9 GEOLOGY AND SOILS

9.1 Introduction

This chapter assesses the potential impacts on geology, geomorphology and soils arising from the construction and operation of the A487 Caernarfon and Bontnewydd Bypass Scheme. Consideration has also been given to potential land contamination constraints. The chapter has been prepared following the conclusions of the screening and scoping exercise in February 2015, the Preliminary Sources Study Report in February 2015, hydrogeological desk study and the Ground Investigation Report provided to inform the detailed design.

The geology, geomorphology and soils assessment is closely related to other assessments including Nature Conservation (Chapter 8), Materials (Chapter 10) Community and Private Assets (Chapter 13) and Road Drainage and the Water Environment (Chapter 14).

This chapter should be read in conjunction with the following reports:

- A487 Caernarfon and Bontnewydd Bypass: Preliminary Sources Study Report, WSP/Parsons Brinckerhoff, February 2015 (included in Volume 3, Appendix F1)
- A487 Caernarfon and Bontnewydd Bypass: Hydrogeological Desk Study, WSP/ Parsons Brinckerhoff, October 2015 (included in Volume 3, Appendix F2)
- A487 Caernarfon and Bontnewydd Bypass: Ground Investigation Report, WSP/Parsons Brinckerhoff, December 2015 (included in Volume 3, Appendix F3)

9.1.1 Study Area

The study area is defined as a 100m wide linear corridor extending from Llanwnda to the south west of Caernarfon through to Plas Menai to the north east of Caernarfon for a length of approximately 10km. This is consistent with the study area defined within the scoping report.

The topography of the surrounding area comprises gently sloping ground towards the coast influenced by the higher grounds of Snowdonia National Park located approximately 5km to the south east.

Volume 11, Section 3 of the Design Manual for Roads and Bridges (DMRB) does not specify a minimum study area distance for the assessment of impacts to geology and soils. However, the defined study area is considered to be consistent with best practice. Guidance contained within R&D Publication 66 ('Guidance for the Safe Development of Housing on Land Affected by Contamination', Environment Agency (EA)/National Housebuilding Council (NHBC)2008) states that off-site features within an area up to 250m from the site boundary should typically be considered within the hazard identification stage of site assessment.

9.1.2 Legislation and Policy Context

The planning policy documents and the legislative context in relation to the assessment of the environmental effects on the geology and soils are set out below in sections covering European, UK, National and Local Level policies. The list is not intended to be exhaustive but includes the main documents relating to the protection, preservation and, where appropriate, enhancement of the geological environment.

European Legislation & Policy

The EU Directives and guidance of particular relevance to the Scheme with respect to geology and soils are listed below:

- Water Framework Directive (2000/60/EC);
- Groundwater Directive (2006/118/EC);
- EU Thematic Strategy on Soils Protection 2006; and
- Waste Framework Directive 2008.

National Legislation & Policy

- The Contaminated Land (Wales) Regulations (2006) and amendment) 2012;
- Contaminated Land Statutory Guidance, Department for Environment, Food and Rural Affairs, April 2012;
- Environmental Protection Act 1990; and
- Planning Policy Wales edition 8, 2016;
- Groundwater Regulations (1998);
- Groundwater (England and Wales) Regulations 2009;
- Water Resources Act 1991 (SI 57) (as partly amended by the Water Act 2003).
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (SI 2003/3243);
- Waste Framework Directive (2008) as transposed via Waste (England and Wales) Regulations 2011; and
- The Landfill (England and Wales) Regulations 2002

Planning Policy Wales, Edition 8, Jan 2016 sets out the land use planning policies of the Welsh Government (WG) and is supplemented by 21 topic based technical advice notes (TANs).

- TAN 5 Nature and Conservation Planning 2009

TAN 5, September 2009 is a supplementary technical advice note to Planning Policy Wales, providing “advice about how the land use planning system should contribute to protecting and enhancing biodiversity and geological conservation”.

- Minerals Planning Policy Wales (MPPW) 2000

The MPPW recognises that extraction is not a permanent land use and restoration should be to a high standard and to a beneficial and sustainable after use. The key principle is to provide and safeguard mineral resources.

Local Planning Policy

The local policies relevant to the geology and soils assessment for the Scheme is detailed below, expressed in the Gwynedd Unitary Development Plan (UDP), 2001 - 2016.

- Developments Which Create Risk – Strategic Policy 5;

- Minerals - Strategic Policy 7; and
- Waste - Strategic Policy 8.

Specific natural resource policies that may be applicable to this Scheme are outlined below:

- Policy C11 - Safeguarding Mineral Resources;
- Policy C12 – Buffer;
- Policy C28 - Safeguarding Agricultural Land; and
- Policy C29 - Safeguarding Water Resources.

Additional Guidance

Further guidance documents relevant to geology, soils and contaminated land have been considered when completing this assessment:

- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5 Assessment and Management of Environmental Effects, August 2008;
- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11 Geology and Soils, June 1993;
- Guidance for the Safe Development of Housing on Land Affected by Contamination. R&D Publication 66. Environment Agency / National House-Building Council (NHBC). Volume 1. 2008;
- Contaminated Land Statutory Guidance, Welsh Government, WG19243, 2013;
- Contaminated Land Report (CLR) 11: Model Procedures for the Management of Land Contamination (Environment Agency and Defra 2004); and
- Contaminated Land Risk Assessment, A guide to good practice, CIRIA C552, 2001.

9.2 Assessment Methodology

This assessment will be undertaken in accordance with the principles of:

- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5 Assessment and Management of Environmental Effects, August 2008; and
- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11 Geology and Soils, June 1993.
- Highways Agency et al. (1995) DMRB Volume 4, Section 1, Part 7, HD73/95 Site Investigation for Highway Works on Contaminated Land.
- Highways Agency et al. (2008a) DMRB Volume 4, Section 1, Part 2, HD22/08 Managing Geotechnical Risk.
- British Standards Institute (2010) BS5930: Code of Practice for Site Investigations including Amendment 2, issued 2015.
- British Standards Institute (2013a) BS10175: Code of Practice for Investigation of Potentially Contaminated Sites.

- British Standards Institute (2013b) Eurocode 7 (BS EN 1997-1 & EN 1997-2) (British Standards Institution 2007) and all relevant Normatives.
- British Standards Institute (2013c) BS8576: Guidance on investigations of ground gas. Permanent gases and Volatile Organic Compounds (VOCs).
- Environment Agency and Defra (2004) Model Procedures for the Management of Land Contamination (CLR11). Welsh Government M4 Corridor around Newport Environmental Statement Chapter 11: Geology and Soils 11-6 March 2016
- CIRIA (1996) Construction Industry Research and Information Association R132: A Guide for Safe Working on Contaminated Sites.
- CIRIA (2007) Assessing risks posed by hazardous ground gases to buildings (C665).
- CIRIA (2014) Asbestos in soil and made ground: A guide to understanding and managing risks (C733).
- CL:AIRE (2011) The Definition of Waste: Development Industry Code of Practice v2.
- Interim Advice Note 125/09(W) (2010) Supplementary guidance for users of DMRB Volume 11 'Environmental Assessment.

In accordance with Part 11, Section 3 of the DMRB (Volume 11), this assessment comprises Stage 2 of the assessment. The objective at this stage is to identify the attribute importance of geology, geomorphology and soils, and the significance of potential effects upon them, to be taken into account when refining the Scheme. There is also a requirement to establish the potential for land contamination within the study area.

9.2.1 Value (Sensitivity) of Resources and Receptors

Environmental values have been assigned to receptors in accordance with the principles established in Volume 11, Section 2, Part 5 of the DMRB (2008). Consideration must also be given to the potential for any post-construction environmental effects, caused by remobilisation of contamination within the ground following disturbance during the construction process. An environmental value has therefore also been assigned to the potential land contamination receptors, as identified within the conceptual site model. Attribute importance definitions are established in Table 9.2.1.

9.2.2 Unexploded Ordnance

Unexploded ordnance maps produced by Zetica have been reviewed for the scheme area and there is a low risk (lowest possible classification) provided for the whole route and significant surrounding area.

Table 9.2.1: Defining Attribute Importance (Sensitivity) for Resources / Receptors

Value (Sensitivity)	Very High	High	Medium	Low	Negligible
Geology & Geomorphology	Very rare and of very high international, national and regional geological/geomorphological importance with no potential for replacement (e.g. designated sites of national importance including SSSI, active quarries and mining activities of national importance).	Geological or geomorphological features of national importance (SSSI)	Regionally Important Geological Sites (RIGS). Within a mineral resources safeguarded area.	No features of importance in close proximity	Of little local geological/geomorphological interest.
Soils	Soils of very high importance and rarity, international scale and very limited potential for substitution.	Good to excellent quality agricultural land	Poor to moderate quality agricultural land	Very poor quality agricultural land Made Ground, with little potential for farming use	Soils of very low importance and rarity, local scale.
Hydrogeology	Groundwater with a high quality and rarity on a regional or national scale with limited potential for substitution (e.g. principal aquifer providing potable water to a large population).	Groundwater with a high quality and rarity on a local scale with limited potential for substitution, or attribute with a medium quality or rarity on a regional or national scale with limited potential for substitution (e.g. aquifer providing potable water to a small population and/or large resource potential).	Groundwater with a medium quality and rarity on a local scale with limited potential for substitution, or attribute with a low quality and rarity on a regional or national scale with limited potential for substitution (e.g. secondary aquifer unit supporting abstraction for	Groundwater with a low quality and rarity on a local scale with limited potential for substitution (e.g. non-aquifer unit that does not afford protection to underlying water bearing units).	None
Surface Waters	European Community (EC) Designated Salmonid/Cyprinid fishery Water Framework Directive (WFD) Class 'High'	WFD Class 'Good' Major Cyprinid Fishery Species protected under	WFD Class 'Moderate'	WFD Class 'Poor'	None

	Site protected/designated under EC or UK wildlife legislation (SAC, SPA, SSSI, WPZ, Ramsar Site, salmonid water)/species protected by EC legislation.	EU or UK habitat legislation			
Contamiantion/ Construction Workers	Human health (High sensitivity land use scenario e.g. residential, public open space).	Sensitive receptor which is the reason for SSSI designation. Human health (Lower sensitivity land use scenario e.g. commercial, industrial, highway construction)	Receptor which is of regional importance.	Receptor which is of local importance.	Receptor with low importance and rarity.

9.2.3 Magnitude of Impacts (Change)

The magnitude of impacts and typical descriptors are detailed within table 9.2.2. They have been adapted from the Volume 11, Section 2, Part 5 of the DMRB (2008).

The magnitude of impact on agricultural land will depend on the amount to be lost due to the Scheme. Agricultural land use is discussed and developed further in Chapter 13. Areas of BMV have been adapted from DMRB, Volume 11, Section 2.

Table 9.2.2: Criteria for Assessing the Magnitude of Impacts

Magnitude		Typical Criteria Descriptors
Major	**Adverse**	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements; exposure to acutely toxic contaminants. Loss of soils resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements. Reduction of water quality rendering groundwater or surface water unfit to drink and/or substantial adverse impact on groundwater dependent environmental receptors. Greater than 100ha of BMV land.
	Beneficial	The proposals are very beneficial to the geological/hydrogeological environment/soils resource of the area.
Moderate	**Adverse**	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements; short-term exposure to contaminants with chronic (long-term) toxicity. Loss of soils resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, feature or elements. Reduced reliability of a supply at a groundwater or surface water abstraction source. Between 50 – less than 100ha of BMV land.
	Beneficial	There is moderate benefit to the geological/hydrogeological environment/soils resource of the area as a result of the Scheme proposals.
Minor	**Adverse**	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. Very minor loss or detrimental alteration to one or more characteristics, features or elements of soils. Non-measurable change to quality, level and flow. Between 20 - < 50ha of BMV land.
	Beneficial	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduce risk of negative impact occurring.
Negligible	**Adverse**	Very minor loss or detrimental alteration to one or more characteristics, features or elements. Less than 20ha of BMV land.
	Beneficial	Very minor benefit to or positive addition of one or more characteristics, features or elements.
No change		No loss or alteration of characteristics, features or elements; no observable impact in either direction.

9.2.4 Significant Effects

The approach to assigning the significance of effects relies on reasoned argument, professional judgement and taking on board the advice and views of appropriate

organisations" (DMRB Volume 11, Section 2, Part 5, August 2008). In order to aid the decision-making process, each potential impact has been assigned a significance category. The methodology for determining the significance of effect categories is detailed within Table 9.2.3.

Table 9.2.3: Arriving at the Significance of Effect Categories

		Magnitude of Impact (Degree of Change)				
		Major	**Moderate**	**Minor**	**Negligible**	**No Change**
Environmental Value (Sensitivity)	**High**	Large or very large	Moderate or large	Slight or moderate	Slight	Neutral
	Medium	Moderate or large	Moderate	Slight	Neutral or slight	Neutral
	Low	Slight or moderate	Slight	Neutral or slight	Neutral or slight	Neutral

Typical descriptors for effects are summarised within 9.2.4.

Table 9.2.4: Typical Descriptors of Effect

Significance Category	Typical Descriptors of Effects
Very Large	Only adverse effects are normally assigned this level of significance. They represent key factors in the decision making process. These effects are generally, but not exclusively, associated with sites or features of international, national or regional importance that are likely to suffer a most damaging impact and loss of resource integrity. However, a major change in a site or feature of local importance may also enter this category.
Large	These beneficial or adverse effects are considered to be very important considerations and are likely to be material in the decision making process.
Moderate	These beneficial or adverse effects may be important, but are not likely to be key decision-making factors. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse effect on a particular resource of receptor.
Slight	These beneficial or adverse effects may be raised as local factors. They are unlikely to be critical in the decision-making process, but are important in enhancing the subsequent design of the project.
Neutral	No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

9.2.5 Potential for Land Contamination

The potential for land contamination within the study area has been assessed in accordance with the principles of the Environment Agency report CLR11 ('Model Procedures for the Management of Land Contamination'). In the context of current UK Government guidance, qualitative risks on land contamination are to be assessed using a 'Source-Pathway-Receptor' methodology, where the following definitions apply:

- Source: potential source of contamination;
- Pathway: means by which contamination can reach and impact upon a receptor; and
- Receptor: that aspect which may be adversely affected by the presence of contamination.

Such an approach recognises that risks from Scheme-based contaminants can only exist where all three components are present, constituting a complete pollutant linkage. This approach forms the basis of the methodology used in this assessment.

Risks have been evaluated on a qualitative basis, in accordance with the methodology set out within CIRIA C552. This involves the classification of the magnitude of the potential consequence of the risk occurring, and the magnitude of the probability of the risk occurring. These classifications are then compared in order to determine the risk presented by each identified pollutant linkage.

The framework for determining the classification of consequence is detailed within Table 9.2.5. It is important to note that the 'severe' classification relates only to acute risks (arising from short-term exposure). The 'medium' classification relates to chronic harm (which may still be classified as 'significant harm' under Part 2A).

Table 9.2.5: Qualitative Risk Assessment – Classification of Consequence

Classification	Definition
Severe	Short term (acute) risks to human health, likely to result in significant harm. Short-term risk of pollution of sensitive water resource. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem.
Medium	Chronic damage to human health (significant harm). Pollution of sensitive water resources. A significant change in a particular ecosystem, or organism forming part of such ecosystem.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings/structures/services or to the environment.
Minor	Harm, not necessarily significant, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health. Easily repairable effects of damage to buildings, structures and services.

The framework for determining the classification of probability is detailed within Table 9.2.6.

Table 9.2.6: Qualitative Risk Assessment – Classification of Probability

Classification	Definition
High Likelihood	There is a pollution linkage and an event that appears very likely in the short term, and/or almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	It is probable that an event will occur. Whilst not inevitable, it is possible in the short term, and likely over the long term.
Low Likelihood	Circumstances are possible under which an event could occur, but it is not certain that (even over a long time period) such an event would occur.
Unlikely	It is improbable that an event would occur, even in the very long term.

Once the consequence and probability have been determined for a pollutant linkage, these can be compared to produce a risk category, ranging from ‘very high risk’ to very low risk’ within Table 9.2.7.

Table 9.2.7: Comparison of Consequence against Probability

		Severity			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very high risk	High risk	Moderate risk	Moderate / low risk
	Likely	High risk	Moderate risk	Moderate/ low risk	Low risk
	Low Likelihood	Moderate risk	Moderate/ low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	Very low risk	Very low risk

9.2.6 Regulatory/Policy Framework

The planning policy documents and the legislative context in relation to the assessment of the environmental effects on the geology and soils are set out below in sections covering European, UK, National and Local Level policies. The list is not intended to be exhaustive but includes the main documents relating to the protection, preservation and, where appropriate, enhancement of the geological environment.

European Legislation & Policy

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- Water Framework Directive (2000/60/EC);
- Groundwater Directive (2006/118/EC);
- EU Thematic Strategy on Soils Protection 2006; and
- Waste Framework Directive 2008.

National Legislation & Policy

- The Contaminated Land (England) (Amendment) Regulations 2012;
- Contaminated Land Statutory Guidance, Department for Environment, Food and Rural Affairs, April 2012;
- Environmental Protection Act 1990; and
- Planning Policy Wales 2016.
- Water Resources Act 1991 (SI 57) (as partly amended by the Water Act 2003).
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (SI 2003/3243); and
- The Landfill (England and Wales) Regulations 2000

Planning Policy Wales, Edition 8, Jan 2016 sets out the land use planning policies of the Welsh Government (WG) and is supplemented by 21 topic based technical advice notes (TANs).

- TAN 5 Nature and Conservation Planning 2009

TAN 5, September 2009 is a supplementary technical advice note to Planning Policy Wales, providing "advice about how the land use planning system should contribute to protecting and enhancing biodiversity and geological conservation".

- Minerals Planning Policy Wales (MPPW) 2000

The MPPW recognises that extraction is not a permanent land use and restoration should be to a high standard and to a beneficial and sustainable after use. The key principle is to provide and safeguard mineral resources.

Local Planning Policy

The local policies relevant to the geology and soils assessment for the Scheme is detailed below, expressed in the Gwynedd Unitary Development Plan (UDP), 2001 - 2016.

- Developments Which Create Risk – Strategic Policy 5;
- Minerals - Strategic Policy 7; and
- Waste - Strategic Policy 8.

Specific natural resource policies that may be applicable to this Scheme are outlined below:

- Policy C11 - Safeguarding Mineral Resources;
- Policy C12 – Buffer;
- Policy C28 - Safeguarding Agricultural Land; and
- Policy C29 - Safeguarding Water Resources.

Additional Guidance

Further guidance documents relevant to geology, soils and contaminated land have been considered when completing this assessment:

- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5 Assessment and Management of Environmental Effects, August 2008;
- Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11 Geology and Soils, June 1993;
- Guidance for the Safe Development of Housing on Land Affected by Contamination. R&D Publication 66. Environment Agency / National House-Building Council (NHBC). Volume 1. 2008;
- Contaminated Land Statutory Guidance, Welsh Government, WG19243, 2013;
- Contaminated Land Report (CLR) 11: Model Procedures for the Management of Land Contamination (Environment Agency and Defra 2004); and
- Contaminated Land Risk Assessment, A guide to good practice, CIRIA C552, 2001.

9.3 Baseline Conditions

The establishment of baseline conditions within the study area has been undertaken following a detailed review of the following documents:

- A487 Caernarfon and Bontnewydd Bypass: Preliminary Sources Study Report, WSP/Parsons Brinckerhoff, February 2015 (included in Volume 3, Appendix F1)
- A487 Caernarfon and Bontnewydd Bypass: Hydrogeological Desk Study, WSP/Parsons Brinckerhoff, October 2015 (included in Volume 3, Appendix F2)
- A487 Caernarfon and Bontnewydd Bypass: Ground Investigation Report, WSP/Parsons Brinckerhoff, December 2015 (included in Volume 3, Appendix F3)

Baseline information has also been cross-referenced with other applicable Chapters that comprise this Environmental Statement including:

- Chapter 8 (Nature Conservation);
- Chapter 10 (Materials);
- Chapter 13 (Community and Private Assets) and;
- Chapter 14 (Road Drainage and the Water Environment)

A ground investigation was undertaken in 2015. The aim of the investigation was to provide a baseline assessment of the ground conditions, establish existing levels of contamination and provide information to enable design of the necessary earthworks and structures required to construct the Scheme.

The investigation comprised a series of machine excavated trial pits, cable percussive boreholes and rotary cored boreholes. In-situ testing, as well as geotechnical and geochemical laboratory testing was undertaken. The analytical data was assessed to establish the baseline soil quality across the study area. Further details are provided in the Ground Investigation Report.

The following sources of information were also consulted:

- British Geological Survey (BGS), Sheet Sheet 118 and part of Sheet 105 Nefyn and part of Caernarfon, 2015, Scale 1:50 000; and
- British Geological Survey (BGS) North West Wales, Mineral Resources Map of Wales, 2010, Scale 1:100,000.
- British Geological Survey (BGS) Viewer for Scanned Hydrogeology Maps of the UK (http://www.bgs.ac.uk/research/groundwater/datainfo/hydromaps/hydro_maps_scanviewer.html) (accessed October 2015)

9.3.1 Ground Conditions

The following section summarises the baseline ground conditions associated with the study area, details of which are presented in the Preliminary Sources Study Report (PSSR) and Ground Investigation Report (GIR) in Volume 3, Appendices F1 and F3.

Made Ground

Whilst Made Ground is not shown on BGS mapping, it was encountered in localised areas throughout the site overlaying natural deposits. The areas of Made Ground encountered are detailed in Table 5.1 of the GIR Report (Volume 3, Appendix F3).

It should be noted that no Made Ground was encountered between Ch0 and approximately Ch4200. However, small localised areas may be present between these points and thus encountered during the construction phase.

Superficial Geology

Alluvium

Alluvium was anticipated in low lying areas and the flood plains of the Afon Gwtrfai, exclusively between Ch 1300 and 2050. Throughout this area, Alluvium was encountered from ground level underlying thin veneers of top-soil to a depth of approximately 5.50m below ground level. The Alluvium is described as dark brown, light bluish grey, slightly sandy, slightly gravelly clay with brown and greyish brown, slightly clayey, gravelly sand and dark grey mottled brownish grey, silty, sandy sub-angular to sub-rounded, fine to coarse mixed lithology cobble, boulders and gravel.

Glacial Deposits

The geological map associated with the area (Sheet 218 (Ref. 8), indicated that glacial deposits were likely to be present along the length of the proposed route. The geological map differentiates glacial deposits defined on their origin; Glaciofluvial and Glacial Till.

Although a differentiation has been identified in terms of the materials encountered based on the geological map, it should be noted that the glaciofluvial and Glacial Till deposits encountered during the ground investigation exhibit similar engineering properties and could be considered similar or identical materials in terms of engineering behaviour.

Glaciofluvial material deposited in en-glacial deposits from glacial outwash and streams were identified in four discrete locations along the route alignment in varying thickness and compositions. The deposits encountered do not reflect a common geomorphological source.

Glacial Till was the most prominent deposit encountered throughout the alignment during the ground investigation. The sediments were not uniform in thickness ranging from thin veneers of less than 1.00m to significant deposits up to 22.00m in thickness. Similar to the Glaciofluvial deposits their identification does not follow a geomorphological common source; this would be expected from a glacially dominated environment.

Generally, the material encountered comprises light brown, light grey and orangish brown, sandy slightly gravelly clays with frequent cobbles and brown, light grey clayey sand and gravel. The gravel is typically sub-angular to sub-rounded, fine to coarse, and of mixed lithologies.

Head

Head deposits were only encountered in one location (BH59) which is located on the steep northern embankments of the Seiont valley, Ch 5570. The material encountered, was 0.60m in thickness and is present as firm, brown, slightly sandy, slightly gravelly clay. The gravel is present as sub-angular to rounded fine to medium sandstone and siltstone.

It is presumed that the poorly sorted and poorly stratified material encountered would have been formed from localised slope processes, formed from either the solifluction and/or soil creep of the material from the higher ground to the north.

River Terrace Deposits

River Terrace Deposits were encountered in all boreholes located between Ch 5350 and 5500 and observed in borehole (BH) 51 to BH56 and TP47 to TP49. Exploratory locations are presented within the Drawings section of the GIR.

The River Terrace Deposits were encountered to a depth of approximately 2.70m below ground level and generally of uniform thickness. However, the full depth of the River Terrace Deposits was not proven in TP47 (where up to 3.70m was identified). The River Terrace Deposits are present as dark grey, very clayey sand and angular to sub-rounded quartzite, sandstone, rhyolite and shale gravel with cobbles of similar lithology.

Bedrock Geology

Solid geology was encountered in the majority of boreholes and some of the trial pits. The varied nature of the solid geology including faulting encountered throughout the alignment is discussed in Section 5 of the GIR and summarised in Table 9.3.1 below.

Table 9.3.1: Weathered and Solid Geology

Ch	Geological Unit	Encountered Exploratory Hole ID	Depths Encountered (m)	Typical Thickness (m)
0195	Pardam Tuff Formation (PTF)	BH01A	5.40	2.00
0520 – 0530	Weathered Fachwen Formation (Wfachwen)	BH04 BH05	12.00 – 15.00	3.00
	Fachwen Formation (FF)	BH04 BH05	13.00 – 15.00	Not proven
0850 – 0960	Weathered Fachwen Formation (Wfachwen)	BH06A BH07A	5.00 – 6.40	1.50
0850 – 0960	Fachwen Formation (FF)	BH06A BH07A BH08A	5.40 – 7.00	Not proven
1530 – 1550	Weathered Nant Ffancon Sub-group (WNF)	BH10A BH12A	17.50 11.50	Not proven
1810 – 2280	Rhyolite Breccia (RB)	BH14 BH15A BH16 BH17 BH18A BH19 BH19A BH20 BH21 BH22 BH23 BH24A BH25 BH26 BH27 BH28 BH29	2.70 – 6.50	Not proven
2920 – 8385	Weathered Nant Ffancon Sub-group (WNF)	BH35A BH37B BH39 BH40 BH41 BH43A BH43.01 BH43B BH43C BH43D BH44 BH45D BH46A BH50C BH51 BH52A BH53 BH54 BH55 BH56 BH58 BH59 BH60 BH61 BH62 BH63 BH67 BH68 BH68A BH72 BH73 BH74 BH76 BH77 BH78 TP39A TP489 TP49 TP54A	0.10 – 22.10	Not proven

Ch	Geological Unit	Encountered Exploratory Hole ID	Depths Encountered (m)	Typical Thickness (m)
		BH47 BH64A BH48 BH65 BH49 BH66		
9340 – 9520	Twt-Hill Granite (TWG)	BH85 BH85A BH85B BH86 BH87A BH88 BH89	0.20 – 9.20 (predominantly 0.20m)	Not proven

9.3.2 Geological Statutory and Non-Statutory Designations

There are no geological features designated as Sites of Special Scientific Interest (SSSI) located along the route alignment.

A Regionally Important Geological Site (RIGS) is present on the southeastern wall of the former Seiont Brickworks quarry site. It refers to the superficial deposits of sands and gravels overlying the bedrock only and is named Pen y Bryn RIGS.

The Afon Seiont Geological Site of Special Scientific Interest (SSSI) lies 0.63 km west of the Scheme. The SSSI has been designated since 1987 due to its geological qualities. The Afon Seiont main river is located along the Scheme and this connects the SSSI to the Scheme.

No non-designated sites of geological interest have been identified to date.

9.3.3 Mineral Extraction and Mining

No records of underground mining activity within the study area have been identified. The main source of mineral extraction in this area has been quarrying.

Seiont Caernarfon Quarry (Location: SH49366 61428 (see Site Location Plan) is a recognised BGS recorded mineral site and is the largest quarry in the area. The quarry is no longer active. During its operational period, the quarry extracted clay and shale from the Ordovician Ogwen Group and the clay was used for the production of brick. The boundary of the quarry falls within the boundary of the Scheme (an embankment is proposed within the current extent of the quarry boundary) although the majority of the quarry is located outside the extent of the Scheme.

There are several smaller disused quarries scattered throughout the area, however they are not located within the boundary of the Scheme. No records of the minerals extracted from these quarries have been found.

No evidence of minerals was encountered during the ground investigation.

9.3.4 Agricultural Land Quality

Full details on the agricultural land quality located along and within the vicinity of the Scheme is provided in Chapter 13 and copy of the Agricultural Classification Map for the area is including in Volume 3, Appendix J.1. A summary is provided below:

The Scheme is associated with 'predicted' Grade 2, Sub-Grade 3A and Grade 4 agricultural land. The majority of this is considered 'best and most versatile agricultural land' (BMV). Published Agricultural Land Quality (ALC) information shows the area associated with the Scheme to comprise 'undifferentiated Grade 3 and Grade 4' land.

Environmental Sensitivity (Sites of Special Scientific Interest (SSSIs) and other Designated Environmentally Sensitive Sites.

The nearest Environmentally Sensitive Area the Afon Gwyrfai valley that has been identified as a Site of Specific Scientific Interest (SSSI) and the river itself as a Special Area of Conservation (SAC). The river flows east to west and crosses the road alignment to the south of Bontnewydd. This SSSI and SAC are considered of high sensitivity.

Beyond that, the Menai Strait and Conwy Bay SAC lies 0.38km from the site. This SAC has indirect connectivity to the Scheme via a series of surface watercourses (Afon Carrog, Rhyd, Gwyrfai, Seiont and an unnamed watercourse to the north of the Afon Cadnant).

There are several other SACs located in the wider area although all are located >1km from the Scheme.

A detailed summary of ecological receptors including aquatic ecology and habitat is provided within Chapter 8 and a detailed summary of the water environment is provided in Chapter 14.

9.3.5 Hydrogeological Conditions

Full details of the hydrogeological conditions are described in the Hydrogeological Desk Study (Volume 3, Appendix F2).

A visual representation of the hydrogeology present in proximity to the scheme can be found within the Envirocheck Report, which is included as an appendix to the PSSR in Volume 3, Appendix F1.

Bedrock Geology – Hydrogeology

The bedrock hydrogeology associated with the Scheme is summarised below:

Table 9.3.2: Hydrogeological Conditions (Bedrock)

Bedrock Geology	Aquifer Classification	1:625,000 Bedrock Classification
Padarn Tuff Formation – Tuff – Felsic	Secondary A	Unnamed Extrusive Rock, Neoproterozoic – Felsic Tuff
Fachwen Formation – Siltstone & Limestone, Interbedded	Secondary B	Lower Cambrian Rock (undifferentiated) – Sandstone and Conglomerate, Interbedded
Nant Ffrancon Subgroup - Siltstone	Secondary B	Llanvirn Rocks (Undifferentiated) – Mudstone, Siltstone and Sandstone
Allt Lwyd Formation – Sandstone	Secondary A	Unnamed Igneous Intrusion, Ordovician to Silurian – Felsic-Rock
Unnamed Igneous Intrusion, Ordovician - Granite	Secondary B	

The majority of the route is underlain by Secondary B bedrock aquifers. The Environment Agency classifies Secondary A and Secondary B aquifers as follows:

- Secondary A – permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important base flow to rivers. These are generally aquifers classified as minor aquifer; and
- Secondary B - pre predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

The BGS Viewer for scanned hydrogeology maps of the UK provides the following additional information about the aquifer potential:

- Lower Cambrian Rocks (undifferentiated) – Low productivity aquifer. Highly indurated (hardened) rocks with limited groundwater in near surface weathered zone and secondary fractures;
- Llanvirn Rocks (Undifferentiated) – Low productivity aquifer. Highly indurated rocks with limited groundwater; and
- Unnamed Igneous Intrusion, Ordovician to Silurian – Low productivity aquifer. Small amounts of groundwater in near surface weathered zone and secondary fractures; rare springs.

In summary, there is limited resource potential with respect to bedrock aquifers.

Superficial Deposits – Hydrogeology

The majority of the proposed alignment is underlain by Glacial Till deposits which comprise sandy, gravelly clays and cobbles and clayey sand and gravel. Glaciofluvial deposits were encountered in four locations and Alluvium (present as matrices of sandy, gravelly clay) was encountered in low lying areas and in the flood plains of the Afon Gwyrfai. Superficial Head deposits were only encountered in one location and River Terrace Deposits were encountered in the flood plains of the Seiont Valley.

Corresponding aquifer types are provided in Table 9.3.3.

Table 9.3.3: Superficial Geology Information

Superficial Geology	Aquifer Classification
Glacial Till - Diamicton	Secondary A
Glaciofluvial Deposits	Secondary A
Alluvium (Gravel, Silt and Clay)	Secondary A
River Terrace Deposits	Secondary A

9.3.6 Groundwater Abstractions

Licensed Abstractions

The Envirocheck data indicates that there are no licensed groundwater abstractions present within the vicinity of the Scheme and that the Scheme does not lie within a Groundwater Source Protection Zone.

Potential Unrecorded Abstractions

Based upon the geology and hydrogeology it is considered likely that a number of small scale private abstractions (that may be active or inactive) exist within 300 m of the scheme area. Historically the area would not have had a piped supply of water and so property/landowners/farmer that were not located adjacent to a river or stream are likely to have sourced their water via a private well or by capturing spring flow. These water supplies would be fed from groundwater originating in the superficial deposits. It is considered unlikely that many deep abstractions would exist.

Over time, the introduction of a piped supply is likely to have rendered most water supplies obsolete although the properties are likely to have retained their wells.

In order to establish the potential number of unrecorded groundwater abstractions, a desk study review was completed; full details of this are presented in the Hydrogeological Desk Study (Volume 3, Appendix F2).

Full details of the desk study are presented in Volume 3, Appendix F1. To summarise, an extensive review of available information, including the Envirocheck report and information obtained following consultation with Natural Resources Wales and Gwynedd Local Authority was undertaken. Potential unlicensed abstractions were then plotted prior to completion of an abstraction survey. The results of the desk-based abstraction survey indicated features shown in Table 9.3.4 to be potentially present.

Table 9.3.4 Abstractions located within the vicinity of the Scheme

Location information	Wells	Springs	Boreholes	Dewatering Licences
Within 300 m and active	2	28	1	0
Within 300 m and retained as a back-up	5	3	0	0

Within 300 m and inactive or removed	30	13	1	3
Beyond 300 m	15	12	0	2
Total	**52**	**56**	**2**	**5**

A physical, on-site survey of all locations was then undertaken. The results indicate that, of the locations visited, there are a total of 31 wells, springs and boreholes which are currently in use and a further 8 locations which have the potential to be used and are retained as a back-up supply.

Groundwater Levels in Boreholes

Groundwater levels were recorded within boreholes during the works and during the period of post-works monitoring. Data indicates that groundwater levels vary across the Scheme from 0.39m b.g.l. (57.0m AOD) in BH70 to 17.65m b.g.l. (36.27m AOD) in BH83. In a number of locations along the Scheme, groundwater is expected to be very close to or at surface where superficial deposits are present.

9.3.7 Hydrological Conditions

Surface Water Features

The surface water features present within the vicinity of the Scheme are discussed in detail in Chapter 14.

Afon Carrog catchment

The Afon Carrog, a main river, is located 380m from the route alignment, with indirect hydraulic connectivity to the Scheme via a tributary. The catchment also includes various ditches and an unnamed tributary with direct hydraulic connectivity to the Scheme.

Afon Rhyd catchment

The Afon Rhyd is a main river located along the route alignment with direct hydraulic connectivity to the Scheme. The catchment also includes an ordinary watercourse (the Afon Plas) and various unnamed ditches that have direct connectivity to the Scheme.

Afon Gwyrfai catchment

The Afon Gwyrfai is a main river located along the route alignment with direct hydraulic connectivity to the Scheme. The catchment includes two further main rivers; The Afon Rhosdican located along the route alignment with direct connectivity to the Scheme and the Afon Bueno located 300m from the alignment with no connectivity. Various unnamed ditches that have direct connectivity to the Scheme, are also located within the catchment.

Afon Seiont catchment

The Afon Seiont is a main river located along the route alignment with direct hydraulic connectivity to the Scheme. Downstream of the Scheme buffer zone, The Afon Seiont is a designated SSSI (for geological reasons). The catchment also includes unnamed ditches that have direct connectivity to the Scheme.

Afon Cadnant catchment

The Afon Cadnant is a main river located along the route alignment with direct hydraulic connectivity to the Scheme. The catchment includes an unnamed tributary (a main river) of the Afon Cadnant with direct connectivity to the Scheme and various unnamed ditches that have no connectivity to the Scheme.

Catchments north of Afon Cadnant

Features within these catchments include unnamed watercourse that discharges to the Menai Strait that has direct hydraulic connectivity to the Scheme and unnamed ditches and watercourses with no connectivity.

Menai Strait

The Menai Strait is a SAC designated for its sandbanks, mudflats, sandflats, reefs, large shallow inlets, bays and caves and is located a minimum distance of 420m from the Scheme.

9.3.8 Surface Water Abstractions

Envirocheck data provided for the Scheme indicates that thhere are no recorded active surface water abstractions or discharge consents within 500m of the proposed alignment.

There are four active permitted surface water abstractions located in the wider Scheme area. These include an abstraction from the Afon Gwyrfai for use as effluent/slurry dilution, two abstractions from the Afon Seiont for use as process water and lake through flow and an abstraction from an old clay pit for use as process water.

There are known to be private water abstractions within the Scheme area although further detail on the sources and uses are unknown and, as such, have not been listed.

Further details on hydrological conditions and information with respect to flooding are discussed in Chapter 14.

9.3.9 Historical Development

Historical maps are provided in the Appendix B of the PSSR in Appendix F1. The historic development of the scheme is summarised for areas divided by Chainage in Table 9.3.5.

Table 9.3.5: Historical Development

Date	Southern section (Ch0000-3500)	Central section (Ch3500-6500)	Northern section (Ch6500-9700)
1880s to 1960s	The majority of the corridor is used as farmland. The Caernarfonshire Branch railway is present and runs south to north through Llanwnda and alongside Bontnewydd.	The majority of the area comprises farmland with small farms and holdings scattered throughout. Various brick works, mills and tanneries are opened and subsequently closed.	The majority of the area is farmland.
1976 to present	In the 1970s, minor residential development had taken place and a sewage works has been constructed 500m west of the proposed alignment at Ch1500. Few changes took place until 2006, when changes to transport infrastructure (highway changes and railway line re-construction) took place. Few changes have taken place since then until the present day.	A holiday park has opened (adjacent to the site at Ch5500). A refuse Tip in *Peblig Industrial Estate* adjacent closed. Road from Bontnewydd to Caeathro constructed and parts of old road widened (runs parallel to proposed alignment from Ch3500-Ch5500). By the 1990s, a large mill had opened in Peblig Industrial Estate. Cibyn Indsutrial Estate continued to expand throughout the 1990s and 200s and an abbatoir opened in 2006, adjacent to proposed alignment from CH5700 – Ch6500. No further changes took place to the present day.	Water works constructed near to Caerleon Tibot and Griffiths Crossing Industrial Estate has opened. By the 1990s, the Plas Menai National Water Centre Opened (350m north west of the proposed alignment at Ch9700). By 2000, the A487 trunck road from Port Dinorwic to Plas Menai had been constructed (adjacent to the northern extent of the proposed alignment at Ch9700). Few changes have taken place since then until the present day.

9.3.10 Recorded Landfill Sites

The alignment lies adjacent to a landfill located at Cibyn Industrial Estate and, whilst the proposed route itself does not cross directly over the area of the landfill, the facility does fall within the study corridor. Landfill waste was encountered in exploratory holes undertaken adjacent to the route during the ground investigation. Information below summarises the findings relating to landfill sites within the vicinity to the Scheme.

The central section (Ch3500-Ch6500) passes along the outskirts of two industrial estates, the Peblig Industrial Estate and the larger Cibyn Industrial Estate to the west of the Scheme. Located to the east of these industrial estates to the west of the proposed road alignment, are registered landfill sites adjacent the Afon Seiont. Located 500m to the west of the proposed alignment at Ch5000, the Envirocheck Report records Peblig Mill Tip, specifying it contains inert, industrial and household

waste. The usage of Peblig Mill has changed over the years from a flour mill to a woollen factory and then to a synthetic fibre mill. Peblig landfill site may contain the industrial waste produced from these workings.

Located adjacent to (but not on the alignment) the proposed alignment between Ch5700-6500, the Cibyn Industrial Estate contains two recorded licensed waste management facilities. The Envirocheck Report indicates that the Rhos Bodrual landfill, Grid Ref (250300, 362800) at this estate contains inert waste comprising builder's rubble, subsoil and domestic waste. This landfill site ceased to operate in June 1990. An earlier landfill (Pontrug landfill) located approximately 100m to the east of the Rhos Bodrual landfill ceased in 1987 and recorded to contain inert waste only.

The landfills described above are situated adjacent the Afon Seiont and partially above Secondary Aquifers, which are potentially water bearing. Any potential pollutant leakages from these landfills would migrate downstream from the original source. There is also the possibility of contamination migrating through groundwater in the underlying aquifers.

A smaller local authority landfill site is located in the vicinity of Plas Menai adjacent Parciau Farm. The Envirocheck Report indicates that the types of waste contained on this site are industrial waste and asbestos. This site is not in the immediate vicinity of the proposed alignment.

During the ground investigation, landfill material was encountered in BH68, BH68A and TP60 to depths between 1.2m b.g.l. in BH68 to the base of TP60 at 4m b.g.l. This comprised domestic and industrial waste including metal, glass, plastic, brick, concrete, fabric and ash. TP56A and TP56B also encountered waste including metal, glass, plastic, brick, concrete and steel to 1.4 and 2.4m respectively. TP56A and TP56B were located very close to the proposed culvert construction (construction number 112B).

9.3.11 Potential for Land Contamination

A geo-environmental assessment, associated with the results of the ground investigation, has been undertaken and this is presented in Appendix B of the GIR (which forms Volume 3, Appendix F3 of this Environmental Statement).

The geo-environmental assessment details the ground investigation rationale, presents all monitoring and laboratory test data and discusses the soil, gas and groundwater laboratory test results in the context of the encountered ground conditions and proposed Scheme. An updated risk appraisal and conceptual site model, detailing the applicable sources, pathways and receptors is included.

A summary of the geo-environmental appraisal is provided in the following paragraphs.

9.3.12 Potentially Contaminative Land Uses

The potentially contaminative land uses are summarised in Table 9.3.6.

Table 9.3.6 Potentially Contaminative Land Uses

Process/ Land Use	Location	Contaminant Groups Potentially Present on-site
Potential Made Ground associated with the existing roads and potential infilling of surrounding quarries	Along the route alignment in areas of existing road and surrounding the Scheme in various locations	Metals and metalloids, polycyclic aromatic hydrocarbons (PAHs), oil / fuel hydrocarbons, sulphates, asbestos, landfill gas, acids, ammonia.
Agricultural land	Along the route alignment	Hydrocarbons and lubricating oils associated with machinery and nitrates from fertilisers. Potential pesticides and herbicides.
Landfills (Inert, industrial, commercial, household, special waste, liquids or sludge wastes)	Historically located along the route alignment and adjacent to the Scheme, at various locations	Metals and metalloids, polycyclic aromatic hydrocarbons (PAHs), oil / fuel hydrocarbons, sulphates, asbestos, landfill gas, leachate, acids, ammonia.
Industrial land uses (tannery, mill, sewage works, brickworks)	Historically adjacent to the Scheme	Metals and metalloids, polycyclic aromatic hydrocarbons (PAHs), oil / fuel hydrocarbons, sulphates; asbestos.
The historic and current railway lines	Adjacent to the Scheme	Metals and metalloids, polycyclic aromatic hydrocarbons (PAHs), oil / fuel hydrocarbons, lubricating oils, creosotes, sulphates, asbestos.

9.3.13 Contamination Assessment: Soil Quality

The soil quality data was tested as part of the ground investigation completed in 2015 and has been assessed based on the Scheme's end use as a highway. The assessment confirms that contaminant concentrations, elevated above the relevant soil assessment criteria applicable to the Scheme, do not exist within the scheme corridor, with the exception of one single marginally elevated concentration of benzo(a)pyrene. However, it is understood that the sample location of the exceedance is located within an area of proposed future cut and thus would be removed as part of the site preparation and clearance works. As such, upon completion of construction and based on the available information, there would be no recorded soil contaminant concentrations that would exceed the relevant soil assessment criteria.

Based on the available information, the overall potential for soil contamination within the study area has therefore been assessed as low.

9.3.14 Contamination Assessments: Water

Details associated with the groundwater quality, including tabulated data and drawings showing sampling locations, are presented in the Ground Investigation

Report (Volume 3, Appendix F3) and summarised below. The available groundwater quality data has been compared to a number of nationally recognised screening criteria published by a variety of authoriatative bodies and for the purposes of this assessment the most stringent water quality standards that are listed in the Geo-Environmental Assessment were adopted for comparison of laboratory results and are referred to as the "Generic Assessment Criteria". Full details are provided in Appendix B of the GIR Report (Volume 3, Appendix F3).

A number of exceedances were recorded in BH68 and BH68A which are both considered to be associated with the landfill material encountered at this location similar to that seen in the soil analyses.

A limited number of exceedances were also identified in BH08, BH20, BH40, BH64 and BH67. A review of the borehole logs and visual and olfactory information does not indicate any source of contamination for locations BH08, BH20 and BH40. In addition, soil samples from these locations did not record elevated concentrations of any determinands. It is therefore considered that these theoretical exceedances are not representative of the surrounding ground conditions and may be contamination introduced locally during drilling which has not been effectively purged from the well before sampling.

The above may also be the case for BH64 and BH67, although these locations are hydraulically down gradient of the adjacent Industrial Estate which could act as a potential source of contamination.

Exceedances of Total PAHs were noted at all locations. These exceedances are however marginal in all cases with the exception of BH67, BH68 and BH68A. This may be as a result of the landfill.

In the case of aliphatics >C21-C35 which has also been noted in a number of locations, there is no source of contamination noted in the soil samples with the exception of those at the landfill. These are considered to be derived either from laboratory error or from contamination introduced during sampling or borehole formation which has not been suitably purged prior to sampling.

9.3.15 Ground Gas

Details of the gas monitoring assessment are presented in Volume 3, Volume 3, Appendix F3, Appendix B of the factual Ground Investigation Report. A summary is provided below.

Six rounds of gas monitoring were undertaken within selected boreholes, over a period of 10 weeks between July and October 2015.

A ground gas risk assessment was undertaken using the monitoring data in accordance with CIRIA C665 guidance which uses Gas Screening Values (GSVs) to assess the risks posed by ground gases to buildings. Whilst the development proposals associated with this highway scheme do not include proposed buildings, confined spaces associated with future man entry (including the underground chambers and service cabinets) are included as part of the design. Therefore, this approach to gas risk assessment is considered relevant.

Gas screening values (GSV) (l/hr) are calculated by multiplying the maximum borehole flow rate (l/hr) with the maximum gas concentration (%v/v). The calculation was carried out for both methane (CH_4) and carbon dioxide (CO_2) and the worst case

maximum concentrations were adopted. The 'characteristic situation', which has a corresponding risk classification, is then determined in accordance with the methodology presented in CIRIA C665.

53 out of the 61 boreholes monitored were classified as 'very low risk' (Characteristic Situation 1) with a few exceptions that remained fairly consistent over the six rounds.

BH68 and BH68A consistently recorded elevated concentrations of both methane and carbon dioxide but relatively low flow rates over the six rounds. Both boreholes consistently recorded a steady state flow of 0.1 l/hr after any initial peaks. Landfill material was encountered in both of these locations which is a likely source of these more elevated concentrations of methane and carbon dioxide.

High concentrations of gases were also recorded in BH43B. The gases were recorded within superficial deposits comprising gravelly clay and gas generation at this location is considered likely to be associated with natural sources.

It should be noted that the response zones associated with some of the boreholes were flooded at times during the period of monitoring and this may have restricted the flow rates and concentrations recorded during the works.

Notwithstanding the above, risks from hazardous ground gases associated with the ground conditions are considered to be low. Whilst the development proposals do not include construction of buildings, underground chambers and service cabinets that have the potential for man entry would be included across the scheme. As such, relevant risk assessments, including correct use of PPE associated with confined space entry should be carried out and implemented by personnel wishing to access these areas, especially those locations within the vicinity of the historical landfill.

9.3.16 Geotechnical Assessment

The laboratory test data associated with the potential aggressivity of ground conditions to concrete are presented in the GIR Report (Volume 3, Appendix F3). The concrete type used across the Scheme would be tailored to the ground conditions present to prevent risk of future attack. As such, risks associated with ground aggressivity would be minimal.

The construction of all earthworks and rock cuttings along the line of the A487 Caernarfon and Bontnewydd Bypass Scheme would be designed to an appropriate factor of safety to minimise the potential for slope instability. These profiles should maintain long term slope stability and obviate the need for direct, active slope stabilisation measures during construction.

9.3.17 Conceptual Site Model (CSM)

Using the information detailed above, the CSM has been refined. The CSM identifies potential contaminants, receptors and exposure pathways that may be present based on the assumption that the Scheme is to be a newly constructed road over areas of predominantly agricultural land and some existing highway pavement.

The identification of potential "pollutant linkages" is a key aspect of the evaluation of potentially contaminated land. An approach based on the UK CIRIA report C552 (Contaminated Land Risk Assessment: A Guide to Good Practice, 2001) has been adopted within this report. The methodology is presented in Appendix B of the GIR (Volume 3, Appendix F3).

The CSM has been refined and updated based on all available information and this is presented as Table 9.3.7. The CSM is based on end use as a public highway.

Table 9.3.7 Conceptual Site Model for the Proposed End Use as Highway (Post Ground Investigation and Construction)

Source	Pathway	Receptor	Risk	Comment
General localised areas Made Ground associated with previous land use	Direct Contact, Ingestion and Inhalation of Dust	End Users and Construction Workers	Very Low	***(Severity: Mild, Probability: Unlikely)*** The ground investigation did not record significant sources of contamination within the scheme corridor. Construction workers should utilise correct PPE.
	Infiltration and migration to underlying groundwater/surface water	Controlled Waters: Secondary A and B Aquifers, numerous watercourses in the area	Low	***(Severity: Mild, Probability: Low Likelihood)*** Generally low concentrations of substances recorded in the soils and groundwater means risks to controlled waters is currently considered to be low. Future development of the highway will result in increased areas of hardstanding, which will reduce infiltration and further reduce the risk.
Made Ground from the historic landfill (including domestic waste), and potentially infilled quarries: Contaminants may include metals, aromatic and petroleum hydrocarbons and generation of ground gas	Direct Contact, Ingestion and Inhalation of Dust	End Users and Construction Workers	Very Low	***(Severity: Mild, Probability: Unlikely)*** No substances recorded in excess of generic assessment criteria. Construction workers should utilise correct PPE.
	Infiltration and migration to underlying groundwater/surface water	Controlled Waters: Secondary A and B Aquifers, numerous watercourses in the area, potential unrecorded abstractions	Moderate/ Low	***(Severity: Medium, Probability: Low Likelihood)*** Generally low concentrations of substances recorded in the soils and groundwater means risks to controlled waters is currently considered to be negligible. Future development of the highway will result in increased areas of hardstanding, which will reduce infiltration and further reduce the risk to listed receptors.
	Migration of ground gas	Future maintenance and ground workers	Moderate/ Low	***(Severity: Medium, Probability: Low Likelihood*** Ground gas monitoring shows elevated levels of methane and carbon dioxide which have potential to accumulate in subsurface structures. Maintenance workers have the potential to be exposed to accumulation of vapours in these confined spaces. Appropriate mitigation measures including PPE will reduce this risk.

9.3.18 Sensitivity (value) of Potential Receptors

The significance of a project effect is a function of the environmental value (or sensitivity) of an environmental receptor and the magnitude of the potential change. Therefore, in order to determine the significance of an environmental effect, a value must be assigned to the appropriate receptors.

The following section considers the receptors likely to be most impacted at the construction and operational stages of the Scheme. The sensitivity has been determined using the descriptive scale offered within Table 9.4.

Geology and Geomorphology and Soils are the attributes against which impacts and effects will be assessed. All other receptors are considered in the context of existing contaminated land issues located along the site.

Attribute: Geology and Geomorphology

The geology along the Scheme is in part designated as a RIGS where it passes the former Seiont Brick Works Quarry. There are no further designations and RIGS is non statutory.

The sensitivity of this attribute is assessed as being **Medium.**

Attribute: Soils

The effects on agricultural land are described in detail within Chapter 13.

The Scheme would be associated with predicted Grade 2, predicted Sub-Grade 3A and predicted Grade 4 agricultural land. The majority of this is considered 'best and most versatile agricultural land'. Published Agricultural Land Quality (ALC) information shows the area associated with the Scheme to comprise land of undifferentiated Grade 3 and Grade 4.

The sensitivity of this receptor is therefore assessed as being High.

Contaminated Land Receptor: Groundwater

The aquifers beneath the Scheme have been classified as Secondary A and B aquifers. However, the Scheme would not lie within a Source Protection Zone.

The sensitivity of this receptor is therefore assessed as being Medium.

Contaminated Land Receptor: Surface Waters

Several main rivers (the Afon Rhyd, Afon Gwyrfai, Afon Seiont and the Afon Cadnant) flow through the route alignment and The Menai Strait (a SAC is located within 500m of the route alignment.

The sensitivity of this receptor is therefore assessed as being High.

Contaminated Land Receptor: Ecological Designations

The nearest Environmentally Sensitive Area would be the Afon Gwyrfai valley that has been identified as a Site of Specific Scientific Interest (SSSI) and the river itself as a Special Area of Conservation (SAC). The river flows east to west and crosses the road alignment to the south of Bontnewydd.

The sensitivity of this receptor is therefore assessed as being High.

Contaminated Land Receptor: The Built Environment

The Scheme is predominantly agricultural land at present, and would cross a number of A and B roads, and lanes. There are no buildings within the immediate area of what would be the Scheme corridor.

The sensitivity of this receptor is therefore assessed as being Low.

Contaminated Land Receptor: Construction Workers

The Scheme is considered to encompass extensive earthworks and therefore the sensitivity of this receptor is assessed as being High.

Contaminated Land Receptor: Existing and Proposed End Users

The sensitivity of the existing end users of the Scheme is considered to be Medium as there is currently a moderate exposure to the underlying soils, based on the land use being predominantly agricultural.

The sensitivity of proposed end users of the Scheme is considered to be Low as the Scheme would be predominantly a 'hard end use' with some landscaped areas (constructed with materials suitable for use); there would be little exposure to the underlying soils and geology.

9.4 Predicted Environmental Effects

A detailed description of the proposed construction of the Scheme is included in Chapter 2. To summarise, for the purposes of this chapter, the Scheme is a new construction located through current areas of agricultural land and which would involve the construction of embankments and cuttings along the route alignment.

The potential environmental effects are associated with the initial Scheme preparation, groundworks and general construction activities. The operational phase includes use as a public highway.

9.4.1 Scheme Preparation and Construction

Site preparation and construction works would comprise site clearance, groundworks including cuttings, earthworks and installation of culverts and underground services prior to construction of the key infrastructure.

Earthworks

The earthworks for the Scheme would re-use material excavated from site and Caernarfon quarry in embankments, false cuttings and re-graded landscaping areas.

The Scheme will be constructed via a combination of cut and fill earthworks using site won and imported material. Embankments will be formed using approximately 739,200m^3 of general fill, of which approximately 74,020m^3 will be imported and sourced locally where practicable. The remaining 665,180 m^3 will be site won.

Total material excavated from the route of the Scheme and quarried adjacent to the Scheme boundary is approximately 1,173,530 m^3 including topsoil and rock fill. Most of this material (877,390m^3) will be used by the Scheme as fill and aggregates for roads and structures. The remaining 296,140m^3 will include topsoil and geotechnically material. The topsoil (136,130m^3) will be used for reinstating the side slopes and remaining 160,010m^3 of geotechnically unsuitable material will be taken off site and placing in a local tip. Low nutrient soil is preferred for reinstatement to encourage a diverse sward of wildflowers. Exisitinfg topsoil is high nutrient content, but it is expected this will reduce with excavation and mixing with subsoil during stockpiling, but should be tested (with further potential blending with low nutrient soils) prior to reuse.

The following section describes the predicted effects upon geological and geomorphological features and soil quality within the study area as a result of the construction and subsequent operation of the Scheme. Constraints resulting from existing soil conditions have been identified and impacts have been assessed assuming the implementation of confirmed mitigation measures. The magnitude of impacts has been determined using the descriptive scale offered within Table 9.2.4.

9.4.2 Construction Phase

Attribute: Geology and Geomorphology

Whilst the construction phase will include construction of embankments and also include areas of cut, these works will not result in any significant geological or geomorphological change.

Where the route passes the former Seiont brick works quarry, the Pen-y-Bryn RIGS site will be affected by the proposed scheme dependant on the exact alignment of the road as it passes the quarry. Some of the exposure should however remain.

There is an opportunity within the proposed cut at Plas Menai (Ch9060 to Ch9700) to enable geological structures comprising a graben and fault feature to be visible in an area of limited geological exposure and where few if any graben structures are exposed. If exploited a regional area of geological educational significance (RIGS) may be created.

On balance a **Minor beneficial** change can be predicted for the Plas Menai cutting and a **Minor adverse** change can be predicted on the Pen-y-Bryn RIGS site. The significance of the effect on geology and geomorphology (low sensitivity) is considered **Neutral.**

Attribute: Soils

Approximately 13.8 ha of predicted Grade 2, 13.2 ha of predicted Sub-Grade 3A and 10.4 ha of predicted Grade 4 agricultural land would be likely to be affected by the Scheme. The majority of this is considered ‘best and most versatile agricultural land’. Published Agricultural Land Quality (ALC) information shows the area affected by the

Scheme to comprise land of undifferentiated Grade 3 and Grade 4. Twenty-two farm and land-based rural units would be directly affected.

During the construction phase, site clearance involving vegetation removal and soils stripping would take place, followed by earthworks to create required ground levels. Land take during construction would involve permanent loss of agricultural land. Construction activities with the potential to cause an adverse effect on ALC and loss of agricultural land are vegetation removal and the stripping of topsoil and subsoil.

Chapter 13 discusses the magnitude of impacts associated with agricultural land and soil resources in detail. To summarise, soil stripping and storage would cause a loss of soils within the construction area and a loss of land with potential for agricultural use. This would affect best and most versatile (BMV) agricultural land and some non-agricultural land.

Based on the descriptive scale, the magnitude of the impact would be Moderate Adverse. The significance of effect would be Large or Moderate Adverse.

Contaminated Land Receptor: Controlled Waters

Impacts and effects associated with controlled waters are discussed in Chapter 14.

Contaminated Land Receptor: Groundwater

During the construction phase of the Scheme, there would be the potential for the creation of new migratory pathways for contamination both inside and outside of the main construction area. However, baseline soil quality data does not indicate the presence of elevated contaminant concentrations within the study area, relative to background, and groundwater quality is not expected to be impacted by land contamination during the construction of the Scheme. No Change is predicted, therefore the significance of the effect on groundwater (medium sensitivity) is Neutral.

Contaminated Land Receptor: Surface Waters

During the construction phase of the Scheme, there would be the potential for the mobilisation of soil contamination, which could impact on surface waters. However, baseline soil quality data does not indicate the presence of elevated contaminant concentrations within the study area, relative to background. Surface water quality would not expect to be impacted by land contamination during the construction of the Scheme. No Change is predicted, therefore the significance of the effect on surface waters (high sensitivity) is Neutral.

Contaminated Land Receptor: Ecological Systems

During the construction phase of the Scheme, there is the potential for the mobilisation of soil contamination, which could impact on ecological receptors within the study area. Baseline soil quality data does not indicate the presence of elevated contaminant concentrations within the study area, relative to background. However, site run off with elevated suspended sediment loads is a risk common to all earthworks schemes. The magnitude of impact is considered Minor Adverse; therefore, the significance of the effect on ecological systems (high sensitivity) is Slight or Moderate Adverse.

Contaminated Land Receptor: Built Environment

Chemicals that are destructive to concrete have the potential to constrain the design of the Scheme corridor. The chemicals most likely to attack concrete are sulphates and acids. However, any aggressive ground conditions along the Scheme corridor would be identified in the Ground Investigation Report and concrete and structure designed accordingly. Therefore No Change is predicted and the significance of effect Neutral.

Ground gas has been assessed as a predominantly low to very low risk, however there were two areas of the Scheme considered as a moderate risk. Ground gas migrates and can accumulate within subsurface structures, including utility corridors and culverts. The built environmental may be impacted by ground gas during the construction of the Scheme. The magnitude of impact is considered Minor Adverse and significance of effect Slight Adverse.

Contaminated Land Receptor: Construction Workers

There is the potential for adverse impacts to health due to oral, inhalation or dermal contact with potential contaminants within soils during any ground disturbance. Baseline soil quality data does not indicate the presence of elevated contaminant concentrations within the study scheme that would potentially pose a risk to construction workers. Excavation works and materials handling associated with construction of the site would create the potential for adverse impacts to the health of construction workers, by the generation of soil derived dusts therefore the magnitude of impact is considered Negligible Adverse.

The existing soil conditions are not anticipated to negatively impact upon construction workers as a result of the construction phase of the Scheme. The significant of effect is assessed as Slight Adverse.

Contaminated Land Receptor: End Users

There is the potential for adverse impacts to health due to oral, inhalation or dermal contact on existing land users during any ground disturbance. Baseline soil quality data does not indicate the presence of elevated contamination concentrations within the study area that would potentially pose a risk to existing land users. Therefore, the magnitude of impact is considered Negligible Adverse. The significance of effect is assessed as Slight Adverse.

9.4.3 Operational Phase

Attribute: Geology and Geomorphology

Attribute: Soils

There is a RIGS designated site present at the former Seiont brick works quarry which will be affected by the proposed scheme. However, an exposure will be created in the northern section of the scheme and therefore, the operational phase of the Scheme is not anticipated to result in an impact to these attributes overall. No Change is predicted. The significance of the effect on geology is Neutral.

Agricultural land of moderate to good quality has been identified across the scheme. The area of agricultural land affected by the Scheme would not be able to continue. Moderate adverse impacts have been identified during the construction phase of the scheme, associated with land take of the existing fields. During the operational phase of the scheme, a potential increase in vehicle emissions may result in an adverse

impact on soil quality along the periphery of the scheme. Negligible Adverse change is predicted. The significance of the effect is Slight Adverse.

Contaminated Land Receptor: Controlled Waters

Adverse impacts associated with the potential mobilisation of soil contamination are only likely to occur during the construction phase of the Scheme. There are not anticipated to be any adverse or beneficial impacts to groundwater quality during the operation phase of the Scheme as a result of land contamination. Potentially contaminated ground has not been identified within the study area. Therefore, impacts associated with ground improvement works are not anticipated. No Change is predicted with a Neutral significance of effect.

Contaminated Land Receptor: Surface Waters

There are not anticipated to be any adverse or beneficial impacts to surface water quality during the operation phase of the Scheme as a result of land contamination. No Change is predicted with a Neutral significance of effect. Further information about surface waters is contained within Chapter 14 - Road Drainage

Contaminated Land Receptor: Ecological Systems

Adverse impacts associated with the potential mobilisation of soil contamination are likely to occur during the construction phase of the Scheme. There are no anticipated impacts to ecological systems during the operational phase of the Scheme as a result of land contamination. Therefore, the magnitude of impact is considered No Change and the significance of effect Neutral. Further information about ecological systems is contained within Chapter 8 - Nature Conservation.

Contaminated Land Receptor: Built Environment

Aggressive ground conditions have the potential to cause adverse impacts during the operational phase of the Scheme by damaging and reducing the design life of structures. However, the specific design conditions will be detailed in the GIR to prevent any future maintenance. The magnitude of impact therefore is considered No Change and the significance of effect Neutral.

Contaminated Land Receptor: End Users

The existing soil quality data indicated one minor elevated contaminant concentration of benzo(a)pyrene within the Scheme corridor. The only plausible exposure pathway which would expose future end users to potential sources of contamination along the Scheme are associated with the increased potential for fuel spillages leading to direct pathways to pedestrians and cyclists. The impact is considered Negligible Adverse. The significance of the effect is assessed as Neutral.

Contaminated Land Receptor: Topsoils and subsoils

Pollution of soils immediately adjacent to the carriageway due to traffic containaing heavy metals, polyaromatic hydrocarbons, de-icing salts and airbourne pollutants. The impact is considered Negligible (adverse). Thesignificance of the effect is assessed as Neutral.

9.4.4 Assessment of Cumulative Effects

The assessment of cumulative effects with other proposed developments is provided in Chapter 15 of this ES.

9.5 Proposed Mitigation

9.5.1 Construction mitigation

With respect to ground conditions there are certain embedded mitigation measures that will address and mitigate against potential ground condition-related effects.

Relevant Best Practice Documentation and Working Practices

All proposed works will be carried out in accordance with the following documents:

- *Health and Safety in Construction, HSE, 2006.* This document establishes the key principles to take into account when designing and implementing work on contaminated sites, in order to ensure the proper protection of the health and safety of employees and others who may be affected by such work; and
- *A Guide to Safe Working on Contaminated Sites, R132, CIRIA, 1996*. This document includes checklists to help in the preparation of health and safety risk assessments, the development of safe working practises, etc.
- *Health and safety in construction HSG150, 2006*

Other mitigation, considered to be 'embedded' in the design and construction of the Scheme includes:

- The adoption of good working practices, such as security measures to prevent access to the general public during construction works and minimise nuisance to site neighbours;
- Preparation of general construction-related best practice documents (including site waste management plans, health and safety plans and environmental management plans). Such documents will contain methods and procedures to manage construction related environmental risks.

The Construction Environmental Management Plan (CEMP), Materials Management, Aftercare Plan, Maintenance Environmental Management Plan and Environmental Masterplan

A Scheme-specific CEMP will be developed for the Scheme and this will contain details of the Scheme-specific mitigation.

The CEMP is a live document that will be continually updated in consultation with the Statutory Environmental Bodies (SEBs) although some of the licences method statements and draft Register of Commitments (ROC) that would form part of the CEMP have been developed already. The ROC will be developed further in the future and may include additional commitments associated with the outcomes of consultation with the landowners, the SEBs and other stakeholders and commitments made during the public inquiry. Typically, the CEMP will include procedures for managing the earthworks during the cut and fill activities such as stockpile control. The CEMP will also set out procedures to mitigate against sediment run-off associated with the stockpiling of soils, will set out waste storage areas and relevant permitting regulations and mitigation plans. The CEMP will also make consideration

for the potential effects of a pollution incident from a spillage, refuelling or other construction activity and put in place measures to be enacted in such a case

All materials that are to be re-used in the Scheme will need to be done so in accordance with a relevant environmental permit/Materials Management Plan. Site-specific re-use criteria will require derivation by a suitably qualified person and these will apply to any soils that are proposed for re-use to ensure that the materials do not represent a risk to human health and the wider environment. The derivation of such criteria and adherence to this process will in turn will mitigate many of the risks associated with the presence of potential contamination in the ground and contact with construction works/end users.

The main impact of the scheme will be associated with soil stripping and stockpiling. Construction mitigation measures that are likely to apply include:

- Careful stripping of topsoils (using suitable soil handling equipment);
- Storage of soils in temporary low stockpiles, protected from contamination by other materials and sown with grass if being stored for more than 6 months;
- Spreading of topsoils only on subsoils that have been de-compacted;
- No repetitive handling of soils;
- The use of bunds to prevent run-off, including silt, entering watercourses;
- Design of runoff control features to minimise soil erosion;
- The use of appropriate structures at culvert outlets to prevent erosion;
- Clean and maintain drainage ditches and culverts on a regular basis;
- The use of regular inspection to assess effectiveness of and the maintenance requirements for erosion and sediment control systems.

It is understood that the current Aftercare Management Plan is to be implemented by the Contractor for 5 years following completion of the design works. The plan includes measures including protection management and maintenance of existing retained vegetation together with new planting and seeding. It also includes habitat creation areas and procedures for monitoring compliances and reporting on completion and establishment of measures during the aftercare period.

A Maintenance Environmental Management Plan will also be implemented which will set out a proposed strategy for the future maintenance and management of all Environmental Areas to cover a period of 10 years.

The environmental mitigation measures proposed are illustrated on the Environmental Masterplan. Specific landscape integration measures, including the proposed planting of native species, woodland species, woodland planting and retention of existing vegetation, would exhibit a binding effects and, in some areas, would offer canopy-style protection to soils. Incorporation of such measures would therefore reduce the effects of soil stripping and erosion associated with run-off that could otherwise offer if the soils were to be left exposed. The creation of balancing ponds would also serve to reduce the effects of infiltration and thus mitigate against the effects of soil stripping and erosion.

9.5.2 Potential Contamination

During the construction there is potential that previously unidentified contamination is encountered during earthworks. This material should be chemically tested and assessed against derived criteria (completed during the ground investigation) before being removed or remediated.

Any soil arisings that have visual or olfactory evidence of contamination will be stored on a bunded sheeted stockpile on hardstanding or in a covered skip.

If shallow groundwater is encountered during the earthworks, suitable consideration should be given for the storage and disposal of groundwater from any likely dewatering activities that may be required.

Suitable drainage design including the provision of filter drains, wetlands and detention ponds will provide a high degree of treatment to surface water runoff from the road prior to infiltration or discharge, in accordance with the recommendations of the Draft National Standards for Sustainable Drainage.

The aggressivity of the soils is as determined within the Ground Investigation Report, recommending the concrete type to be used which will be included in the detailed design and implemented during construction works.

Risks to construction workers during the construction phase of the Scheme will be mitigated by the correct implementation of Health and Safety measures, such as suitable working methods and the correct use of personal protective equipment. These will be developed as part of the Construction Environmental Management Plan for the Scheme. For further guidance, reference should be made to the Health and Safety Executive document EH40 'Workplace Exposure Limits'. The protective measures are considered standard practice and should include the following:

- Selection of appropriate PPE (e.g. gloves and overalls);
- Implementation of best practice procedures such as washing hands before eating, no eating in the work area;
- Clear signage of contaminated land if encountered; and
- Adequate site security is required to prevent trespassers gaining access to the Scheme corridor during the construction phase.

Private Abstractions

During construction there is the potential that operations will impact on identified groundwater wells and springs. To be able to monitor any impacts on these attributes a monitoring programme is required.

A total of 33 locations comprising 5 wells, 27 springs and 1 borehole may be affected by the proposed construction. To protect and observe any impact from the proposed scheme, a monitoring programme for these locations should be put in place prior to the start of construction to establish a baseline data set of a minimum of 3 rounds of data retrieved quarterly. They should continue to be monitored throughout and post construction on a quarterly basis to include three rounds post construction.

Monitoring should in brief comprise the following:

A visual inspection and estimation where possible of spring flow rates;

A visual inspection and comments on the quality of abstracted water or spring water;

Groundwater sampling where there is sufficient flow to allow samples to be retrieved; and

Photographs of each source will also be collected during each monitoring round.

Sampling should include in-situ testing of physiochemical properties and retrieval of samples for laboratory analysis. Laboratory analysis should include the following as minimum:

- Biological Oxygen Demand;
- Hardness filtered as CaCO3
- Nitrite and nitrate,
- pH
- Metals;
- Total Petroleum Hydrocarbons (Total);

Should peat be encountered during construction, it is recommended that the likely extent be investigated and appropriate measures taken to ensure that it is not adversely affected by the scheme.

9.6 Residual Environmental Effects (following mitigation)

9.6.1 Construction Phase

Following the implementation of mitigation measures along with best practice during construction, residual impacts to geology and soils are considered to be Minor Adverse to Slight Beneficial, with an overall impact significant to all receptors of Slight Adverse to Neutral.

9.6.2 Operational Phase

Following the implementation of mitigation measures along with best practice during construction, residual impacts to geology, soils and hydrogeology are considered to be Negligible to No Change with an overall Neutral significant of effect on all receptors.

9.6.3 Significant Effects

No significant effects to geology, geomorphology or soils have been identified during the construction or operational phases of the Scheme. There are no land contamination-related constraints on the Scheme.

9.7 Summary and Conclusions

An assessment of the potential impacts associated with construction and operational phases of the Scheme has been undertaken in relation to geology and soils (including land contamination). The assessment identified potential effects that the Scheme may have on geology and soils within the Scheme corridor and surrounding area. Mitigation measures have been proposed to minimise the scale of the impacts identified where necessary.

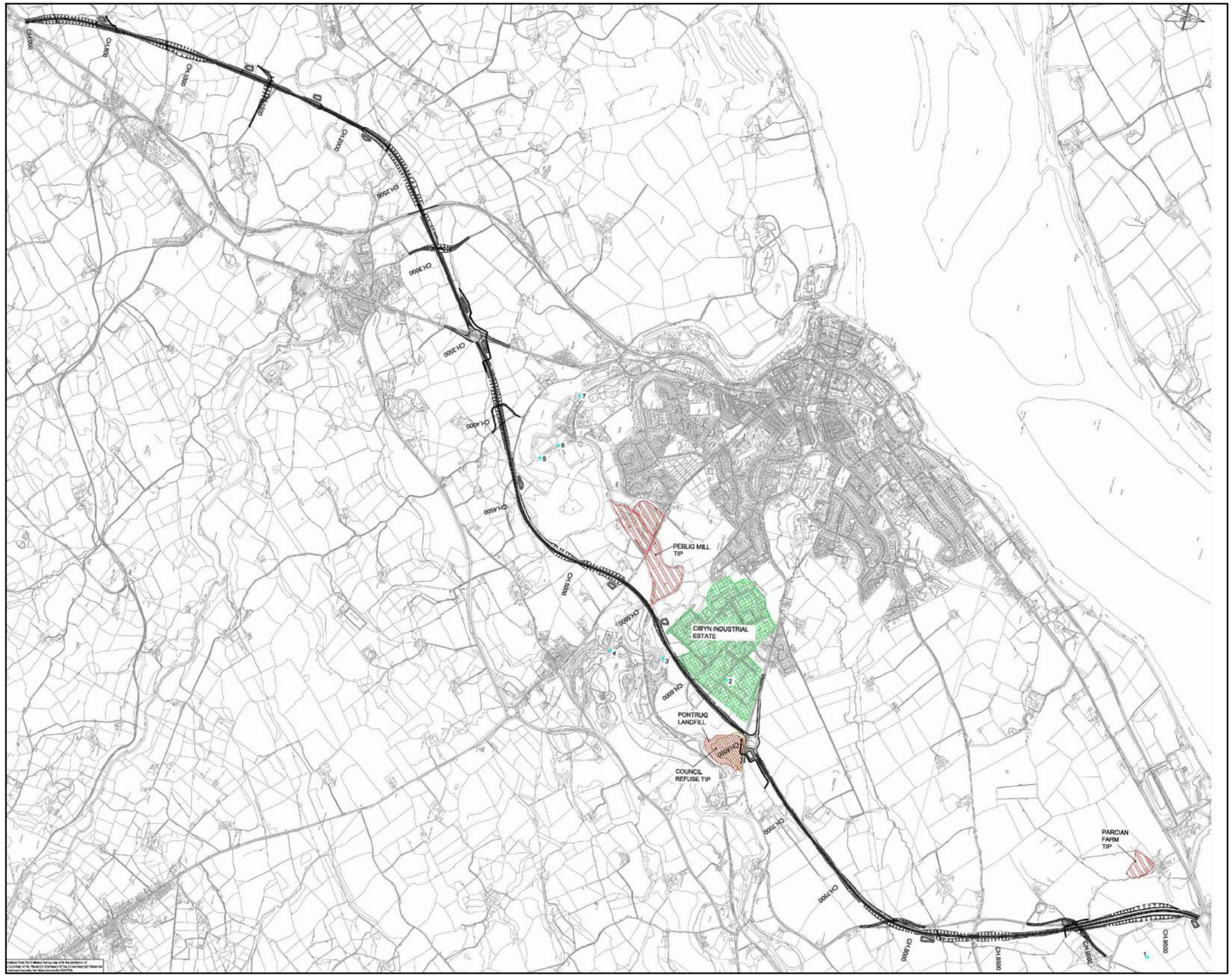
The ground investigation identified one minor exceedance of benzo(a)pyrene in one location across the whole Scheme. Made Ground was only encountered in areas of existing road. The Scheme is underlain by Secondary A and B aquifers to the north, and also unproductive strata, with a primary watercourse flowing across the Scheme.

The sensitivity of resources and / receptors are range from low to high. Magnitude of impacts without mitigation is considered to range from minor beneficial to moderate adverse.

Following the implementation of mitigation during construction and sufficient design taking into account mitigation measures, no significant effects to geology or soils has been identified.

Table 9.6.1 Summary of Impacts and Effects

Operation					
Attribute / Receptor	**Potential Impacts**	**Nature of Impact**	**Predicted Effects (without Mitigation)**	**Mitigation Measures**	**Residual Effects (with Mitigation)**
Construction					
Attribute	Geological and geomorphological features	No change	Neutral	None required	Neutral
Attribute	Soils: Agricultural land	Negligible adverse	Slight adverse	No mitigation	Slight adverse
Contaminated Land Receptor: Controlled Waters	Groundwater	No change	Neutral	None required	Neutral
	Surface water	No change	Neutral	Scheme designed to mitigate risks	Neutral
Attribute	Soils: Agricultural land	Moderate adverse	Large or moderate adverse	Scheme-specific CEMP including re-use of materials and careful stockpiling, the use of bunds and retention of vegetation together with new planting, and a MEMP.	N/A
Contaminated Land Receptor	Ecological systems	No change	Neutral	Scheme designed to mitigate risks	Neutral
Contaminated Land Receptor	Built environment from ground aggressivity	No change	Neutral	Scheme designed to mitigate risks	Neutral
Contaminated Land Receptor: Controlled Waters	Groundwater	No change	Neutral	Best practice procedures, CEMP, creation of balancing ponds	Neutral
	Impact to end users	Negligible adverse	Neutral	Scheme designed to mitigate risks	Neutral
	Surface waters	No change	Neutral	Best practice procedures and CEMP, creation of balancing ponds	Neutral
Contaminated Land Receptor	Ecological systems	Minor adverse	Slight or moderate adverse	Best practice procedures and CEMP, creation of balancing ponds	Neutral
Contaminated Land Receptor	Built environment from ground aggressivity	No change	Neutral	Scheme designed to mitigate risks	Neutral
Contaminated Land Receptor	Built environment from ground gas	Minor adverse	Slight adverse	Best practice procedures and CEMP	Neutral
Contaminated Land Receptor	Construction workers	Negligible adverse	Slight adverse	Best practice procedures and CEMP	Neutral
Contaminated Land Receptor	Impact to end users	Negligible Adverse	Slight Adverse	Follow industrial best practice procedures, develop CEMP	Neutral



KEY

- HISTORIC LANDFILL
- RECORDED POLLUTION ACCIDENT - SIGNIFICANT IMPACT
- CIBYN INDUSTRIAL ESTATE (POTENTIAL SOURCE OF CONTAMINATION)
- AUTHORISED LANDFILL TIP

REV	DATE	DESCRIPTION	BY	CHKD	APPD

• TITLE

A487 CAERNARFON AND BONTNEWYDD BYPASS

Geology & Soils
Potential Contamination Sources
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FINAL

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• SCALE Not to scale

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APPROVED PM

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