railway and road network maintenance workers;
- Neighbours of the proposed development site including St Mellons residents located directly to the west of the site, workers of a business park located directly to the north of the site;
- Surface waters, including the Faendre Reen and Hendre Park lake
- Groundwater contained within the bedrock aquifer; groundwater contained within the superficial deposits, classed as unproductive strata, is not considered a receptor.

6.7.52 The identification and justification of the baseline source-pathway-receptor linkages are summarised in Table 6.7.

Table 6.7: Potential pollutant linkages at baseline scenario.

Potential Sources of Contaminants	Potential Receptor	Possible Pathway	Comment
Onsite Made ground Fly tipped Waste Infilled land	Current site users i.e. agricultural workers;	Direct dermal	The area of the proposed development is currently largely undeveloped and used as grazing land. Except for nearby residents long-term and frequent exposure to the identified sources of contaminants is unlikely. The nearby residents
		Ingestion	

Potential Sources of Contaminants	Potential Receptor	Possible Pathway	Comment
Ground gas from peat Pollution incidents Groundwater impacted by off-site sources e.g. landfills	Maintenance Workers (railway/ nearby roads); Site neighbours (residents)	Inhalation of gas or vapours	may be exposed to dust generated from areas of made ground although considering the extent and distance to these areas, the exposure is unlikely to be resulting in significant risk to human health. Ground gas generation may be occurring within the peat/ organic alluvium deposits, however due to the cohesive nature of the underlying soils, significant migration to ground surface is unlikely.
	Surface waters (Faendre Reen and reen along eastern boundary)	Leaching, lateral migration within groundwater, contaminated surface water run off	Due to the cohesive nature of the soils present at the site, the migration of groundwater through these layers is likely to be very limited. Surface run-off or trans-evaporation processes are likely to be principal drainage mechanism within the site area. Groundwater within the bedrock aquifer may have been impacted by off-site sources.
	Groundwater (bedrock aquifer)	Leaching and downward migration via superficial deposits	

6.8 Assumed construction practices

6.8.1 An outline CEMP has been developed, as presented in Appendix A2, to be secured through planning condition. This sets out requirements with respect to health and safety and pollution control and includes the requirement to develop:

- an action plan to deal with unexpected contamination;
- consideration for UXO mitigation measures identified within the detailed UXO risk assessment;
- where there is a potential risk of asbestos published guidance with respect to managing risk of asbestos in soil and made ground will be considered;
- a materials management plan to set out suitability for use criteria that are protective of both the water environment and human health; and
- an environmental monitoring plan and associated action plan to set out a system preventing detrimental impact on the water environment.

6.8.2 A number of assumptions have been made with respect to implementing legislation and good practice during construction as detailed in Section 6.6, which constitute design (embedded) mitigation. These include appropriate health and safety, materials management and pollution prevention systems applied during the works.

6.9 Embedded mitigation

6.9.1 The design of the proposed development has incorporated assessments in accordance with BRE Special Digest 1 on Concrete in Aggressive Ground to

determine appropriate concrete class selection for the proposed structures and infrastructure. This is presented in the Ground Investigation Report (enclosed in Appendix D4).

6.9.2 The design will consider appropriate ground gas protection measures identified through ground gas risk assessments completed for the proposed development as presented in the Ground Investigation Report (enclosed in Appendix D4). The protection measures will be designed in accordance with BS8485:2015 or equivalent.

6.10 Assessment of effects

Assessment of effects from construction on geology

6.10.1 Construction of the proposed development will require earthworks including placement of fill materials and excavation of soils, as detailed in Section 3. This will result in burying or removal of shallow superficial deposits. In addition, both driven and augered/bored piling and band drains are likely to be required to allow for construction of buildings, widened embankments and roads. These construction activities would primarily impact superficial deposits with an overall minor magnitude of impact.

6.10.2 No statutory designated sites of geological importance are located within the study area. However, the proposed development is located within an area of non-statutory designation of local geological importance (a Pill Du Geological Landscape Area, [GLA]) due to its value as a reclaimed marshland. Based on its local importance, the sensitivity of the geology is considered to be low. The proposed development will result in a partial loss of the GLA with a moderate adverse impact. Consequently, the proposed development is likely to have a ***slight adverse*** effect on geology. This is not considered significant and no further action is required.

Assessment of effects from construction on hydrogeology

6.10.3 Construction of the proposed development will require earthworks including placement of fill materials. This will result in consolidation of cohesive superficial deposits leading to a decrease in permeability. No impact on the underlying bedrock is anticipated. Considering that these deposits already exhibit relatively low permeability and are unlikely to allow for major groundwater flow, the effect of consolidation is likely to have a minor magnitude of impact on hydrogeology.

6.10.4 Introduction of piling and band drains have a potential to influence groundwater flows e.g. by creating preferential flow path. However, considering that there is currently limited groundwater flow within the superficial deposits, construction

works associated with either piling or band drains are likely to have a minor magnitude of impact on hydrogeological properties of these deposits.

6.10.5 It is proposed to lower the ground to 4.93m AOD in the south-western corner of the proposed development site. Groundwater monitoring completed within this part of the site indicated groundwater piezometric pressure of between 4.3 and 4.6 m AOD, which is below the base of the excavation. Where excavations to create new reens will be required these are likely to extend below the measured groundwater piezometric pressure, however due to the cohesive nature of the soils, no major groundwater inflows are expected. Similarly, any other shallow excavations (1-2m below ground level) like those associated with pile caps or underground utilities, may require excavations below the groundwater level, however also without major groundwater inflows. Therefore, overall no major de-watering (active lowering of groundwater level) during the construction works is likely to be required. Consequently, dewatering is considered to have a negligible magnitude of impact on groundwater flows.

6.10.6 The superficial deposits are classed as unproductive strata and therefore are considered to be of low sensitivity. Consequently, the proposed development is likely to have an overall ***neutral*** effect on hydrogeology. This is not considered significant and no further action is required.

Assessment of effects from construction on land contamination

6.10.7 The construction works would introduce new pollution linkages into the baseline conceptual site model. The revised conceptual site model and a generic qualitative risk assessment are detailed below.

6.10.8 The review of the identified potential sources of contaminants, receptors and pathways and plausible pollution linkages, as detailed in sections below, allows for assessment of the likely impacts of construction on land contamination.

Sources and Contaminants (Construction)

6.10.9 The potential baseline sources of contamination identified in relation to the study area are presented in Section 6.7 Baseline Environment, Land Contamination. The construction works would introduce the following additional sources as a result of construction activities:

- Areas of unexpected contamination that would be encountered and excavated as a result of construction works.
- Dust (also containing fibres) derived from areas of made ground exposed during construction (primarily the existing railway embankment and its vicinity).
- Groundwater removed as a result of de-watering of shallow excavations to either lower ground level or for utilities/foundations.
- Groundwater discharging from band drains due to ground consolidation.

- Surface water removed during works within the reens.
- Cement used to form piles/structures (subject to piling technique).

Potential Receptors (Construction)

6.10.10 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in relevant sections in Section 6.7 Baseline Environment, Land Contamination. The construction works would introduce the following additional receptors:

- Construction workers: It has been assumed that the construction workers include adults and also apprentices aged 16 and above.

Potential Pathways (Construction)

6.10.11 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 6.7 Baseline Environment, Land Contamination. The construction works would introduce the following additional pathways:

- Direct discharge of groundwater/surface water removed from ground/reen as a result of dewatering operations.
- Groundwater outflows generated as a result of surcharging works and discharge into the reens.
- Direct exposure to soils, groundwater or surface water, such as ingestion, dermal contact and/or inhalation of vapours/fibres, during excavation works.
- Surface run-off where made ground is exposed during excavation works.
- Escape of cement to groundwater or surface water during foundation construction including piling (subject to piling technique).
- Vertical migration of contaminants due to piling activities (subject to piling technique)
- Ground gas (methane) release from gas pockets potentially present within the organic alluvium/peat during deep foundations/band drains installation.

Plausible Pollution Linkages (Construction)

Human health

6.10.12 Construction workers have the potential to be directly exposed to soils and dust from exposed made-ground materials. Providing that health and safety measures are in place in accordance with current legislation and good practice, as assumed in Section 6.6, it is unlikely to pose a risk to construction workers. There is however an increased risk due to encountering unexpected contamination.

6.10.13 Encountering unexpected contamination during the works may also pose a risk to controlled water receptors as a result of mobilisation of contamination due to disturbance or exposure to rainfall. The outline CEMP (refer to Appendix A2) sets out minimum requirements with respect to a contingency plan for dealing with unexpected contamination. This will minimise the potential exposure to contaminants and impact on the environment.

6.10.14 During dry weather conditions, the proposed development may result in dust generation, which may migrate towards nearby residential and commercial areas. Dust from areas of made-ground may contain contaminants. Considering the distance from known areas of made-ground to the neighbours of the proposed development (at least 250m between the railway embankment and residential areas), the potential for major dust migration into the residential area is considered low.

6.10.15 Although the ground gas monitoring did not indicate significant generation of methane, there is a risk that isolated pockets of methane are intercepted during either inserting of piles or band drains. This may lead to a sudden gas release, which may pose a risk to immediate construction workers due to a risk of explosion.

6.10.16 Considering the low sensitivity of the construction works as an exposure scenario (short-term and temporary exposure) and a moderate magnitude of impact of encountering unexpected contamination prior to implementation of contingency plan, the effect on construction workers is likely to be ***slight adverse***. This is not considered significant and no further action is required.

6.10.17 The risk to construction workers from encountering isolated pockets of methane may have a major magnitude of impact with a ***slight or moderate adverse*** effect. This is considered significant and requires mitigation measures. These are presented in Section 6.11.

6.10.18 The nearby residents are of a very high sensitivity however the impact of migration of dust impacted by contaminants is likely to be negligible, with a potential ***slight adverse*** effect. This is not considered significant and no further action is required.

Controlled waters

6.10.19 Construction of the proposed development will require earthworks (including excavations, moving materials within the study area, temporary storage, backfill), which may result in contaminants mobilisation. This is due to increased exposure to rainfall and consequent increased rate of contaminants migrating via surface run-off into the reens network.

6.10.20 Major infiltration of water and/or contamination into the ground is unlikely due the relatively low permeability of the ground. The excavation works are also unlikely to extend into the bedrock therefore no impact on the bedrock aquifer is anticipated.

6.10.21 The majority of the reens currently present within the proposed development area will be backfilled. However, where these are retained, widening and/or redefining works are proposed. The reens to be incorporated into the development are located away from the areas of anticipated made-ground.

6.10.22 As stated in Section 6.6, the outline CEMP (as presented in Appendix A2) will set out requirements with respect to pollution control, which will minimise the impact from the surface water run-off. Therefore, the potential for impact from contaminants is considered to be low.

6.10.23 During the earthworks there may be a need to dewater the excavations. These are likely to be limited in extent. The removed water could be discharged to the wider site drainage, and potentially impact the receiving controlled water receptors. As stated in Section 6.6, it is assumed that such discharge will not have detrimental impact on the receiving water quality. Reference should be made to Section 5 Water Resources for discharge control in relation to silt management.

6.10.24 Activities associated with installation of piles and band drains may create a preferential flow path for contaminants downward migration. The piles are likely to be socketed into the bedrock. Therefore, there is a potential that the quality of groundwater contained within the bedrock aquifer may be impacted. This is subject to the selected piling technique and the impact is likely to be temporary and localised.

6.10.25 The band drains are likely to fully penetrate the superficial deposits. During the consolidation process water released through the band drains is likely to flow towards the ground surface and therefore downward migration is considered unlikely.

6.10.26 The proposed development is located within a sensitive setting with respect to controlled waters, with surface water receptors that are retained as part of the development being assigned very high value due to the SSSI designation, as detailed in Section 5 Water Resources. The bedrock aquifer has been assigned a medium sensitivity due to its designation as a secondary aquifer. The magnitude of impact of surface run-off containing contaminants from made-ground and of discharge of removed water from excavations (dewatering) or as a result of surcharging on reen quality is considered to be negligible, as discussed above, with a potential ***slight adverse*** effect. Potential impact on the aquifer quality due to the piling is considered to be of minor magnitude of impact with a ***slight adverse*** effect. These are not considered significant and no further action is required.

6.10.27 The assessment of effects on aquatic life is presented in Section 7 Biodiversity.

Assessment of effects from operation on geology

6.10.28 During operation there will be ongoing residual settlement of filled areas due to consolidation of the soft clays and peat. The residual settlement is expected to have a negligible magnitude of impact.

6.10.29 No statutory designated sites are located within the study area. However, the proposed development is located within an area of non-statutory designation of local importance (a Pill Du Geological Landscape Area, [GLA]) due to its value as a reclaimed marshland. Based on its local importance, the sensitivity of the geology is considered to be low. The proposed development will result in a partial loss of the GLA with a moderate adverse impact. Consequently, the proposed development is likely to have a ***slight adverse*** effect on geology. This is not considered significant and no further action is required.

Assessment of effects from operation on hydrogeology

6.10.30 During operation there will be ongoing residual settlement of filled areas due to consolidation of the soft clays and peat. The amount of consolidation will be less that that experienced during the construction phase and is expected to have a negligible magnitude of impact on the underlying hydrogeology.

6.10.31 During operation, piles and/or band drains may continue to influence groundwater flows although this is likely to have a minor magnitude of impact on hydrogeological properties of the superficial deposits.

6.10.32 The superficial deposits are classed as unproductive strata and therefore are considered to be of low sensitivity. Consequently, the proposed development is likely to have an overall ***neutral*** effect on hydrogeology. This is not considered significant and no further action is required.

Assessment of effects from operation on land contamination

6.10.33 The operational phase would introduce new pollution linkages into the baseline conceptual site model. The revised conceptual site model and a generic qualitative risk assessment are detailed below.

6.10.34 The review of the identified potential sources of contaminants, receptors and pathways and plausible pollution linkages (as detailed in sections below) allows for assessment of the likely impacts of construction on land contamination.

Sources and Contaminants (Operation)

6.10.35 The potential baseline sources of contamination identified in relation to the study area are presented in Section 6.7 Baseline Environment, Land Contamination. The construction works would introduce the following additional sources during the operation of the proposed development:

- Made ground exposed at surface in soft landscaped areas.

6.10.36 As detailed in Section 6.6, it has been assumed that any imported materials or materials from the proposed development excavations would be suitable for use and therefore not considered a potential source.

Potential Receptors (Operation)

6.10.37 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in relevant sections in Section 6.7 Baseline Environment, Land Contamination. The operation of the proposed development would introduce the following additional receptors:

- People who use the proposed development including workers of the business park and railway station, railway station users and visitors (general public): Considering the commercial setting of the proposed development, it has been assumed that these primarily would include adults and also apprentices aged 16 and above. Visitors and railway station users may include children, however considering exposure duration and frequency these receptors are not considered sensitive receptors in the applied scenario; and
- Maintenance workers.

6.10.38 In accordance with design mitigation presented in Section 6.8 concrete selection will consider the ground chemistry beneath the proposed development, therefore building fabric is not considered a potential receptor.

Potential Pathways (Operation)

6.10.39 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 6.7 Baseline Environment, Land Contamination. The operation of the proposed development would introduce the following additional pathways:

- Direct exposure to soils or dust/fibres (such as ingestion, dermal contact and/or inhalation);
- Inhalation of hydrocarbon vapours from soils and groundwater;
- Exposure to dust generated from the landscaped areas (such as ingestion, dermal contact and/or inhalation);
- Vertical ground gas migration along the piles/band drains towards the ground surface or into backfilled reens or new/existing service corridors and horizontal migration, and accumulation into confined spaces posing a risk of asphyxiation via inhalation and/or explosion. In accordance with design mitigation presented in Section 6.8, buildings will be equipped with appropriate ground gas protection measures and therefore no ground gas ingress is likely to occur;
- Leaching of contaminants;

- Surface run-off towards the reens;
- Vertical contamination migration along the piles/band drains towards the bedrock aquifer;
- Horizontal contamination migration along back-filled reens or service corridors (new or existing) towards the reens.

Plausible Pollution Linkages (Operation)

Human health

6.10.40 During dry weather conditions the end users of the proposed development may be exposed to dust (and potentially fibres) generated in areas of made-ground should it be exposed at the surface. This is likely to be a short-term exposure as the soft landscape areas of the proposed development are likely to be vegetated and maintained for the majority of the time. Considering the distance from known areas of made-ground to the neighbours of the proposed development (at least 250m between the railway embankment and residential areas), the potential for major dust migration into the residential area is also considered very low.

6.10.41 Maintenance workers however may be exposed to made-ground or vapours/fibres during intrusive works. However, providing that health and safety measures are in place in accordance with current legislation and good practice, as assumed in Section 6.6, is unlikely to pose a risk to the maintenance workers.

6.10.42 The introduction of piles and band drains beneath buildings may introduce preferential flow paths for ground gas migration towards the surface and into confined spaces. No ingress into the buildings is anticipated as the design will incorporate adequate protection measures. The gas may however migrate via back-filled reens and service corridors and accumulate in confined spaces e.g. manholes, potentially posing a risk to maintenance workers. This is however considered unlikely as the assessments did not indicate a significant gas generation and migration potential.

6.10.43 The ground gas monitoring registered detectable concentrations of VOCs within the ground atmosphere. No sources of VOCs have been identified. It is therefore presumed that these measurements are likely to be due to human or equipment error with further monitoring recommended. Until more data is available there remains a potential risk of exposure to these volatile compounds during operation as a result of vapour ingress into confined spaces, also posing a risk to maintenance workers.

6.10.44 Considering the medium sensitivity of the end users of the proposed development as for a commercial exposure scenario (albeit short-term exposure is most likely) and a moderate magnitude of impact of potential exposure to dust potentially containing contaminants above screening criteria, the effect on end users is considered to be ***moderate adverse***. This is considered to be a significant effect, which requires mitigation measures. These are presented in Section 6.11.

6.10.45 The risk to maintenance workers (with low sensitivity of exposure) from ground gas and vapour migration into confined spaces and accumulation may have a major magnitude of impact with a ***slight or moderate adverse*** effect. This is considered to be a significant effect, which requires mitigation measures. These are presented in Section 6.11.

6.10.46 The nearby residents are of a very high sensitivity however the impact of migration of dust impacted by contaminants is likely to be negligible, with a potential ***slight adverse*** effect. This is not considered to be a significant effect and no further action is required.

Controlled waters

6.10.47 The piles and band drains may introduce preferential flow paths allowing for downward migration of contamination towards the bedrock aquifer. Band drains would be required only in areas of fill. Considering the known areas of made - ground, only in the area along the existing railway embankment there is a potential for made-ground to be present beneath the fill. Made-ground may contain contaminants that leach if subjected to either rainwater or groundwater infiltration. It is however considered unlikely that a sufficient head of perched water would be present within the fill materials to allow for a downward flow of water within band drains. Therefore, band drains are unlikely to pose a significant risk to groundwater quality. Subject to the design and selected piling technique, piles may however allow for downward contamination migration albeit this is unlikely to be an issue in areas of Tidal Flat Deposits.

6.10.48 Where made-ground would be exposed at surface, increased rainwater infiltration may result in leachate generation and lateral migration or surface run-off towards the reens. The reens incorporated into the development are located away from the areas of anticipated made ground. Although there is a potential for the back-filled reens and new/existing service corridors to create preferential flow paths towards the reens, there is a potential for high dilution prior to discharge into the reens. Therefore, there is a relatively low potential for impact from contaminants on reen water quality.

6.10.49 The proposed development is located within a very sensitive setting with respect to controlled waters, with surface water receptors that are retained as part of the development being assigned very high value due to the SSSI designation, as detailed in Section 5 Water Resources. The bedrock aquifer has been assigned a medium sensitivity due to its designation as a secondary aquifer. The magnitude of impact of surface run-off containing leachable contaminants from made ground above the EQS and lateral migration of contaminates along the back-filled reens/service corridors on reen quality is considered to be minor with a potential ***moderate or large adverse*** effect. Potential impact on the aquifer quality in areas of made ground with no or little tidal flat deposits due to the piling is considered to be moderate with a ***moderate adverse*** effect. These are considered significant and require mitigation measures. These are presented in Section 6.11.

6.11 Mitigation and enhancement

6.11.1 This section describes the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.

Mitigation of effects from construction

6.11.2 The assessment of effects resulting from the construction activities identified generally neutral or slight adverse effects on either geology, hydrogeology or land contamination.

6.11.3 This is with the exception of a potential risk to construction workers with a slight or moderate adverse significance of effect due to encountering isolated pockets of methane during deep intrusive works like piling or band drain installation. This health and safety risk will require management during construction, as outlined in CEMP (presented in Appendix A2). This will ensure that health and safety risk assessments will consider available information on ground conditions and ground gas monitoring data and will inform identification of adequate mitigation measures e.g. implementing procedures to control and monitor exposure to ground-gas during any intrusive construction activities.

Mitigation of effects from operation

6.11.4 The assessment of effect resulting from the operation of the proposed development identified generally neutral or slight adverse effects on either geology or hydrogeology.

6.11.5 The proposed development has been identified to pose a potential risk with respect to land contamination issues. End users of the proposed development may be exposed to dust generated in areas of made-ground exposed in areas of soft landscaping with a potential moderate significance of effect. This dust may contain contaminants at concentrations posing a risk to human health as a result of a long-term exposure. The exposed areas of made-ground may also pose a risk to controlled waters as a result of increased rainwater infiltration with a moderate to large significance of effect. Therefore, any made-ground exposed within soft landscaped areas will require validation through sampling and laboratory testing and assessment of results against criteria for an appropriate end-use scenario or controlled water receptor. Should this indicate a potential risk, remediation measures would be required e.g. placement of clean materials at surface or removal of made-ground. This is to be undertaken during a detailed design stage and secured through a reserved matters planning application.

6.11.6 The risk to maintenance workers with a slight to moderate significance of effect due to potential ground gas/VOC vapours accumulation in confined spaces will require appropriate health and safety measures during maintenance works. In order to manage these risks, it is proposed that further monitoring be undertaken in advance of any works taking place on site. These measures can be assured through the use of a planning condition. As a minimum, all available information on ground-gas risk should be communicated through the Health and Safety file

and should inform the development of appropriate method statements. This should set out procedures allowing for control and monitoring of exposure to ground-gas during maintenance activities, where relevant.

6.11.7 Insertion of piles in areas of made-ground with no or limited Tidal Flat Deposits may present a risk to controlled waters with a moderate adverse significance of effect. This is subject to the selected piling technique, therefore a foundation works risk assessment would be required to ensure that an appropriate piling methodology is applied. This should be completed in accordance with published guidance primarily the Environment Agency's Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination. In addition, characterisation of made ground encountered during construction works to inform these assessments will be required. This is to be undertaken during a detailed design stage and secured through a reserved matters planning application.

6.12 Residual effects

6.12.1 The completed assessments of effects did not identify significant residual effects from the proposed development.

Residual effects from construction

6.12.2 The assessment of effect resulting from the construction activities including mitigation, as summarised in Section 6.13 below, identified generally neutral or slight adverse effects on either geology, hydrogeology or land contamination which are not significant.

Residual effects from operation

6.12.3 The assessment of effect resulting from the operation of the proposed development including mitigation, as summarised in Section 6.13 below identified generally neutral or slight adverse effects on either geology, hydrogeology or land contamination which are not significant.

6.13 Assessment summary matrix

Potential Effect	Receptor (s)	Sensitivity of Receptor	Magnitude (prior to mitigation)	Significance (prior to mitigation)	Mitigation	Magnitude (following mitigation)	Significance (following mitigation)
Effects from construction on geology							
Earthworks and piling	Superficial deposits	Negligible	Minor	Neutral	N/A	Minor	Neutral
Earthworks	Pill Du Geological Landscape Area	Low	Moderate	Slight	N/A	Moderate	Slight
Effects from construction on hydrogeology							
Earthworks and piling	Superficial deposits – unproductive strata	Low	Negligible	Neutral	N/A	Negligible	Neutral
Effects from construction on land contamination							
Unexpected contamination	Construction workers	Low	Moderate	Slight adverse	N/A	Moderate	Slight adverse
Ground gas	Construction workers	Low	Major	Slight or moderate adverse	H&S management	Minor	Neutral or slight adverse
Contaminated dust migration	Site neighbours - residents	Very high	Negligible	Slight adverse	N/A	Negligible	Slight adverse
Contaminated surface water run-off	Reens (SSSI designation)	Very high	Negligible	Slight adverse	N/A	Negligible	Slight adverse
Piling	Bedrock – secondary aquifer	Medium	Minor	Slight adverse	N/A	Minor	Slight adverse
Effects from operation on geology							
Development platform	Superficial deposits	Negligible	Minor	Neutral	N/A	Minor	Neutral
	Pill Du Geological Landscape Area	Low	Moderate	Slight	N/A	Moderate	Slight
Effects from operation on hydrogeology							
Development platform and piled foundations and band drains	Superficial deposits – unproductive strata	Low	Negligible	Neutral	N/A	Negligible	Neutral

Potential Effect	Receptor (s)	Sensitivity of Receptor	Magnitude (prior to mitigation)	Significance (prior to mitigation)	Mitigation	Magnitude (following mitigation)	Significance (following mitigation)
Effects from operation on land contamination							
Exposed made ground dust	End site users	Medium	Moderate	Moderate adverse	Made ground sampling and testing. Risk assessment. Remediation measures, if required.	Negligible	Neutral or slight adverse
Ground gas/vapours	Maintenance workers	Low	Major	Slight or moderate adverse	H&S management. Further monitoring to confirm VOCs levels.	Minor	Neutral or slight adverse
Contaminated dust migration	Site neighbours - residents	Very high	Negligible	Slight adverse	N/A	Negligible	Slight adverse
Exposed made ground surface run-off	Reens (SSSI designation)	Very high	Moderate	Moderate or large adverse	Made ground sampling and testing. Risk assessment. Remediation measures, if required.	Negligible	Slight adverse
Piled foundations	Bedrock – secondary aquifer	Medium	Moderate	Moderate adverse	Foundations works risk assessment; Made ground sampling and testing.	Minor	Slight adverse