

Welsh Government

**A40 Llanddewi Velfrey to Penblewin
Improvements**

Environmental Statement Chapter 6: Geology
and Soils

A40LVP-ARP-EGT-SWI-RP-C-0001

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6 Geology and Soils

6.1 Chapter Introduction

6.1.1 This chapter of the Environmental Statement (ES) describes and characterises the baseline geological setting of the proposed A40 scheme ('the Scheme') allowing for the assessment of the impact that the Scheme may have on soil and geological resources such as designated sites, geological features or mineral resources. The features referred to in this Chapter are shown on Volume 2 Figures 6.1A to 6.1C.

6.1.2 This chapter also sets out a baseline conceptual site model with respect to soil and groundwater contamination, and identifies plausible contaminant linkages that may be created as a result of the proposed Scheme during the construction and operational phases.

6.1.3 The assessments of potential effects lead to identification of mitigation measures to ensure that the proposed Scheme does not adversely affect geological resources or is adversely affected by land contamination.

6.1.4 The relevant site-specific information used for the derivation of the baseline and to support the assessments is presented in appendices:

Appendix 6.1 Preliminary Sources Study Report, Mott MacDonald, March 2016¹

Appendix 6.2 Ground Investigation Factual report, WYG, 2016²

Appendix 6.3 Ground Investigation Report, Arup 2017³

Appendix 6.4 Soil chemical testing data. Criteria for human health and controlled waters risk assessments. Detailed Assessment Methodology

6.1.5 Potential impacts on groundwater associated with drainage and discharge proposals are considered within Chapter 7 (Road Drainage and Water Environment) of this ES. It should be noted that effects on the agricultural resource of soils are considered within Chapter 11

¹ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

² Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016.

³ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, ref. A40LVP-ARP-VGT-SWI-RP-C-0001, Arup, July 2017

Community and Private Assets. Waste and management of materials are considered in Chapter 16 Materials.

6.2 Legislation

6.2.1 Geological sites of national importance are principally afforded protection under the Wildlife and Countryside Act 1981 (as amended) or the National Parks and Access to the Countryside Act 1949 by designation as SSSI or NNR. The Joint Nature Conservation Committee (JNCC) is a public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation. On the Defra website, the JNCC state that the aim of their Geological Conservation Review (GCR) for the selection of non-statutory designated Earth Science sites was “to identify the best, most representative, earth science sites in Great Britain, with a view to their long-term conservation. Geological Conservation Review (GCR) and Earth Science Conservation Review (ESCR) sites are non-statutory sites identified by the statutory nature conservation agencies as having national or international importance for earth science conservation on the basis of their geology, palaeontology, mineralogy or geomorphology. Although GCR/ESCR identification does not itself give any statutory protection, many GCR/ESCR sites have been notified as SSSIs/ASSIs”

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

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

6.2.3 In Wales, Part IIA of the Environmental Protection Act, as introduced by Section 57 of the Environment Act 1995, came into effect in September 2001 with the implementation of the Contaminated Land Regulations 2000 (now superseded by The Contaminated Land Regulations 2006/2012). Under Part IIA of the Environmental Protection Act, sites are identified as 'contaminated land' if they are causing, or if there is a significant possibility of causing significant

harm to human health or significant pollution of controlled waters (as defined by Section 104 of the Water Resources Act 1991).

- 6.2.4 The Environment (Wales) Act 2016 sets out a framework for the sustainable management of natural resources. An accompanying Natural Resources Policy Statement is currently awaited.
- 6.2.5 In general terms the legislation advocates the use of a risk assessment approach to the assessment of contamination and any remedial requirements.
- 6.2.6 A list of additional legislation and guidance considered within the assessment and relating to contamination and water environment includes:
- a) Water Resources Act 1991 as amended in Wales by the Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009;
 - b) EU Water Framework Directive (WFD) 2000/60/EC (as amended by supplementary directives and decisions);
 - c) The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 which implement Water Framework Directive (2000/60/EC), and transpose aspects of the Groundwater Directive (2006/118/EEC) and the Priority Substances Directive (2008/105/EC).
 - d) Groundwater Regulations (England and Wales) 2009, which transpose the EC Groundwater Directive 80/68/EC into UK law;
 - e) Groundwater Daughter Directive (GWDD) (2006/118/EC);
 - f) The Water Framework Directive (Standards & Classification) Directions (England and Wales), 2015;
 - g) The Environmental Damage (Prevention and remediation) (Wales) Regulations 2009; and
 - h) Flood and Water Management Act 2010.
- 6.2.7 Chapter 6 Geology and Soils documents the assessments carried out in line with the requirements of DMRB Volume 11 Section 3 Part 11, which does not include assessment of waste production, disposal or management, which are included in Chapter 16 Materials.

6.3 Policy Context

National and Regional Policy

- 6.3.1 The 10th edition of Planning Policy Wales⁴ (PPW10) was published in December 2018. It sets out land use and planning policy for Wales. The new planning policy incorporates principles derived from the Well-being of Future Generations (Wales) Act 2015.
- 6.3.2 The policy document is set out into themes, geological features is addressed in the Distinctive and Natural Places theme. Section 6.3 Landscape of PPW10, highlights the importance that geological features have in the natural environment. Specific reference is made to the protection, conservation and enhancement of:
- a) UNESCO Global Geoparks;
 - b) Regionally Important Geological and Geomorphological Sites (RIGS);
 - c) Sites of Special Scientific Interest (SSSIs).
- 6.3.3 In addition, PPW10 encourages planning authorities to promote opportunities for the incorporation of geological features within the design of development.
- 6.3.4 Section 6.9 Unlocking Potential by Taking a De-risking Approach of PPW10 covers both development on contaminated land and developments which may pose risks to the health and environment. Physical ground conditions and land instability are also considered within this section.

Local Planning Policy

- 6.3.5 The Pembrokeshire County Council Local Development Plan (LDP) was adopted in February 2013⁵. Pembrokeshire County Council commenced a review of the LDP in May 2017.

⁴ Welsh Government (2018) Planning Policy Wales Edition 10 (PPW10)

⁵ Local Development Plan. Planning Pembrokeshire's Future (up to 2021), Pembrokeshire County Council, Adopted 28th February 2013

6.3.6 The following policies are considered relevant to the proposed Scheme:

- a) Strategic Policy (SP) 1 Sustainable Development: Requires all development proposals to demonstrate how positive environmental impacts will be achieved and adverse impacts minimised.
- b) SP 6 Minerals: Mineral resources such as hard rock and sand and gravel will be maintained and where known to be present at outcrop locations these will be safeguarded from permanent development to ensure a continuous supply of minerals in support of local, regional and national development.
- c) General Policy (GN) 1 General Development Policy: Development will be permitted on the condition that it would not cause or result in unacceptable harm to health and safety, and would not have a significant adverse impact on water quality.
- d) GN 22 Prior Extraction of the Mineral Resource: Consideration for extraction of safeguarded mineral resources from an area of a new permitted development should be made, wherever appropriate in terms of economic feasibility and environmental and other planning considerations prior to the commencement of the development. The Good Practice Guidance Note on LDP policy GN.22⁶ provides a list of considerations, where no extraction of mineral resources would be required.
- e) GN 23 Mineral Working: Proposals for mineral working and extensions of existing sites will be permitted where the demand cannot be met from secondary or recycled materials, or existing reserves, or there is provision for landscaping, groundwater protection, a beneficial after-use, restoration and/or post-closure management of the site.
- f) GN 25 Buffer Zones Around Mineral Sites: New mineral extractions will not be permitted within a Buffer Zone around mineral sites to avoid an adverse impact on one another because of their close proximity. Volume 3 Appendix 2 to the LDP provides a list of current mineral workings with the location presented on Proposal Maps (PM). PM covers the area of the proposed Scheme.

6.4 Relevant Guidance

6.4.1 The assessment will be undertaken with due consideration of the relevant general Environmental Impact Assessment guidance, as detailed in Chapter 4 Environmental Impact Assessment Methodology and of the following topic specific guidance:

⁶ Good Practice Guidance Note. LPD policy GN. 22- prior extraction of the mineral resource, Pembrokeshire County Council

- a) Geotechnics and Drainage, Earthworks, Managing Geotechnical Risks DMRB Volume 4, Section 1, Part 2 HD22/08⁷;
- b) Environmental Assessment, Environmental Assessment Techniques, DMRB Volume 11, Section 3, Part 11 Geology and Soils⁸;
- c) Model Procedures for the Management of Land Contamination (CLR11)⁹;
- d) Construction Industry Research and Information Association R132: A Guide for Safe Working on Contaminated Sites¹⁰;
- e) CIRIA SP73: Roles and Responsibility in Site Investigations¹¹;
- f) BS5930: 2015: Code of Practice for Site Investigations including Amendment 2¹²;
- g) BS10175:2011 + A1 2013: Code of Practice for Investigation of Potentially Contaminated Sites¹³;
- h) The Environment Agency's approach to groundwater protection¹⁴
- i) CIRIA 552: Contaminated Land Risk Assessment, A guide to good practice¹⁵;
- j) BS 8485:2015: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings¹⁶;
- k) CIRIA 665: Assessing risks posed by hazardous ground gas to buildings¹⁷;
- l) CIRIA 681: Unexploded ordnance (UXO) A guide for the construction industry¹⁸;
- m) CIRIA 733: Asbestos in soil and made ground: a guide to understanding and managing risks¹⁹;

⁷ Design Manual for Roads and Bridges, Volume 4, Section 1, Part 2, HD22/08, Highways Agency, Scottish Government, Welsh Assembly Government, Department for Regional Development Northern Ireland, 2008.

⁸ Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11: Geology and Soils, Highways Agency, 1993.

⁹ Model Procedures for the Management of Land Contamination (CLR11), Environment Agency and Defra, 2004.

¹⁰ A Guide for Safe Working on Contaminated Sites (R132), Construction Industry Research and Information Association (CIRIA), 1996.

¹¹ Roles and Responsibility in Site Investigations (SP73), Construction Industry Research and Information Association (CIRIA), 1991.

¹² BS5930:2015 Code of Practice for Site Investigations including Amendment 2, British Standards Institution, 2015.

¹³ BS10175:2011+A1 2013 Code of Practice for Investigation of Potentially Contaminated Sites British Standards Institution, 2011.

¹⁴ The Environment Agency's approach to groundwater protection, Environment Agency, 2017

¹⁵ Contaminated Land Risk Assessment, A guide to good practice (C552), Construction Industry Research and Information Association (CIRIA), 2001

¹⁶ BS 8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, British Standards Institution, 2015

¹⁷ Assessing risks posed by hazardous ground gas to buildings (C665), Construction Industry Research and Information Association (CIRIA), 2007.

¹⁸ Unexploded ordnance (UXO) A guide for the construction industry (C681), Construction Industry Research and Information Association (CIRIA), 2009

¹⁹ Asbestos in soil and made ground: a guide to understanding and managing risks (C733), Construction Industry Research and Information Association (CIRIA), 2014

- n) CIRIA 765: Asbestos in soil and made ground: good practice site guide²⁰;
- o) Definition of Waste: Development Industry Code of Practice²¹ sets out a framework for management of materials during construction. This is currently not obligatory for use in Wales, and therefore has not been referenced as a requirement that will be followed. Refer to Chapter 16 Materials for more details;
- p) Eurocode 7 (BS EN 1997-1²² & EN 1997-2²³) and all relevant Normatives; and
- q) Natural Resources Wales (formerly Environment Agency Wales) Pollution Prevention Guidelines of relevance in relation to protection of soils and waters (note that these PPGs have now been withdrawn and are currently being reviewed and updated).

6.5 Study Area

- 6.5.1 The study area for the contaminated land assessment covers the construction land take and permanent land take as presented on Volume 2 Figures 2.3A and 2.3B. The baseline study area includes all potential contaminated land sites that intersect the Scheme and those sites that have plausible pollutant linkages that may be intercepted by the proposed alignment, typically within approximately 250m of the route corridor²⁴, although potential pollutant linkages will be considered on a case by case basis.
- 6.5.2 The geology and geomorphology study area has been determined on the basis of the published information on geology for the area and the site-specific data gathered during investigations along the Scheme. The detailed study area for geology is therefore based along a corridor following the route.
- 6.5.3 The extent of the study area is shown on Volume 2 Figures 6.1A to 6.1C.

²⁰ Asbestos in soil and made ground: good practice site guide (C765), Construction Industry Research and Information Association (CIRIA), 2017

²¹ Definition of Waste Development Industry Code of Practice. Version 2. In association with the Homes and Communities Agency, DEC UK and Hydrock. Contaminated Land: Applications in Real Environments (CL:AIRE), 2011.

²² BS EN 1997-1: 2004 and Amendment 1: 2013: Eurocode 7 Geotechnical Design. General Rules British Standards Institution, 2013.

²³ BS EN 1997-2: 2007 UK National Annex to Eurocode 7 Geotechnical Design. Ground Investigation and Testing, British Standards Institution, 2007.

²⁴ Guidance for the Safe Development of Housing on Land Affected by Contamination, RD66, EA, NHBC and CIEH, 2008

6.6 Methodology

Scope of Baseline Studies

- 6.6.1 The identification of baseline conditions in relation to site geology, geomorphology and land contamination has been undertaken based on review of available desk study information included within the Preliminary Sources Study Report (PSSR) prepared for the Scheme by Mott MacDonald in March 2016²⁵ (enclosed in Volume 3 Appendix 6.1) and information obtained during the preliminary ground investigation that was undertaken on behalf of the Welsh Government by WYG Environment Planning Transport Ltd in June 2016. The ground investigation information is presented in the WYG factual report²⁶ (enclosed in Volume 3 Appendix 6.2) with the interpretation presented in the Arup Ground Investigation Report²⁷ (enclosed in Volume 3 Appendix 6.3).
- 6.6.2 The baseline conditions in relation to agricultural soils are presented in Chapter 11 Community and Private Assets of this ES and in relation to hydrogeology in Chapter 7 Road Drainage and Water Environment.
- 6.6.3 The information contained within the 2016 PSSR²⁸ will be validated and updated where appropriate in the following topic areas (as detailed in Appendix 6.4):
- a) Geology. Based on published geological maps and memoirs;
 - b) Current and historical land use.
 - c) Hydrology and hydrogeology.
 - d) Mines and mineral deposits.
 - e) Natural cavities.
 - f) Soil survey information.
 - g) Ground conditions encountered during ground investigations completed to date (exploratory hole locations are shown on Volume 2 Figures 6.1A to 6.1C).
 - h) Consultation with statutory bodies and agencies.

²⁵ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

²⁶ Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016.

²⁷ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, ref. A40LVP-ARP-VGT-SWI-RP-C-0001, Arup, July 2017

²⁸ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

Baseline assessment methodology

- 6.6.4 The baseline Conceptual Site Model has been based on the review of the information presented in section 6.6.3. From review of the information, geological or geomorphological features that have potential to be impacted by the Scheme have been identified. In addition, this information informed land contamination baseline Conceptual Site Model as detailed in Appendix 6.4.

Methodology for Assessments of Impacts from Construction and Operation

- 6.6.5 This section outlines the methodology for the assessment of construction or operational impacts. The assessment includes consideration of possible effects on statutory and non-statutory geological sites along the route of the Scheme. The assessment also considers general effects posed by potential contaminated land exposure along the proposed route.
- 6.6.6 Assessment of the likely impact on the geology/geomorphology and land contamination arising from construction has been undertaken by review of baseline conditions in a context of the proposed works. The detailed description of the Scheme proposals is presented in Chapter 2 the Project and Volume 2 Figure 2.4.
- 6.6.7 For the purpose of the assessments the following construction activities have been considered:
- a) Construction of earth embankments;
 - b) Construction of cuttings; and
 - c) Structures and other features, such as culverts, attenuation ponds, underpasses, overbridge and footbridge.
- 6.6.8 A review of the baseline data described in Section 6.6.3 identifies and refines the extent of potentially contaminated land sites within the study area. The need for further focused assessment has been considered where existing or suspected contaminated land may be affected by the route, i.e. by creating or altering pollutant linkages between sources of potential contaminants and sensitive receptors such as humans, ecological receptors, surface water and groundwater bodies.

- 6.6.9 The baseline Conceptual Site Model has subsequently been revised to include for new pollution linkages. These Conceptual Site Models have been used to establish the risks posed to each location and the potential need for further assessment.
- 6.6.10 Those contaminated land and potentially contaminated sites identified fully outside of the zone of influence of the study area (including adjacent earthworks), have been scoped out and therefore require no further assessment. The study area is presented on Volume 2 Figures 6.1A to 6.1C.

Assessing Potential Effects Methodology

- 6.6.11 The assessment of the environmental effects on the geology and soils of the Scheme has been carried out in accordance with the requirements of DMRB Volume 11, Section 3, Part 11²⁹, whilst the detailed assessment on the magnitude of impacts and significance criteria for effects has been undertaken using the methodology outlined in HA205/08 Principles of Environmental Assessment – Assessment and Management of Environmental Effects³⁰.
- 6.6.12 Assessment of effects in relation to contamination has been undertaken in accordance with industry best practice as presented in CLR11³¹. The risk assessment process is underpinned throughout by the development of the Conceptual Site Model (CSM) which provides a schematic representation of the identified pollutant linkages. The baseline Conceptual Site Model has subsequently been revised to include new pollution linkages introduced by either construction activities or operation of the Scheme. These Conceptual Site Models have been used to establish the risks posed to each location and the potential need for further assessment. The risk assessment process is detailed in Volume 3 Appendix 6.4.

²⁹ Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 11: Geology and Soils, Highways Agency, 1993.

³⁰ Design Manual for Roads and Bridges HA 205/08 Volume 11, Section 2, Part 5. Assessment and Management of Environmental Effects, Highways Agency, Scottish Government, Welsh Assembly Government, Department for Regional Development Northern Ireland, 2008.

³¹ Model Procedures for the Management of Land Contamination (CLR11), Environment Agency and Defra, 2004.

6.7 Significance Criteria

Environmental Value (or Sensitivity) of Resource/Feature

6.7.1 The significance of impacts has been assessed by attributing a value or sensitivity to each receptor impacted, in combination with the magnitude of impact that would occur to it. The sensitivity of each receptor has been assessed based on Table 6.1, and the magnitude of impact in accordance with Table 6.2. The significance of impact has then been assessed by considering the combination of both the sensitivity of the receptor in combination with the magnitude of impact in accordance with Table 6.3.

Table 6.1 Criteria and DMRB Definitions of Sensitivity or Value (based on HA205/08³²)

Value (sensitivity)	Typical Descriptors
Very high	<p>Geology/ Mineral Resources: Very rare and of very high 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).</p> <p>Groundwater: 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).</p> <p>Surface water: European Community (EC) Designated Salmonid/Cyprinid fishery Water Framework Directive (WFD) Class 'High' Site protected/designated under EC or UK wildlife legislation (SAC, SPA, SSSI, WPZ, Ramsar Site, salmonid water)/species protected by EC legislation.</p> <p>Land Contamination: Human health (High sensitivity land use scenario e.g. residential with plant uptake).</p> <p>UXO Human health</p>
High	<p>Geology/ Mineral Resources:</p>

³² Design Manual for Roads and Bridges HA 205/08 Volume 11, Section 2, Part 5. Assessment and Management of Environmental Effects, Highways Agency, Scottish Government, Welsh Assembly Government, Department for Regional Development Northern Ireland, 2008

Value (sensitivity)	Typical Descriptors
	<p>Of medium national and high regional geological/ geomorphological importance with limited potential for replacement (e.g. currently non-designated GCR site, regionally important site, active quarries and mining activities of regional or local importance).</p> <p>Groundwater: 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. principal aquifer providing potable water to a small population and/or large resource potential).</p> <p>Surface water: WFD Class 'Good' Major Cyprinid Fishery Species protected under EU or UK habitat legislation</p> <p>Land Contamination: Sensitive receptor which is the reason for SSSI designation. Human health (Lower sensitivity land use scenario e.g. residential without plant uptake, public open space)</p>
Medium	<p>Geology / Mineral Resources: Of low regional and high local geological/ geomorphological importance with some potential for replacement (e.g. allocated RIGS or recommended RIGS).</p> <p>Groundwater: 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 agricultural or industrial use and/or moderate resource potential).</p> <p>Surface Water: WFD Class 'Moderate'</p> <p>Contamination: Receptor which is of regional importance. (Lower sensitivity land use scenario e.g. commercial, industrial)</p>
Low (or Lower)	<p>Geology / Mineral Resources: Of local geological/geomorphological importance with potential for replacement (e.g. non-designated exposure/former quarries and mining activities).</p> <p>Groundwater: 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).</p> <p>Surface Water: WFD Class 'Poor'</p> <p>Land Contamination: Human health (Low sensitivity land use scenario e.g. highway construction). Receptor which is of local importance.</p>

Value (sensitivity)	Typical Descriptors
Negligible	<p>Geology / Mineral Resources: Of little local geological/geomorphological interest.</p> <p>Land Contamination: Receptor with low importance and rarity.</p>

Table 6.2 Criteria and DMRB Definitions of Impact Magnitude (based on HA205/08³³)

Magnitude of Impact	Typical Criteria Descriptors
Major	<p>Geology / Mineral Resources: The proposals are very damaging to the geological environment/soils resource of the area. May result in loss or damage to areas designated as being of regional or national geological interest. Loss of resource and/or quality and integrity of resource. Severe damage to key characteristics, features or elements. Impacts cannot be mitigated for (e.g. destruction of a designated site (SSSI or RIGS)). (Adverse)</p> <p>Controlled Waters (aquifers/surface water): Reduction of water quality rendering groundwater or surface water unfit to drink and/or substantial adverse impact on groundwater dependent environmental receptors. (Adverse)</p> <p>Land Contamination: Major effect upon receptor. Severe or irreversible effect on human health. Temporary severe or irreversible effect on ground/surface water quality. (Adverse).</p> <hr/> <p>Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).</p>

³³ Design Manual for Roads and Bridges HA 205/08 Volume 11, Section 2, Part 5. Assessment and Management of Environmental Effects, Highways Agency, Scottish Government, Welsh Assembly Government, Department for Regional Development Northern Ireland, 2008.

Magnitude of Impact	Typical Criteria Descriptors
<p>Moderate</p>	<p>Geology / Mineral Resources: The proposals may adversely affect the geological/hydrogeological conditions/soils resource existing at the site but would not result in the loss of, or damage to, areas designated as being of regional or national geological interest. Loss of resource, but not adversely affecting the integrity. Partial loss of/damage to key characteristics, features or elements. Some mitigation may be possible but would not prevent scarring of the geological environment, as some features of interest would be lost or partly destroyed. (Adverse)</p> <p>Controlled Waters (aquifers/surface water): Reduced reliability of a supply at a groundwater or surface water abstraction source. (Adverse)</p> <p>Land Contamination: Moderate effect upon receptor. Long term or short term moderate effect on human health. Moderate effect on ground/surface water quality, reversible with time. (Adverse)</p> <hr/> <p>Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).</p>
<p>Minor</p>	<p>Geology / Mineral Resources: The proposals would not affect areas with regional or national geological interest/soils resource but may result in the loss of, or damage to, areas of local geological/soils resource interest. Cannot be completely mitigated for but opportunities exist for the replacement of lost or damaged areas which may be of similar local geological/soils interest. (Adverse)</p> <p>Controlled Waters (aquifers/surface water): Marginal reduced reliability of a supply at a groundwater or surface water abstraction source. (Adverse)</p> <p>Land Contamination: Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.). Slight effect on ground/surface water quality, reversible with time. (Adverse)</p> <hr/> <p>Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial).</p>

Magnitude of Impact	Typical Criteria Descriptors
Negligible	<p>Geology / Mineral Resources: The proposals would result in very minor loss or damage to local area of geological interest/soils resource such that mitigation is not considered practical. Very minor loss or detrimental alteration to one or more characteristics, features or elements. (Adverse)</p> <p>Controlled Waters (aquifers/surface water): Non-measurable change to quality, level and flow. (Adverse)</p> <p>Land Contamination: Results in no discernible change or an impact on attribute of sufficient magnitude to affect the use/integrity. (Adverse) E.g. Soil contaminants present, but risk assessment suggests negligible/ low risk to human health. (Adverse)</p>
	<p>Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).</p>
No change	<p>No loss or alteration of characteristics, features or elements; no observable impact in either direction.</p>

Significance of Effect

- 6.7.2 The criteria for assessing the significance of the impact takes account of the following factors:
- a) The value of the resource (international, national, regional and local level importance).
 - b) The magnitude of the impact.
 - c) The duration involved.
 - d) The reversibility of the effect.
 - e) The number and sensitivity of receptors.
- 6.7.3 The level of significance that merits further consideration / mitigation has been determined following the procedures set out in Chapter 4 Environmental Impact Assessment Methodology. In terms of the EIA Regulations, significant effects are generally those where the significance of the effect is 'moderate' or greater.
- 6.7.4 The significance criteria used are summarised in Table 6.3.

Table 6.3 Approach to Evaluating Significance of Effect (based on HA205/08³⁴)

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

6.8 Consultation

6.8.1 The Scoping Report has been issued to the Environmental Liaison Group that has been set up for the Scheme, which comprises a range of key Statutory Consultees. No comments have been received to date.

6.9 Limitations and Assumptions

6.9.1 Professional judgement has been applied where necessary in assignment of sensitivity and magnitude of effects in line with definitions provided in Table 6.1 and Table 6.2.

6.9.2 The 2016 investigations provide only preliminary information on ground conditions and detailed information will be obtained at Key Stage 6 detailed design stage.

6.9.3 This is in line with a standard practice, where the preliminary investigations are undertaken to create a ground model and identify the required mitigation measures. This is considered sufficient at the initial design stage and to inform the environmental impact assessments. Further detailed ground investigations are typically undertaken on confirmation of the design. The information obtained during these investigations will form the basis for a detailed design of the Scheme.

³⁴ Design Manual for Roads and Bridges HA 205/08 Volume 11, Section 2, Part 5. Assessment and Management of Environmental Effects, Highways Agency, Scottish Government, Welsh Assembly Government, Department for Regional Development Northern Ireland, 2008.

- 6.9.4 The assessment of pollution releases as a result of operational or construction activities and potential impacts on hydrogeology are covered in Chapter 7 Road Drainage and Water Environment.
- 6.9.5 Notwithstanding the limitations, sufficient information has been available for the completion of the assessment of geology, geomorphology and contaminated land.

6.10 Inbuilt Mitigation

- 6.10.1 Health and safety management based on best working practices will be implemented during construction, which will be informed by available information with respect to soil quality and any identified potential sources of contamination.
- 6.10.2 Pollution control measures based on best working practices will be implemented during construction. The management of environmental issues arising during construction e.g. groundwater management during excavations or dust generation as a result of transport of materials will be undertaken in line with best practice as outlined in the Preliminary Construction Environmental Management Plan (Pre-CEMP) presented in Volume 3 Appendix 2.2 and as such will not have an impact on identified receptors. Nonetheless, to reinforce the requirement for particular environmental management measures, these have been outlined within Section 6.13 Construction Mitigation.
- 6.10.3 In addition, the following principles will be applied:
- a) Any discharge to the watercourse will only be carried out with an appropriate environmental permit or consent from NRW or Local Flood Authority, where required, following monitoring, and if needed, treatment to ensure it is of acceptable quality.
 - b) The reuse of site won or import of materials to the Scheme will be managed by a verification system applied via the Specification for Highway Earthworks Series 600, and only materials found suitable for use will be acceptable for construction works.

6.11 Baseline Environment

- 6.11.1 This section presents baseline conditions with respect to geological setting and resources within the study area as shown on Volume 2 Figures 6.1A to 6.1C. It also describes conceptual site model where the

link between potential sources, pathway and receptors of contamination are identified.

Site Topography

- 6.11.2 The current alignment of the A40 is generally located towards the top of a local west-easterly orientated ridge bounded in the northeast by the Afon Taf valley and in the south by the Afon Marlais valley. Ground levels vary between 80m Above Ordnance Datum (AOD) and 130m AOD. The length of the proposed route crosses undulating terrain primarily associated with valleys of streams (tributaries to the Afon Taf and the Afon Marlais) as described below. The topography of the area of the proposed Scheme is presented on Volume 2 Figures 6.1A to 6.1C.
- 6.11.3 The existing topography dips gently to the south in the western part of the Scheme (from Ch. 0+000 to 1+250). The ground level within this section of the proposed alignment lies approximately at 90m AOD. Immediately east of Ffynnon Chapel (Ch. 1+250), the ground levels drop sharply in the valley of an existing watercourse after which they rise again gently (to approximately 100m AOD) up to Pen-troydin-fach Farm (approximately Ch. 2+350). From there to Pen-troydin-fawr Farm (approximately Ch. 2+850), the ground levels drop sharply along the route alignment.
- 6.11.4 The bottom of the valley at the location of the two watercourses between approximate Ch. 3+000m and Ch. 3+120m is at around 75m AOD. Moving east, ground levels then step up to 85m AOD before gradually rising to 125m AOD at Ch. 3+600m. To the northwest of the Scheme alignment, the topography drops away along this length.
- 6.11.5 From Ch. 3+600m to the Bethel Roundabout, the topography drops sharply to the northeast perpendicular to the proposed route.
- 6.11.6 At the eastern end of the Scheme, the south side of the proposed route drops sharply to the south towards a valley.

Published Geology

Superficial deposits

- 6.11.7 Published geological maps generally show no superficial deposits across the proposed Scheme area, as presented on Volume 2 Figures 6.1A to 6.1C.
- 6.11.8 An isolated area of glaciofluvial deposits approximately 250m in length and 50m in width has been recorded at the western end of the Scheme crossing the proposed alignment between Ch. 0+430m and Ch. 0+510m. The county maps note a “pit in gravel 7ft+” within this area. An area of boulder clay is also indicated as encroaching on the Scheme alignment between Ch. 3+010m and Ch. 3+090m. The county map shows this area to extend 250m further to the south than on the 1:50,000 map.
- 6.11.9 An area of alluvium associated with the watercourse east of Ffynnon Chapel at Ch. 1+710m extends south for a distance of up to 200m from the proposed alignment. The county map shows the alluvium to extend 50m further to the south than shown on the 1:50,000 map. An additional area of alluvium east of the sewage works some 300m away from the proposed alignment is recorded on the county map.
- 6.11.10 It should be noted that other areas of superficial deposits that have not been recorded on the geological maps could be present.

Bedrock

- 6.11.11 The bedrock beneath the Scheme comprises three formations. Primarily the Slade and Redhill Formation, in the east and the Haverford Mudstone Formation with some discrete areas of the Portfield and Haverford Formation, in the west (see Volume 2 Figures 6.1 A to 6.1C).
- 6.11.12 The geological sequence of the three formations comprises the Haverford Mudstone Formation overlying the Portfield Formation and Haverford Mudstone Formation (undifferentiated) which in turn is underlain by the Slade and Redhill Formation. Refer to the Arup Ground Investigation Report (GIR)³⁵ (enclosed in Volume 3 Appendix 6.3) for more details regarding detailed descriptions of the abovementioned formations. The Haverford Mudstone and Slade and

³⁵ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, ref. A40LVP-ARP-VGT-SWI-RP-C-0001, Arup, July 2017

Redhill Formations predominantly comprise mudstones with occasional sandstone bands; whereas the Portfield and Haverford Mudstone Formation comprise layers of mudstone, sandstone and conglomerates.

- 6.11.13 There are two north-west to south-east trending faults crossing the site at Llanddewi Velfrey and at Penblewin. The most eastern fault is shown on a section on the 1:50,000 plan as an inversed fault, downthrowing to the north-east at an angle estimated to be approximately 15° from the horizontal. Between the faults, the Haverford Mudstone Formation that overlies the undifferentiated Portfield and Haverford Mudstone Formation is generally shown as being present from the ground surface beneath the Scheme, with the exception of an area north of Ffynnon Wood where the underlying formation is recorded due to the presence of an anticline, and the section between Caermaenau-fach farm and the service area.
- 6.11.14 A syncline trending in a north-west to south-east direction is shown to the north of Llanddewi Velfrey. Dip angles of 50 to 60 degrees and 10 to 30 degrees are recorded on the northern and the southern limb respectively.
- 6.11.15 Where the Haverford Mudstone Formation and Portfield and Haverford Formation sequence are absent, the mudstone of the Slade and Redhill Formation covers the site.
- 6.11.16 It is noted that some solid geology boundaries have been noted as ‘no evidence’ and ‘supposed’ on the county maps.

Geomorphology

- 6.11.17 The topography of the area, with valley features and watercourse, as well as presence of glacial till indicates the area has been shaped by glaciation and subsequent fluvial action.

Mineral Resources

- 6.11.18 The mineral resources map identifies resources of sand and gravel (sub-alluvial) within the Scheme area. The extent of these resources coincides with the outcrop of the Portfield and Haverford Formations, as shown on Volume 2 Figures 6.1A to 6.1C.

- 6.11.19 The aggregate safeguarding map identifies sandstone deposits as Category 2 Aggregates Safeguarding Area (ASA) in the area of the western part of the Scheme. These deposits are identified as the Portfield & Haverford Formation on Volume 2 Figures 6.1A to 6.1C. This shows that the Scheme generally runs adjacent to and only locally encroaching on these deposits at the proposed Scheme chainages 0+370 to 0+420, 0+510 to 0+700, Ch. 1+740 to 1+850 and 2+740 to 2+850. Category 2 resources are those resources that have a regional importance.
- 6.11.20 Sand and gravel deposits (Category 1 ASA) are shown on the aggregate safeguarding map to underlie the proposed Scheme between Scheme chainage 0+420 to 0+510. These areas are also identified in the Pembrokeshire County Council LDP. Category 1 resources are those resources that have a national importance in Wales or potentially in the UK.
- 6.11.21 No records of mines or mineral deposits have been identified for the Scheme area. However, a number of historical quarries and gravel pits have been identified as detailed in Section 2.6.67 (site history) and shown on Volume 2 Figures 6.1A to 6.1C.

Hydrology and hydrogeology

- 6.11.22 The 2016 Preliminary Sources Study Report (PSSR)³⁶ (enclosed in Volume 3 Appendix 6.1) provides an overview of the hydrology and hydrogeological setting of the Scheme. A summary is presented below. A further detailed hydrological and hydrogeological setting of the Scheme is presented in Chapter 7 Road Drainage and Water Environment.
- 6.11.23 The proposed Scheme is located within two main surface water catchments of the Eastern Cleddau (SAC) to the west and the Afon Taf to the east, with numerous direct and indirect tributaries (including the Afon Daulan, Afon Marlais, direct tributaries to the Afon Taf, and Longford Brook, a direct tributary to the Eastern Cleddau (SAC)) issuing directly to the south and north of the proposed alignment. Locally, the proposed route of the Scheme broadly follows the watershed between the Longford Brook, Taf and Marlais catchments

³⁶ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

with areas south of the Scheme draining to the south and areas to the north draining northwards.

- 6.11.24 As detailed in Chapter 7 Road Drainage and Water Environment, the Water Framework Classifications of the watercourses and associated catchment areas indicate that the western section and eastern end of the Scheme both lie within the Afon Marlais catchment awarded a ‘Good’ WFD status in 2015. The remainder of the Scheme is split between the Longform Brook catchment (tributary to the Eastern Cleddau (SAC)) and the Afon Taf catchments, both of ‘Moderate’ WFD status.
- 6.11.25 The following watercourses transect the proposed alignment (from west to east):
- a) Two unnamed watercourses, tributary to the Afon Daulan, currently culverted beneath the existing A40 at chainage between 1+700 and 1+800 of the Scheme (‘Moderate’ WFD status).
 - b) Unnamed watercourse, indirect tributary to the Afon Daulan, crosses the proposed alignment at chainage 2+640 (‘Moderate’ WFD status).
 - c) Two unnamed watercourses, indirect/direct tributaries to the Afon Daulan, crosses the proposed alignment at chainage 3+110 and 3+250 (‘Moderate’ WFD status).
- 6.11.26 Three ponds are located within the study area, as presented on Volume 2 Figures 6.1A to 6.1C:
- a) A pond located approximately 150m to the west of the Penblewin Roundabout at chainage 0+000.
 - b) A pond located directly to the east of the Penblewin Roundabout at chainage 0+000.
 - c) A pond located approximately 110m to the north of the proposed Scheme at chainage 1+720.
- 6.11.27 The bedrock underlying the proposed Scheme is classed as a Secondary B aquifer. No superficial deposits have been identified to overlie the bedrock except for isolated deposits of Glaciofluvial Deposits at approximately chainage 0+500 and Glacial Till at approximately chainage 3+100. The Glaciofluvial Deposits comprise sands and gravels and are classed as a Secondary A aquifer. The Glacial Till deposits are classed as unproductive strata. The groundwater beneath the Scheme is of ‘Poor’ WFD status due to point source pollution from abandoned mines within the wider catchment area.

- 6.11.28 A number of groundwater abstraction wells are marked on the Ordnance Survey (OS) plan within the study area. Only one of these wells has been identified as a private water supply and it is possible that the remainder of the wells still may be used:
- a) A well located approximately 10m north of the Scheme alignment at chainage 1+600.
 - b) A well located approximately 25m south of the Scheme alignment at chainage 1+630.
 - c) A well located approximately 90m north of the Scheme alignment at chainage 1+780.
 - d) A well located approximately 70m north of the Scheme alignment at chainage 2+220, location also registered as a private water supply.
 - e) Licensed abstraction (No. 356) at Blaen-Pentroydin from an enclosed well, at chainage 3+660, located approximately 250m south of the Scheme alignment.
- 6.11.29 There are a further four private water supplies within the study area, all registered at the same postcode location, located approximately 150m north of the Scheme alignment at chainage 3+660. No details are available on the nature of these abstractions.
- 6.11.30 The location of all identified features are marked on Volume 2 Figures 6.1A to 6.1C.
- 6.11.31 Based on a review of topography and location of surface water features (springs and watercourses) shown on the OS mapping, groundwater springs are present emanating from hillsides in the Scheme vicinity. The interrelation between springs and water bearing strata within the bedrock may be difficult to establish due to the geology of the area being relatively complicated as a result of the folding and faulting of the strata.

Ground Hazards

- 6.11.32 Based on information presented in the Envirocheck report, included in the 2016 PSSR report³⁷ (enclosed in Volume 3 Appendix 6.1), no significant ground hazards are present within the proposed alignment. Low or very low risk of shrinking or swelling clays, landslide or collapsible ground stability hazards have been identified.

³⁷ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

Geological Designated Areas

- 6.11.33 No statutory designated areas of geological or geomorphological interest are present within the Study Area.
- 6.11.34 However, the proposed Scheme is located within the Narberth to Llanddewi Velfrey Special Landscape Area (SLA), a non-statutory designated area due to high geological landscape importance of lowland escarpment. The value of this SLA has been evaluated as high because a proposed geological SSSI at Pengawse Hill is located within this SLA. This proposed SSSI is located nearly 2km to the east of the proposed Scheme area.

Site history

- 6.11.35 The historical development of the area within the proposed alignment has been reviewed as part of the 2016 PSSR³⁸ (enclosed in Volume 3 Appendix 6.1). In summary, very little historical development occurred since the first published map dated 1888, with the existing A40 alignment, farm locations, open fields, field boundaries and wooded areas remaining unchanged.
- 6.11.36 Several historical, now disused and possibly partially or fully infilled, quarries and gravel/sand pits have been identified along the Scheme alignment. These are detailed in Table 6.5. Refer to Volume 2 Figures 6.1A to 6.1C for the location.

Completed Ground Investigations

- 6.11.37 A ground investigation was specified and supervised by Mott MacDonald in 2016 for the Phase 1 Scheme. The ground investigation was undertaken by WYG between April and May 2016. Details of the original scope and completed field works are presented in the Arup GIR³⁹ (enclosed in Volume 3 Appendix 6.3). In summary, the following ground investigations have been completed:
- a) 19 machine excavated trial pits
 - b) 18 rotary percussive boreholes
 - c) 9 in situ California Bearing Ration (CBR) tests

³⁸ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvement, Preliminary Sources Study Report, Mott MacDonald, December 2015.

³⁹ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, ref. A40LVP-ARP-VGT-SWI-RP-C-0001, Arup, July 2017

- d) 3 rounds of groundwater level monitoring
- e) Geotechnical and geo-environmental sampling and laboratory testing.

6.11.38 The factual results from the ground investigation including exploratory holes logs and in-situ and laboratory test results are contained within the WYG factual report⁴⁰ (enclosed in Volume 3 Appendix 6.2). The exploratory hole positions are shown on Volume 2 Figures 6.1A to 6.1C.

Encountered Ground conditions

6.11.39 Based on the results of the ground investigation across the site, the ground conditions typically comprise topsoil overlying weathered bedrock, with the degree of weathering typically reducing with depth. Localised areas of made ground were encountered in some of the exploratory holes, as summarised in a table below. No other superficial deposits were encountered during the ground investigation, however, the geological map indicated localised areas of glaciofluvial deposits and till.

⁴⁰ Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016

Table 6.4 Summary of encountered made ground

Scheme chainage	Exploratory hole	Depth of base (mbgl)	Description	Likely origin
1+300	TP20	0.25	Brown clayey gravel. Gravel is fine to medium angular to subangular mudstone, sandstone, tile, brick and metal wire.	Materials placed within a field. Likely to be localised.
	BH14	0.85	Dark grey brown sandy clayey gravel underlain by soft to firm brown silty slightly gravelly clay.	
1+780	BH12	4.1	Hardcore with dark grey clay underlain by brown clayey sandy fine to coarse sub-angular to angular gravel of mudstone and sandstone.	Possibly fill of a historical quarry
1+940	BH102	0.8	Soft brown slightly sandy clay with many gravel of mudstone.	Materials associated with construction of the layby.
Llanddewi Velfrey Roundabout	TP03	3.1	Soft brown sandy gravelly clay. Gravel is fine to coarse angular to sub-angular brick (including partial brick wall), metal, plastic, tile and concrete. Numerous cobble and boulder sized pieces.	Possibly fill of a historical quarry.
	TP01	0.5	Dark grey slightly sandy, slightly clayey angular to sub-angular fine to coarse mudstone gravel with some cobbles and boulders.	Materials associated with the road embankment
	BH01	1.5	Boulders of mudstone.	

6.11.40 The details including the descriptions of the encountered soils and rock, and geological cross sections are presented in the Arup GIR⁴¹, enclosed in Volume 3 Appendix 6.3.

Groundwater

6.11.41 The detailed review of the groundwater monitoring has been undertaken in the Arup GIR (enclosed in Volume 3 Appendix 6.3) and summarised below.

⁴¹ Welsh Government, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, ref. A40LVP-ARP-VGT-SWI-RP-C-0001, Arup, July 2017

- 6.11.42 During the investigation, groundwater strikes were recorded in majority of the borehole locations between 1 and 6 m below ground level (74.9 to 126.5 mOD), primarily in the weathered rock or conglomerate strata. Refer to Appendix C of the GIR, enclosed in Volume 3 Appendix 6.3 of the ES.
- 6.11.43 Eight boreholes, namely BH01, BH04, BH08, BH10, BH11, BH12, BH17 and BH102, were equipped with groundwater monitoring instrumentation with the installation response zones within the Slade and Redhill Formation. Following the field works, three rounds of groundwater monitoring were undertaken in May and June 2016. The results of the groundwater monitoring are presented in the Arup GIR, enclosed in Volume 3 Appendix 6.3. The location of the monitoring wells is marked on Volume 2 Figures 6.1A to 6.1C.
- 6.11.44 In summary, groundwater monitoring recorded depths ranging from 0.2m to 4.4m and elevations ranging from 65.9mAOD and 95.9mAOD in BH01, BH08, BH11 and BH17. In each borehole, the installation response zone was within the Slade and Redhill Formation. No significant groundwater level variations were recorded during the monitoring period.
- 6.11.45 BH04, BH10, BH12 and BH102 remained dry during the three visits. With the exception of BH12, these boreholes were located at higher points in the topography and therefore it is anticipated the response zone of the installation may not have been within the main groundwater body.
- 6.11.46 Seepages were recorded when boring BH04, BH10 and BH102. In accordance with a standard practice, long term monitoring installations were placed to confirm the equilibrium groundwater levels. The long-term monitoring showed dry conditions over the installation response zones during the monitoring period, indicative of a low groundwater table. The seepages during boring have therefore been interpreted as being associated with pockets of perched water rather than a groundwater table. There are also a number of springs located on hillsides at higher points in the topography as indicated on Volume 2 Figures 6.1A to 6.1C. Based on the groundwater monitoring data and review of the hydrogeological model, it is anticipated that these seepages and springs are associated with groundwater flows through more permeable bands in the weathered bedrock and are not necessarily associated with the main groundwater body.

Unexploded Ordnance

- 6.11.47 The area of the Proposed Scheme has been reviewed for the potential presence of Unexploded Ordnance (UXO). No Ministry of Defence sites or strategic sites that may have been targeted during WWII have been identified. In the unlikely event that a bomb was dropped on the site during WWII, due to the general lack of superficial deposits and presence of rock from the ground surface, the bomb would have either detonated on impact or remained on the ground surface and would have been dealt with. Therefore, the UXO risk for the Scheme is low and the presence of UXO is considered to be very unlikely.

Land Contamination

- 6.11.48 This section presents the Conceptual Site Model for the existing baseline conditions and identifies potential sources, receptors and pathways and plausible pollution linkages that will allow the assessment of the likely impacts of land contamination.

Potential Sources

- 6.11.49 The potential sources of contamination identified in relation to the study area are summarised in Table 6.5. A review of chemical testing of soils and groundwater, and ground gas monitoring is presented in sections below. No past industrial uses and no petrol filling stations have been identified within the Scheme area.

Table 6.5 Summary of identified potential sources of contamination

Potential sources	Potential Contaminants
On-site (within Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C)	
<p>Made ground associated with the existing road infrastructure; Encountered in TP01, BH01 and BH102 (2016). Refer to Table 6.4 for descriptions.</p> <p>Penblewin Roundabout to chainage 1+950 and Llanddewi Velfrey Roundabout</p>	Metals, hydrocarbons, asbestos, ground gas
<p>Activities associated with the operation of the existing road network and agricultural activities located within the proposed Scheme alignment and its close proximity. These activities may have resulted in accidental spillages or leakages of fuel;</p> <p>Penblewin Roundabout to chainage 1+950 and Llanddewi Velfrey Roundabout</p>	Metals, hydrocarbons
<p>Made ground possibly associated with agricultural activities; encountered in TP20 and BH14 (2016). Refer to Table 6.4 for descriptions.</p> <p>Scheme chainage 1+300.</p>	Metals, hydrocarbons, asbestos, ground gas
<p>Historical infilled quarries or gravel pits (fill of unknown origin) located within or adjacent to the proposed Scheme alignment:</p> <p>A disused possibly infilled gravel pit adjacent to the proposed alignment at approximate chainage 0+450m;</p> <p>An infilled disused quarry located adjacent to the proposed alignment from approximate chainage 1+750m to 1+800m; Encountered in BH12 (2016). Refer to Table 6.4 for description.</p> <p>Two disused possibly infilled gravel pits located adjacent to the proposed alignment at approximate chainages 2+850m and 3+250m;</p> <p>A disused possibly infilled quarry encroaching on the southern edge of the proposed alignment at approximate chainage 3+850; Encountered in TP03 (2016). Refer to Table 6.4 for descriptions.</p>	Metals, hydrocarbons, asbestos, ground gas
Off-site (outside Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C)	
<p>Sewage discharge to ground (via a soakaway) located approximately 140m north of the proposed alignment at approximate chainage 1+700m.</p>	<p>This may have resulted in groundwater becoming impacted by sewage and related contaminants such as metals and ammoniacal nitrogen.</p>
<p>Sewage treatment works located approximately 160m of the proposed alignment at chainage 2+180m.</p>	

Potential sources	Potential Contaminants
Trefanor Burial Ground located approximately 210m north of the proposed alignment at approximate chainage 1+120m.	Contaminants including metals leaching into groundwater and migrating into the Scheme area.
<p>Historical infilled quarries (fill of unknown origin) located in the vicinity of the proposed Scheme alignment (300m radius):</p> <p>A disused possibly infilled quarry located approximately 190m north of Penblewin Roundabout;</p> <p>A disused possibly infilled sand, gravel and clay pit approximately 250m north of Penblewin Roundabout;</p> <p>A disused possibly infilled gravel pit located approximately 260m south of the proposed alignment at approximate chainage 0+750m;</p> <p>A disused possibly infilled quarry located approximately 30m north of the proposed alignment at approximate chainage 1+300m;</p> <p>An infilled disused quarry located approximately 40m north of the proposed alignment at approximate chainage 1+700m;</p> <p>A disused possibly infilled gravel pit located approximately 100m south of the proposed alignment at approximate chainage 2+400m;</p> <p>A disused possibly infilled sand/gravel pit located approximately 50m south of the proposed alignment at approximate chainage 3+550; and</p> <p>In addition to the above, a possible disused pit has been identified at chainage 3+740m.</p>	Metals, hydrocarbons, ground gas migrating into the Scheme area.

- 6.11.50 Made Ground materials were encountered in seven exploratory holes located across the Scheme alignment, as detailed in Tables 6.4 and 6.5.
- 6.11.51 No visual or olfactory evidence of contamination with hydrocarbons or asbestos was observed during the field works. The encountered Made Ground materials in the majority of the cases comprised reworked natural materials with low potential for significantly elevated levels of contaminants. However, unidentified isolated areas of hydrocarbon contamination, resulting from with the use of the existing road network e.g. accidental spillages and leakages of fuel, may be present.
- 6.11.52 Five soil samples were subjected to laboratory testing for the presence of contaminants. The samples were obtained from the Made Ground encountered in five exploratory holes (TP01, TP03, BH12, TP20 and BH102). The results are summarised in Table 6.6 below and presented

in Volume 3 Appendix 6.4. Laboratory certificates are enclosed in the 2016 WYG factual report⁴² (enclosed in Volume 3 Appendix 6.2). The assessment of the risks to human health associated with the soil quality undertaken in accordance with the methodology set out in Section 6.6, is presented in Sections 6.10.63 to 6.10.67.

Table 6.6 Summary of chemical soil testing results (mg/kg)

Contaminant	Minimum concentration	Maximum concentration
Arsenic	11.5	22.5
Barium	63	245
Beryllium	1	1.6
Cadmium	<0.1	0.4
Chromium	42.6	54.8
Copper	15	39
Lead	8	48
Mercury	<0.1	0.2
Nickel	18.2	38.1
Selenium	<1	1
Vanadium	19	34
Water Soluble Boro	0.4	1
Zinc	41	371
Total aliphatics and aromatics(C5-35)	<38	583
pH	6.73	8.27
Asbestos	Not detected	Not detected

- 6.11.53 Groundwater level monitoring was undertaken as part of the investigation; however, no chemical laboratory testing was undertaken on samples of groundwater.
- 6.11.54 One round of ground gas monitoring was undertaken in June 2016 within the monitoring installations as detailed in Section 6.6.35.
- 6.11.55 The measured gases included methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide. Gas flow rates were also obtained. The ground gas monitoring results are presented in in WYG factual report⁴³ (enclosed in Volume 3 Appendix 6.2).

⁴² Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016

⁴³ *ibid*

- 6.11.56 In summary, methane and carbon dioxide were measured at low concentrations (0.1 – 0.2 %v/v and 0.5 to 3.3%v/v respectively). The gas flow was measured below the detection level of 0.1 l/hr. The gas screening values (GSVs) were calculated using the maximum measured concentration of methane (0.2% w/w) and of carbon dioxide (3.3% w/w) with the maximum measured flow rate of 0.1 l/hr. The derived GSVs are 0.0002 l/hr for methane and 0.0033 l/hr for carbon dioxide. This indicates a very low risk from ground gases.

Potential Receptors

- 6.11.57 Potential receptors to the identified sources of potential contamination within the study area are as follows:

1. Human receptors:

- a) Residents and workers of the farms located in the vicinity of the Scheme such as:
 - i. Penblewin, located at Penblewin Roundabout.
 - ii. Caermaenau-fach, located approximately 20m south of the Scheme at chainage 0+600.
 - iii. Trefangor Farm, located approximately 20m south of the Scheme at chainage 0+750 to 0+950.
 - iv. Trefangor Cottage, located within the Scheme at chainage 1+080.
 - v. Residential property, located adjacent to the Scheme at chainage 1+250.
 - vi. Ffynnon Farm, located adjacent to the Scheme at chainage 1+600 to 1+700.
 - vii. Pen-troydin-fach, located 50m north to the Scheme at chainage 2+220 to 2+400.
 - viii. Maes-y-ffynnon, located 50m south to the Scheme at chainage 2+320 to 2+400.
 - ix. Pen-troydin-fawr, located 80m north to the Scheme at chainage 2+750 to 2+850.
- b) Users of the agricultural land.
- c) Maintenance workers of the existing A40.
- d) Users of the existing A40 road, including motorised and non-motorised users (such as cyclists, pedestrians, horse riders, etc).

2. Environmental receptors:

- a) Surface watercourses and associated springs identified in Sections 6.5.21 to 6.5.22.

- b) Ponds identified in Section 6.5.23.
- c) Water abstraction points as listed in Sections 6.5.25 to 6.5.26.
- d) Groundwater beneath the site (secondary aquifers).

6.11.58 Residents and workers of the farms, and the existing highway maintenance workers are considered the most sensitive receptors to be impacted by regular and long-term exposure to the areas of potential contamination. The users of both the road and agricultural land are considered less sensitive due to a likely short-term duration and infrequent exposure.

Potential Pathways

6.11.59 The preliminary pathways between identified sources of contamination and receptors are as follows:

1. Human health:

- a) Ingestion of soils and dust.
- b) Inhalation of dust, gases and volatile hydrocarbon contamination.
- c) Dermal contact with soils, dust and groundwater.
- d) Gas migration from made ground into near surface.

6.11.60 As regular maintenance works typically do not involve deep excavations, no direct exposure to groundwater or ground gas/vapours is likely to occur.

6.11.61 Risk of exposure to ground gas is considered to be low, as no elevated levels of ground gas were measured during the ground investigations.

2. Controlled waters:

- a) Vertical and lateral migration of contaminants released to the ground through spillage or leaks; particularly from the uses of the existing road infrastructure or agricultural land, and the potential for vertical or lateral migration through the underlying strata.
- b) Soil leachate generation and migration from made ground materials.
- c) Made ground materials that remain on-site may leach contaminants into the underlying groundwater resulting in contamination. The groundwater may flow towards the identified surface water features or abstraction points. There is potential therefore for the contamination present within the made ground materials to impact surface water or groundwater quality via lateral groundwater migration. Equally contamination that may be

present hydraulically up gradient of the Scheme may impact the quality of groundwater beneath the Scheme area.

Plausible Pollution Linkages

6.11.62 The plausible pollution linkages are summarised in Table 6.7 below.

Table 6.7 Identified Baseline Source-Pathway-Receptor Linkages within the study area

Sources	Pathways	Receptors	Comments
<p><i>On-site (within Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C)</i></p> <p>a) Made ground associated with: b) Existing road network c) Agricultural activities</p> <p>Historical infilled quarries/ gravel pits</p> <p>Leaks and spillages from operation of the existing road network and agricultural activities.</p> <p>Groundwater impacted by off-site sources.</p>	<p>Direct exposure to soil and/or soil dust via ingestion, dermal contact and inhalation</p>	<p><u>Human health:</u> Residents and workers of the farms; Existing A40 maintenance workers and users; Agricultural land users;</p>	<p>Maintenance workers and highway users may be directly exposed to soil and dust generated from made ground in areas of soft landscaping.</p> <p>The risk of significant levels of contaminants is low as no evidence of contamination has been observed during the completed ground investigations.</p> <p>Users of the existing A40 and surrounding agricultural land are unlikely to be significantly impacted by contamination due to short-term exposure only.</p>
<p><i>Off-site (outside Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C)</i></p> <p>Sewage treatment works, sewage soakaway, burial ground, infilled quarries/ gravel pits</p>	<p>Leaching and migration</p>	<p><u>Controlled waters:</u> Surface water features (streams, springs and ponds); Groundwater secondary aquifers; Water abstractions;</p>	<p>Potential contaminants within the identified sources may leach to groundwater and via lateral migration have potential to impact the controlled waters quality.</p>

Assessment of Potential Impact of Baseline Conditions on Human Health

6.11.63 The above indicates that for the current baseline conditions the potential plausible pollution linkage is:

- a) Maintenance workers direct exposure to made ground materials.

6.11.64 Therefore, a Generic Quantitative Risk Assessment (GQRA) has been carried out to assess the risks in more detail, as presented below.

Generic Quantitative Risk Assessment (GQRA)

6.11.65 Following the methodology set out in Section 6.6, a GQRA has been carried out to assess the risks posed at the baseline conditions of the Scheme, as presented below. This has taken into account the results obtained from the ground investigation completed within the Scheme area, presented in the WYG factual report⁴⁴, enclosed in Volume 3 Appendix 6.2.

6.11.66 Considering the identified receptors, the maintenance workers of the existing A40, the available soil testing from the area of the proposed Scheme, have been screened against the assessment criteria for a commercial end use scenario, which is considered appropriate for the likely exposure scenario.

6.11.67 This indicated no exceedances of the applied assessment criteria and therefore the identified potential soil sources of contamination at baseline conditions are unlikely to pose a risk to the identified receptors.

Assessment of Potential Impact of Baseline Conditions on Controlled Waters

6.11.68 Localised areas of made ground were encountered during the 2016 ground investigations and a review of the Scheme area history indicates the presence of backfilled historical quarries/pits. Under the current baseline conditions, leaching of contaminants from the identified potential sources of contamination may be occurring, which may have a potential detrimental impact on controlled waters.

⁴⁴ Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016

- 6.11.69 No soil leachate testing has been undertaken on these made ground materials. However, considering the localised and isolated nature of the made ground and that no evidence of significant contamination has been encountered it is unlikely that made ground would significantly impact the quality of the underlying groundwater.

Future Baseline Conditions

- 6.11.70 Consideration has been given to the potential for changes in the baseline conditions in the medium to long-term as a result of climate change. The Climate Change Risk Assessment for Wales⁴⁵ has been reviewed, together with other climate change prediction tools.
- 6.11.71 As a result of climate change it is considered that there would not be significant change to the baseline conditions with respect to geological conditions or soil quality (sources of contamination). Climate change may however impact to a certain extent the hydrological and to a lesser extent hydrogeological conditions, due to more extreme weather conditions resulting in wetter winters and dryer summers.
- 6.11.72 The Proposed Scheme area is underlain by relatively poor groundwater resources, which are limited to groundwater accumulating in more permeable bands of the bedrock. These support local water supplies or recharge to springs. Reduced precipitation may in the long term reduce the recharge of these bands and therefore impact the local water supply or reduce water flows within streams. This is addressed in more detail in the Road Drainage and Water Environment Chapter 7.
- 6.11.73 There is no planned in a foreseeable future remedial action with respect identified sources of contamination, therefore the baseline conditions in that respect remain unchanged.

6.12 Potential Construction Effects – Before Mitigation

- 6.12.1 This section presents assessment of impact that the construction may have on geology, geomorphology and land contamination. The potential effects of construction works on agricultural soils has been considered as part of Chapter 11 Community and Private Assets of this ES. Issues associated with on-site materials storage, hydrogeology,

⁴⁵ Welsh Government, A climate change risk assessment for Wales, HR Wallingford, January 2012

flooding and drainage discharge are considered in Chapter 16 Materials and Chapter 7 Road Drainage and Water Environment.

Geology and Geomorphology

Assessment of Potential Impact of Construction of Earth Embankments

- 6.12.2 The construction of the embankments (up to 24m height) can result in ground consolidation due to the applied load of the embankment materials onto the underlying ground impacting the ground permeability.
- 6.12.3 The construction of earth embankments is unlikely to result in significant consolidation of the soils. Some insignificant consolidation may occur in the upper layers of the weathered bedrock, near the surface, particularly where it consists of cohesive materials, or in localised areas of alluvium associated with the watercourses or made ground. Any soft materials prone to consolidation that are encountered during construction works would be removed and replaced with competent materials to prevent significant differential settlements.
- 6.12.4 Therefore, the construction of the embankments is unlikely to result in a reduction in permeability of the underlying materials, and therefore no impact on the groundwater movement is anticipated.
- 6.12.5 The sensitivity of the impacted geology/hydrogeology is considered low due its local importance with respect to potential resource for groundwater abstraction with a negligible magnitude of impact. Consequently, the significance of effect of the construction of the earth embankments on the geology is considered to be *neutral*.

Assessment of Potential Impact of Construction of Cuttings

- 6.12.6 The construction of the cuttings, as presented on Volume 2 Figures 6.1A to 6.1C, could result in removal of the underlying mineral resources, or locally impacting hydrological and hydrogeological regime within the Scheme area.
- 6.12.7 Mineral resources of regional importance are located within the footprint of Cutting 2. The construction of the cutting to depths of up to 15m, based on the interpretation of the ground investigation results, is likely to remove the resource from within the Scheme footprint and

would limit access to these resources in its direct vicinity. However, considering the limited extent of the impacted areas, access to the vast majority of these resources would not be affected.

6.12.8 The sensitivity of the impacted mineral resources is considered to be medium due to their regional importance with some potential for replacement. The magnitude of impact is considered to be minor. This is because although the Scheme may result in the partial loss of these resources of regional importance, the loss is not considered significant. Consequently, the significance of effect of the construction of the cuttings on the mineral resources is considered to be *slight adverse*.

6.12.9 The construction of the cuttings would require use of a groundwater control system to the base of the excavation. This may result in lowering of the groundwater level in proximity of the works. This may also lead to a reduction in water entering the catchment area of the local surface watercourses. Therefore, the construction of the cuttings may impact the quantity of water fed into springs and associated downstream watercourses. An assessment of potential impact of the three proposed cuttings on the identified surface water features and groundwater abstraction is presented in Chapter 7 Road Drainage and Water Environment.

Assessment of Potential Impact of Construction of Structures

6.12.10 The construction of the structures such culverts or underpasses will be undertaken as part of the embankment construction and therefore will have no additional impact on the underlying geology.

6.12.11 The construction of the attenuation ponds will require shallow excavations and will include removal of the weather bedrock. Considering the localised nature of these works and the extent of the proposed ponds their impact on the underlying geology is considered negligible.

6.12.12 Mineral resources of regional importance are located within the footprint of the proposed Pond A. The construction of the 2-4m deep pond, based on the interpretation of the ground investigation results, is unlikely to remove the resource from within the pond footprint and would limit access to the resources remaining beneath the pond and in its direct vicinity. However, considering the limited extent of the

impacted areas, access to the vast majority of these resources will not be affected.

- 6.12.13 The construction of the overbridge and a footbridge will require construction of the foundations. Considering the underlying ground conditions these structures are likely to require shallow foundations and therefore only localised excavations will be required. These also are likely to have a negligible impact on the underlying geology or mineral resources. The sensitivity of the local geology within the Scheme is low. Therefore, overall the construction of the structures is considered to have a *neutral* significance of effect on the Scheme geology.

Soils

- 6.12.14 The potential effects of construction works on agricultural soils has been considered as part of Chapter 11 Community and Private Assets.

Land Contamination

- 6.12.15 The construction works would introduce new pollution linkages into the baseline conceptual site model. The revised conceptual site model is detailed below and summarised in Table 6.8.
- 6.12.16 The review of the identified potential sources, receptors and pathways and plausible pollution linkages, as detailed in sections below, allows for assessment of the likely impacts of land contamination on the existing baseline conditions.

Potential Sources

- 6.12.17 The potential baseline sources of contamination identified in relation to the study area are presented in Section 6.10.49 and Table 6.5. The construction works would introduce the following additional sources as a result of construction activities:
- a) Areas of unexpected contamination that would be encountered and excavated as a result of construction works.
 - b) Imported and site won construction materials e.g. for the construction of the earth embankments. However, as detailed in Section 6.10, the reuse of site won or import of materials to the Scheme will be managed by a verification system applied via the Specification for Highway Works, Series 600 – Earthworks, and only materials found suitable for use with respect to human health and controlled waters would be acceptable for construction works.

Consequently, construction materials are not considered to be a viable source of contamination and will not be considered further.

- c) Dust derived from areas of made ground (including fill of infilled historical quarries) created during construction.
- d) Groundwater removed as a result of dewatering of cuttings.

Potential Receptors

6.12.18 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in Section 6.5.54 and Table 6.7. The construction works would introduce the following additional receptors:

- a) Construction workers: It has been assumed that the construction workers include adults and also apprentices aged 16 and above. Based on Section 6.10, application of appropriate health and safety management during construction would mitigate exposure of construction workers to identified sources of contamination. Therefore, construction workers are not considered further in the assessment of effects.

Potential Pathways

6.12.19 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 6.10.59 to 6.10.61 and Table 6.7. The construction works would introduce the following additional pathways:

- a) Direct discharge of groundwater removed from ground as a result of dewatering operations. Based on Section 6.10, discharge of groundwater removed from ground would be regulated by appropriate permits/approvals. This would mitigate potential impact on the surface water quality. Therefore, this pathway is not considered further.
- b) Direct exposure to soils/dust or groundwater (such as ingestion, dermal contact and/or inhalation of vapours) during excavation works. Based on Section 6.10, application of appropriate health and safety management and pollution control during construction would break the pathway of exposure to identified sources of contamination. Therefore, this pathway is not considered further in the assessment of effects.

Plausible Pollution Linkages

6.12.20 The plausible pollution linkages are summarised in Table 6.8 below.

Table 6.8 Identified Source-Pathway-Receptor Linkages during Construction within the study area

Sources	Pathways	Receptors	Comments
<p><u>Baseline sources:</u> <i>On-site (within Scheme footprint as shown Volume 2 Figures 6.1A to 6.1C)</i> a) Made ground associated with: b) Existing road network c) Agricultural activities Historical infilled quarries/ gravel pits Localised leaks and spillages of petroleum products from operation of the existing road network and agricultural activities. Groundwater impacted by off-site sources. <i>Off-site (outside Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C):</i> Sewage treatment works, sewage soakaway, burial ground, infilled quarries/ gravel pits <u>Additional sources during construction</u> Unexpected contamination Imported and site won construction materials Dust created during construction Groundwater removed from ground during dewatering</p>	<p>Direct exposure to soil and/or soil dust via ingestion, dermal contact and inhalation Inhalation of gas and volatile contamination</p>	<p><u>Human health:</u> Residents and workers of the farms; Existing A40 maintenance workers and users; Agricultural land users; <i>Additional during construction works</i> Construction workers;</p>	<p>Construction workers, and also the existing A40 maintenance workers and highway users may be directly exposed to soil and potentially contaminated dust generated from made ground during construction. The risk of significant levels of contaminants is low as no evidence of contamination has been observed during the completed ground investigations. Application of appropriate health and safety management and pollution control during construction is considered sufficient to mitigate any impacts. Risk of exposure to ground gas is considered to be low, as no elevated levels of ground gas were measured during the ground investigations.</p>
	<p>Leaching and migration</p>	<p><u>Controlled waters:</u> Surface water features (streams, springs and ponds); Groundwater secondary aquifers; Water abstractions;</p>	<p>Potential contaminants within the identified sources may leach to groundwater and via lateral migration have potential to impact the controlled waters quality. Surface run-off where made ground is exposed during excavation works may impact surface water receptors. However, no areas of made ground have been identified in the vicinity of the surface waters, and therefore no risk to surface water from potentially impacted made ground is anticipated. During dewatering, groundwater removed from the cuttings will require discharge, which may impact the quality of the surface watercourses. However, any discharge would be regulated by appropriate permits/approvals and therefore unlikely to pose risk to surface water quality.</p>

Unexpected contamination

- 6.12.21 Considering the limited historical development within the proposed Scheme area, there is limited risk of encountering unexpected contamination at localised areas during the construction works. However, should unexpected contamination be encountered this may pose a risk to the construction workers and controlled waters.
- 6.12.22 The sensitivity of the receptors is considered to be medium (Secondary aquifer and moderate WFD surface water classification). The potential magnitude of impact is minor adverse due to the likely localised nature of the unexpected contamination (providing that best practice is implemented). Therefore, the significance of effect is considered to be *slight adverse*.

Assessment of Potential Impact of Construction Works on Human Health

- 6.12.23 Although the construction works would introduce new pollution linkages into the baseline conceptual site model as shown in Table 6.8 above with respect to human health, based on inbuilt mitigation measures presented in Section 6.10 such as health and safety management and pollution control measures, the impact on identified receptors is considered to be negligible. The sensitivity of a resident as a receptor is considered very high. Consequently, the significance of effect of the construction of the Scheme on land contamination is *slight adverse*.

Assessment of Potential Impact of Construction Works on Controlled Waters

- 6.12.24 Although the construction works would introduce new pollution linkages into the baseline conceptual site model as shown in Table 6.8 above with respect to controlled waters, based on inbuilt mitigation measures presented in Section 6.10 such as pollution control measures and the requirement to obtain regulatory consents/approvals with respect to discharge, the impact on identified receptors is considered to be negligible. Considering the high to medium sensitivity of the surface water as a receptor, construction of the Scheme would result in a *slight adverse* significance of effect.
- 6.12.25 Localised areas of made ground were encountered during the 2016 ground investigations and a review of the Scheme area history indicates

the presence of backfilled historical quarries/pits. However, none of these areas of potential made ground has been identified in a vicinity of the identified surface water receptors. Therefore, these areas of made ground are unlikely to impact the quality of the surface water receptor as a result of construction activities and would result in no change to the baseline scenario with a *neutral* significance of effect.

6.13 Potential Operational Effects - Before Mitigation

- 6.13.1 This section presents the assessment of impact that the operation of the Scheme may have on geology and geomorphology and land contamination. The potential effects of operation on agricultural soils has been considered as part of Chapter 11 Community and Private Assets of this ES. Issues associated with hydrogeology, flooding and drainage discharge are considered in Chapter 7 Road Drainage and Water Environment.

Geology and Geomorphology

Assessment of Potential Impact of Earth Embankments during Operation

- 6.13.2 The construction of the embankments could result in eliminating access to the underlying mineral resources, or further ground consolidation due to the applied load of the embankment materials unto the underlying ground impacting the ground permeability.
- 6.13.3 Mineral resources of regional importance are located directly to the north of the proposed Scheme, which locally encroaches on these deposits. The presence of the embankments would eliminate access to the deposits within the Scheme footprint and in its direct vicinity. However, considering the limited extent of the impacted areas, access to the vast majority of these resources will not be affected.
- 6.13.4 Mineral resources of national importance transect the western part of the Scheme. Access to these deposits is currently limited by the existing A40 and construction of Embankment 2 will further limit it. The estimated loss of resources has been estimated at 10% in surface.
- 6.13.5 The sensitivity of the impacted mineral resources is considered to be high due to their regional and national importance. The magnitude of impact is considered to be minor. This is because although the Scheme

may result in the partial loss of these resources of regional/ national importance, the loss is not considered significant. Consequently, the significance of effect of the presence of the earth embankments on the mineral resources is considered to be *slight adverse*.

- 6.13.6 During the operational phase, it is unlikely that the embankment would result in any further consolidation of the soils due to the applied load of the embankment materials. Therefore, there is unlikely to be a further significant reduction in the soils permeability and consequent localised changes to the groundwater movement. Consequently, the effect of the construction of the earth embankments on the geology is considered to be *neutral*.
- 6.13.7 However, the embankments may have an impact on water flow during flooding events. Issues associated with flooding are considered in Chapter 7 Road Drainage and Water Environment.

Assessment of potential Impact of Operation of Cuttings

- 6.13.8 The operation of the cutting would have no additional impact on the underlying geology with a *neutral* significance of effect. The operation of the cuttings could locally impact hydrological and hydrogeological regime within the Scheme area.
- 6.13.9 The Scheme areas where construction of cuttings was required would be equipped with drainage the purpose of which would be to control groundwater level and collect groundwater issues from the slopes formed within the rock. This is likely to impact the groundwater flow direction and levels. An assessment of potential impact of the three proposed cuttings on the identified surface water features and groundwater abstraction is presented in Chapter 7 Road Drainage and Water Environment.

Assessment of potential Impact of Operation of Structures

- 6.13.10 The operation of the structures such culverts or underpasses will have no additional impact on the underlying geology with a *neutral* significance of effect.

Soils

- 6.13.11 The potential effects of operational phase on soils has been considered as part of Chapter 11 Community and Private Assets.

Land Contamination

- 6.13.12 The operation of the Scheme would introduce new pollution linkages into the baseline conceptual site model. The revised conceptual site model is detailed below and summarised in Table 6.9. The assessment of individual pollution linkages is presented in the sections below.
- 6.13.13 This section presents the identified potential sources, receptors and pathways and plausible pollution linkages – in order to assess the likely impacts of land contamination for the existing baseline conditions.

Potential Sources

- 6.13.14 The potential baseline sources of contamination identified in relation to the study area are presented in Section 6.5.46 and Table 6.5. The operation of the Scheme would introduce the following additional sources:
- a) Imported and site won construction materials e.g. for the construction of the embankment. Based on inbuilt mitigation presented in Section 6.10, any materials used within the Scheme construction would be subjected to verification with respect to suitability for reuse and therefore materials reused within the Scheme are not considered a potential source of contamination.
- 6.13.15 The assessment of pollution release as a result of operation is covered in Chapter 7 Road Drainage and Water Environment.

Potential Receptors

- 6.13.16 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in Section 6.10.57 and Table 6.7. The operation of the Scheme would introduce the following additional receptors:
- a) Maintenance workers.
 - b) Road users, including motorised and non-motorised users (such as cyclists, pedestrians, horse riders, etc).

Potential Pathways

- 6.13.17 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 6.10.59 to 6.10.61 and Table 6.7. The operation of the proposed Scheme would introduce the following additional pathways:

- a) Direct exposure to soils or dust (such as ingestion, dermal contact and/or inhalation of vapours).
- b) Leaching of contaminants from materials used for the construction.

Plausible Pollution Linkages

6.13.18 The plausible pollution linkages are summarised in Table 6.9 below.

Table 6.9 Identified Source-Pathway-Receptor Linkages during Scheme Operation within the study area

Sources	Pathways	Receptors	Comments
<p><u>Baseline sources:</u> <i>On-site (within Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C):</i> a) Made ground associated with: b) Existing road network c) Agricultural activities Historical infilled quarries/ gravel pits Localised leaks and spillages of petroleum products from operation of the existing road network and agricultural activities. Groundwater impacted by off-site sources.</p> <p><i>Off-site (outside Scheme footprint as shown on Volume 2 Figures 6.1A to 6.1C):</i> Sewage treatment works, sewage soakaway, burial ground, infilled quarries/ gravel pits</p> <p><u>Additional sources during Scheme operation</u> Imported and site won construction materials.</p>	<p>Direct exposure to soil, soil dust and/or groundwater via ingestion, dermal contact and inhalation Inhalation of gas and volatile contamination</p>	<p><u>Human health:</u> Existing A40 maintenance workers and users; Agricultural land users; <i>Additional during Scheme operation;</i> Maintenance workers; Scheme users;</p>	<p>Maintenance workers, and also the existing A40 (which will remain operational and will run in parallel to the new road) maintenance workers and highway users may be directly exposed to soil, soil dust generated from made ground during maintenance works and/or contaminated groundwater if deep excavations are undertaken. Materials used within the Scheme are not considered a source.</p> <p>There is a potential risk of ground gas upward migration into confined spaces e.g. manholes. However, the risk of exposure to ground gas is considered to be low, as no elevated levels of ground gas were measured during the ground investigations.</p>
<p><u>Additional sources during Scheme operation</u> Imported and site won construction materials.</p>	<p>Leaching and migration</p>	<p><u>Controlled waters:</u> Surface water features (streams, springs and ponds); Groundwater secondary aquifers; Water abstractions;</p>	<p>Potential contaminants within the identified sources may leach to groundwater, which may have potential to impact the river quality via lateral migration.</p>

Assessment of Potential Impact of Operation of the Scheme on Human Health

- 6.13.19 The operation of the Scheme would introduce potential pollution linkages into the baseline Conceptual Site Model.
- 6.13.20 Maintenance workers would undertake regular maintenance works within the Scheme area. They may therefore be exposed to sources identified within the baseline model, i.e. made ground that has not been removed as a result of construction. The exposure pathways would primarily include exposure to potentially impacted soil dust via ingestion, inhalation and dermal contact. Note that potential impacts caused by dust generation during construction is assessed by Chapter 13 Air Quality.
- 6.13.21 As discussed in Sections 6.11.17 and 6.11.18, although there is a potential for the groundwater beneath the proposed Scheme to be impacted by contamination it is considered unlikely that it would pose a significant risk to human health. Therefore, should exposure to groundwater occur during maintenance works, which may involve excavations, the risk of significant impact on human health is considered very low and therefore this pollution linkage will not be considered further.
- 6.13.22 The Scheme users are unlikely to be impacted by any potential contamination within the Scheme area, due to a very short-term exposure, and are therefore not considered further.
- 6.13.23 The Scheme neighbours such as residents and workers of farms located in the Scheme vicinity are unlikely to be exposed to sources within the Scheme area due to their distance from the sources and are therefore not considered further. The above indicates that the operation phase of the Scheme would create new potential plausible pollution linkages such as:
- a) Maintenance workers direct exposure to made ground materials located outside the Scheme footprint.
- 6.13.24 Therefore, a Generic Quantitative Risk Assessment (GQRA) has been carried out to assess the risks in more detail, as presented below.

Generic Quantitative Risk Assessment (GQRA)

- 6.13.25 Following the methodology set out in Sections 6.6.24 to 6.6.25, a GQRA has been carried out to assess the risks posed by the operation of the Scheme, as presented below. This has taken into account the results obtained from the ground investigation completed within the Scheme area, presented in the WYG factual report⁴⁶ enclosed in Volume 3 Appendix 6.2.
- 6.13.26 Considering the identified receptors, the Scheme maintenance workers, the available soil test results from the area of the proposed Scheme have been screened against the assessment criteria for a residential end use scenario. This is considered appropriate for the likely exposure scenario, where as a result of intrusive works, direct exposure to soil and soil dust may occur.
- 6.13.27 The assessment indicated no exceedances of the applied assessment criteria and therefore the identified potential soil sources of contamination are unlikely to pose a risk to the identified receptors. The sensitivity of the receptor is considered medium. Based on the GQRA the identified sources of potential contamination are unlikely to pose a significant risk to human health and therefore the magnitude of impact is likely to be negligible. Consequently, the significance of effect of operation of the Scheme on land contamination is considered to be *neutral*.

Assessment of Potential Impact of Operation of the Scheme on Controlled Waters

- 6.13.28 During the Scheme operation new pollution linkages may be introduced in addition to the baseline conceptual site model as shown in Table 6.7 above with respect to controlled waters. These would be associated with the use of the site won materials within the construction of the embankment. However, as detailed in Section 6.10, it has been assumed that the reuse of site won or import of materials to the Scheme will be managed by a verification system applied via the Specification for Highway Works, Series 600 – Earthworks, and only materials found suitable for use would be acceptable for use as construction materials. Therefore, their application in the Scheme construction would result in no change to the baseline scenario with a *neutral* significance of effect.

⁴⁶ Welsh Government, A40 Llanddewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016

6.14 Mitigation and Monitoring

Construction Mitigation and Monitoring

6.14.1 Assessment of the impacts that construction of the Scheme may have on geology, geomorphology and land contamination identified a number of effects as summarised in Table 6.10.

Table 6.10 Summary of construction effects

Scheme element	Effect	Significance
Geology and Geomorphology		
Earth embankments	Soil consolidation	Neutral
Cuttings	Removal of mineral resources	Slight adverse
Structures and attenuation areas	Removal of mineral resources from footprint of attenuation ponds	Neutral
	Construction of shallow foundations	
Land contamination		
Across the Scheme	Potential impact on human health and controlled waters due to localised unexpected contamination	Slight adverse
Areas of made ground	Potential impact on human health (construction workers and Scheme neighbours) due to exposure to soils/dust impacted by contamination	Neutral to slight adverse
Dewatering during construction	Potential impact on surface water receptors due to direct discharge	Slight adverse
Areas of made ground	Potential impact on surface water receptors due to surface run-off during construction	Neutral

Geology and Geomorphology

6.14.2 The completed assessments identified a number of effects with respect to geology and geomorphology as summarised in Table 6.10. The assessment indicated the overall *neutral to slight adverse* significance of effect of the construction works on the site geology and geomorphology. Therefore, no mitigation measures are considered necessary.

Land Contamination

- 6.14.3 The completed assessments identified a number of effects with respect to land contamination as summarised in Table 6.10. The assessment indicated the overall *neutral to slight adverse* effect of construction works as a result of land contamination. Therefore, no mitigation measures are considered necessary.
- 6.14.4 The absence of the requirement for mitigation is based on the following as detailed in Section 6.10:
- a) The environmental management of the construction activities would be undertaken in line with best practice as outlined in the Preliminary Construction Environmental Management Plan (Pre-CEMP) presented in Volume 3 Appendix 2.2 and as such would not have an impact on identified receptors.
 - b) Any discharge to the river would only be carried out with appropriate approval from NRW, following monitoring and if needed, treatment to ensure it is of acceptable quality.
 - c) The reuse of site won or import of materials to the Scheme will be managed by a verification system applied via the Specification for Highway Works, Series 600 – Earthworks, and only materials found suitable for use, assessed in terms of potential effects on human health and the water environment, would be acceptable for construction works.
- 6.14.5 In addition, the available soil and groundwater chemical testing results from such an action plan could be used to inform health and safety risk assessments for the construction works.
- 6.14.6 The applied environmental management best practice would as a minimum include the following considerations (refer to Volume 3 Appendix 2.2 Outline Construction Environmental Management Plan for details):
- a) Adoption of a watching brief for identification of potential contamination. The discovery of any unexpected contaminated land would require appropriate measures to limit the risk to construction workers and controlled waters.
 - b) Dust control measures to ensure that dust generation and off-site migration is minimised. This may involve dust suppression measures during excavation works, wheel washing facilities and conveyance of materials in covered wagons. Details on the proposed dust mitigation and control measures are also set out in Chapter 13 Air Quality.

- c) Water impacted by chemical contamination and/or cement would require the application of mitigation measures before discharge. Measures may include bunding around working areas to contain any overspill, the use of settlement lagoons, settlement tanks and/or silt busters.
- d) Water with high concentrations of suspended solids can arise from dewatering excavations, exposed ground, stockpiles, plant and wheel washing, site roads and disturbance of watercourse beds. Sediment control measures and dust suppression techniques would be implemented where work is to be undertaken adjacent to or within a watercourse. Disposal of silty water would be undertaken in accordance with current best practice and measures developed and agreed with NRW prior to commencement of the works. This is in addition to the approval requirements with respect to the quality of the discharge water to the river.
- e) Environmental monitoring would be undertaken through the construction period to ensure that environmentally sound working practices are adopted and maintained. NRW may require environmental sampling, particularly in relation to surface water and groundwater quality and would be consulted regarding monitoring programmes.
- f) All contractors would have a briefing on environmental protection measures to protect the water environment during site induction training. This would highlight the methods and working practices employed.

Operational Mitigation and Monitoring

6.14.7 The assessment of impact that the operation of the Scheme may have on geology, geomorphology and land contamination identified a number of effects as summarised in Table 6.11.

Table 6.11: Summary of operational effects

Scheme element	Effect	Significance
Geology and geomorphology		
Earth embankments	Soil consolidation	Neutral
	Reduced access to mineral resources	Slight adverse
Cuttings	None identified	Neutral
Structures	None identified	Neutral
Land contamination		
Materials reuse	Impact on human health and controlled waters due to the presence of materials reused within the Scheme	Neutral
Areas of made ground	Impact on human health (maintenance workers) due to exposure to soils/dust impacted by contamination	Neutral

Geology and Geomorphology

6.14.8 The assessments identified a number of effects with respect to geology and geomorphology as summarised in Table 6.11. The assessment indicated the overall *neutral to slight adverse* significance of effect of the Scheme operation. Therefore, no mitigation measures are considered necessary.

6.14.9 As no significant impacts have been identified there is no requirement for future monitoring of geology and geomorphology as a result of the Scheme.

Land Contamination

6.14.10 The completed assessments identified a number of effects with respect to land contamination as summarised in Table 6.11. The assessment indicated a *neutral* effect of the Scheme operation presented by land contamination. Therefore, no mitigation measures are considered necessary.

- 6.14.11 The absence of the requirement for mitigation is based on Section 6.9 i.e. the reuse of site won or the import of materials to the Scheme will be managed by a verification system applied via the Specification for Highway Works, Series 600 – Earthworks, and only materials found suitable for use would be acceptable for construction works.
- 6.14.12 In addition, the available soil and groundwater chemical testing results would be used to inform health and safety risk assessments for the maintenance works.
- 6.14.13 As significant impacts have been identified, there is no requirement for monitoring of land contamination during the Scheme’s operation.

Construction Effects - With Mitigation

- 6.14.14 No mitigation measures have been proposed over and above the current design proposals and therefore the construction effects, as summarised in Table 6.10, remain unchanged.

Operational Effects - With Mitigation

- 6.14.15 No mitigation measures have been proposed over and above the current design proposals and therefore the construction effects, as summarised in Table 6.11, remain unchanged.