



Llywodraeth Cymru
Welsh Government

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A487 New Dyfi Bridge

Environmental Statement –
Volume 1: Chapter 10 Geology
and Soils

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10 Geology and Soils

10.1 Introduction

10.1.1 This chapter of the Environmental Statement (ES) describes and characterises the baseline geological setting of the proposed A487 New Pont-ar-Ddyfi 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.

10.1.2 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 Scheme both during construction and operational phases.

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

10.1.4 The relevant site specific information used for the derivation of the baseline and to support the assessments is presented within the following appendices within Volume 3 of this ES:

- Appendix 10.1 Preliminary Sources Study Report;
- Appendix 10.2 Ground Investigation Report;
- Appendix 10.3 Geotechnical Design Report;
- Appendix 10.4 Envirocheck Report;
- Appendix 10.5 Chemical Soil and Groundwater Assessment Criteria; and
- Appendix 10.6 Foundations Works Risk Assessment.

10.1.5 It should be noted that effects on the loss of agricultural land is considered within Chapter 14 Community and Private Assets, and effects on groundwater as a result of the discharge of surface water runoff from the road drainage system are considered within Chapter 15 Road Drainage and the Water Environment. The management of materials during construction, including waste disposal, is considered in Chapter 11 Materials.

10.2 Legislation, Policy Context and Guidance

Legislation

10.2.1 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 a Site of Special Scientific Interest (SSSI) or as a National Nature Reserve (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”*.

10.2.2 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:

- Part IIA of the Environmental Protection Act (1990);
- Contaminated Land (Wales) Regulations (2006 as amended in 2012);
- Environment Act (1995); and
- Environmental Permitting Regulations (2010).

10.2.3 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).

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

10.2.5 A list of additional key legislation and guidance considered within the assessment and relating contamination and water environment include:

- Water Resources Act 1991;

- EU Water Framework Directive (WFD) 2000/60/EC (as amended in 2008);
- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 which implement Water Framework Directive (2000/60/EC);
- Groundwater Regulations (1998), which transpose the EC Groundwater Directive 80/68/EC into UK law
- Groundwater Daughter Directive (GWDD) (2006/118/EC); and
- Department for Environment Food and Rural Affairs (Defra) (2015) The Water Framework Directive (Standards & Classification) Directions (England and Wales).

10.2.6 This chapter documents the assessments carried out in line with the requirements of DMRB Volume 11 Section 3 Part 11 Geology and Soils, which does not include assessment of waste production, disposal or management. This assessment is included in Chapter 11 Materials.

Policy Context

National and Regional Policy

10.2.7 Planning Policy Wales (Welsh Government, 2016) provides general guidance and information with regard to development planning throughout Wales. Planning Policy Wales provides extensive information on the planning objectives for the region, and puts particular emphasis on the need for sustainable development in terms of the resources used, the maintenance of the environment, the economic use of land and the consideration of society in the general area. Within the policy, it states the importance for the restoration of derelict and contaminated land.

10.2.8 Planning Policy Wales acknowledges that the natural heritage of Wales includes its geology and associated land forms and soils. In relation to geology, it further states that non-statutory geological designations, such as Special Landscape Areas or Sites of Interest for Nature Conservation (SINC), should be soundly based on a formal scientific assessment of the nature conservation, landscape or geological value of the site but that such designations should not unduly restrict acceptable development.

10.2.9 To comply with this requirement, some geological sites are afforded consideration at a local level by designation. Specific designations include:

- Geological Conservation Review sites (England, Scotland, Wales);
- Geoparks;

- Regionally Important Geological and Geomorphological Sites (RIGS);
- Locally Important Geological and Geomorphological Sites (LIGS); and
- Site of Importance for Nature Conservation (SINC).

10.2.10 The importance / sensitivity of any designations or receptors identified is as defined in Paragraph 10.4.41 and Table 10.1. The objectives for the conservation and improvement of natural heritage are to:

- promote the conservation of landscape and biodiversity, in particular the conservation of native wildlife and habitats;
- ensure that action in Wales contributes to meeting international responsibilities and obligations for the natural environment;
- ensure that statutorily designated sites are properly protected and managed;
- safeguard protected species; and
- promote the functions and benefits of soils, and in particular their function as a carbon store.

10.2.11 In terms of soils, it states the Welsh Government has an objective to promote the functions and benefits of soils, and in particular their function as a carbon store.

10.2.12 Planning Policy Wales also recognises that geology forms part of the natural heritage of Wales and is not constrained to statutorily designated sites but extends across all Wales. It sets out principles for the planning system with respect to development on potentially unstable or contaminated land. It places an emphasis on the requirement to understand the ground risks and on development of appropriate remediation making ground hazards a material consideration during the planning process.

Local Planning Policy

10.2.13 The Powys County Council Unitary Development Plan (UDP) 2001-2016 was adopted in March 2010 (Powys County Council, 2001). Powys County Council are in the process of preparing the Powys Local Development Plan (LDP) (2011-2026) (Powys County Council, 2015). Adoption of the Powys LDP will not be until December 2016 according to the Deliver Agreement. The Powys LDP will replace the Powys UDP 2011-2026

10.2.14 The Eryri Local Development Plan (LDP) 2007-2022 is the adopted plan in the Snowdonia National Park. It was adopted by Snowdonia National Park Authority on the 13 of July 2011. This takes precedence over the council UDPs where the two overlap.

Relevant Policies

- Eryri LDP Strategic Policy (SP) A: National Park Purposes and Sustainable Development: In order to help sustainable development in Snowdonia, conservation of geodiversity should be considered. Where it is in sustainable location, development of brownfield land should take priority over greenfield;
- Eryri LDP Development Policy (DP) 1: General Development Principles: The development will not have an unacceptable adverse impact, through discharges or emissions, on public health, surface and ground water (quality, quantity or ecology) soil;
- Eryru LDP: SP E: Minerals Safeguarding Policy: To ensure that aggregate mineral resources are safeguarded an area has been identified as Mineral Safeguarding Area (MSA). In the MSA planning permission will only be granted for non-mineral development if it can be demonstrated that the proposed development does not permanently sterilise, or restrict, the possible future working of the identified mineral resource. However, where it is considered that the proposed development is of overriding importance consideration will be given to the principle of pre-extraction of the minerals;
- Powys County Council UDP SP1: Sustainability, which requires development to be concentrated on sustainable locations on brownfield land and the provision of integrated transport systems; and
- CE8: Locally Designated Nature Conservation and Geological Sites, which states that proposals affecting locally designated sites will only be permitted where there would be no significant adverse effect on the geological interest of the site.

10.2.15 Snowdonia National Park Authority, Supplementary Planning Guidance 1: Sustainable Design in National Parks of Wales, September 2011 lists key principles of sustainable design to prevent loss or damage to geological features, for example through quarrying and landscape restoration schemes. The designer should explore ways of protecting and enhancing any geological features that are individual to the development site as an integral part of the design of the Scheme.

Relevant Guidance

- 10.2.16** The assessment has been undertaken with due consideration of the relevant general Environmental Impact Assessment (EIA) guidance, as detailed in Chapter 4 Approach to Environmental Impact Assessment and of the following topic specific guidance:
- DMRB Volume 4 HD22/08 (Highways Agency, 2008h);

- DMRB Volume 11, Section 3, Part 11 Geology and Soils (Highways Agency, 1993d);
- Model Procedures for the Management of Land Contamination (CLR11) (Environment Agency and Defra, 2004);
- Construction Industry Research and Information Association R132: A Guide for Safe Working on Contaminated Sites (CIRIA, 1996);
- CIRIA SP73: Roles and Responsibility in Site Investigations (CIRIA, 1991);
- BS5930:2015 Code of Practice for Site Investigations, issued (British Standards Institution, 2015);
- BS10175:2011 + A1 2013: Code of Practice for Investigation of Potentially Contaminated Sites (British Standards Institution, 2013a);
- Eurocode 7 (BS EN 1997-1 (British Standards Institution 2013b) & EN 1997-2 (British Standards Institution, 2007) and all relevant Normatives;
- Groundwater protection principles and practice, GP3 (Environment Agency, 2013);
- Contaminated Land Risk Assessment, A guide to good practice, CIRIA 552 (CIRIA, 2001);
- Assessing risks posed by hazardous ground gas to buildings, CIRIA 665 (CIRIA, 2007);
- Unexploded ordnance (UXO) A guide for the construction industry CIRIA 681 (CIRIA, 2009);
- Asbestos in soil and made ground: a guide to understanding and managing risks CIRIA 733 (CIRIA, 2014);
- Definition of Waste: Development Industry Code of Practice, Version 2 (Contaminated Land: Applications in Real Environments (CL:AIRE) 2011) 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 11 Materials for more details;
- 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):
 - PPG 1 : Understanding Your Environment Responsibilities – Good Environmental Practices ;
 - PPG 2 : Above ground oil storage tanks;
 - PPG 4 : Treatment and disposal of sewage where no foul sewer is available;

- PPG 5 : Works and maintenance in or near water;
- PPG 6 : Working at construction and demolition sites;
- PPG 21 : Incident response planning;
- PPG 22 : Incident Response. Dealing with spills
- PPG3, PPG7, PPG 13 and PPG26 have not been considered in a context of this chapter as operation of refuelling and vehicle washing facilities or storage in bulk containers has been considered in Chapter 15 Road Drainage and Water Environment; and

10.3 Study Area

10.3.1 The study area has covered the construction land take and permanent land take. Consideration has been given to sites associated with ancillary activities, such as temporary works or contractors compounds, that may be situated outside the route alignment. The extent of temporary and permanent land take is presented in detail in Chapter 2 and shown on Figure 2.4, Volume 2.

10.3.2 The baseline study area also included all potential contaminated land sites that intersect the proposed alignment of the Scheme and those sites that have plausible pollutant linkages that may be intercepted by the proposed alignment, typically within approximately 250 metres of the route corridor, although potential pollutant linkages have been considered on a case by case basis; for example if sources of contamination are identified away from the Scheme area and there is a potential for that contamination to migrate towards the Scheme for instance via groundwater.

10.3.3 The geology study area has been determined on the basis of the regional 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.

10.3.4 The extent of the study area is shown on Figure 10.1, Volume 2.

10.4 Methodology

Methodology for Identification of Baseline

10.4.1 The identification of baseline conditions in relation to site geology and geomorphology and land contamination has been undertaken based on review of available desk study information included within the Preliminary Sources Study Report (PSSR, Arup, 2016a; enclosed in Appendix 10.1, Volume 3) prepared for the Scheme and recent 2015 ground investigation findings (CCG,

2016) presented in the Preliminary Ground Investigation Report (GIR, Arup 2016b; enclosed in Appendix 10.2, Volume 3). The proposed design measures are presented in the Geotechnical Design Report (GDR, Arup 2016c; enclosed in Appendix 10.3, Volume 3).

10.4.2 The desk study assessment included a review of the following:

- Published geological maps and memoirs including:
 - Cadair Idris, Sheet 149. 1:50,000 Solid and Drift Geology (British Geological Survey, 1995a);
 - SH70SW (Machynlleth). 1:10,000 Solid and Drift Geology. (British Geological Survey, 1987);
 - SH70SE (Llanwrin). 1:10,000 Solid and Drift Geology (British Geological Survey, 1988);
 - Geology of the country between Aberystwyth and Machynlleth. Memoir of the British Geological Survey, Sheet 163 (England & Wales). (British Geological Survey, 1986);
 - Geology of the country around Cadair Idris. Memoir of the British Geological Survey, Sheet 149 (England & Wales) (British Geological Survey, 1995b);
 - British Regional Geology of Wales, Chapter 9 (British Geological Survey, 2007);
- Current and historical land use information:
 - Envirocheck Report, including historic 1:2,500 and 1:10,000 Ordnance Survey plans;
 - Coflein online database. (Royal Commission on the Ancient and Historical Monuments in Wales, 2015);
- Aerial photography:
 - Welsh Government Aerial Photography Unit archives;
- Records held by British Geological Survey (BGS):
 - British Geological Survey (BGS) online viewer. (British Geological Survey, 2015);
- Records held by NRW:
 - Envirocheck Report;
- Records held by the Coal Authority in relation to mining issues:
 - The Coal Authority online viewer (Coal Authority, 2015);
- Historical ground investigation information:
 - A487 Dyfi Pinch Point, Flood Alleviation at Heol Y Doll Rail Bridge, Feasibility Report. Central Wales Infrastructure Collaboration (CWIC, 2014);

- A487 Pont ar Dyfi Improvement. Site Investigation No M0525 Factual and Interpretive Report. (CJ Associates Geotechnical Limited, 2001);
- Afon Dyfi, Aberangell-Glan Dyfi. Geomorphological Investigation. GeoData Institute (Environment Agency, undated); and
- A487 Fishguard to Bangor Trunk Road Pont ar Ddyfi Improvement. Options Development Report (Powys Country Council, 2010).

Scope of Baseline Studies

10.4.3 A gap analysis of the information contained within the PSSR (Arup, 2016) has been undertaken and the existing information validated and updated where appropriate using the following topic areas:

- Geology:
 - An Envirocheck report has been obtained for the site containing both geological and historical plans. This is enclosed in Appendix 10.4, Volume 3. In addition, the BGS 1:50,000 and 1:10,000 scale geological plans have been used. The geological memoir for the local area has been reviewed;
- Hydrology and hydrogeology:
 - Ordnance Survey (OS) maps at scales of 1:50,000 and 1:25,000 (OS plans) of the area surrounding the site have been reviewed. The groundwater vulnerability has been considered from the Environment Agency's online viewer;
- Mines and mineral deposits:
 - The Coal Authority interactive map viewer (Coal Authority, 2016) and the Review of Mining Instability in Great Britain, Volume 1/iii – Wales Regional report, prepared by Arup for the Department of the Environment (1991) have been consulted. Historic OS plans have been used to identify the potential presence of historic quarries;
 - The Mineral Resources Map for Wales has been reviewed;
- Natural cavities:
 - The potential for natural cavities have been assessed from the available geological maps and memoirs;
- Land use and ground conditions encountered during previous investigations (exploratory hole locations are shown on Figure 10.2, Volume 2):
 - Information obtained during a site walkover undertaken in August 2015 by two geotechnical

- engineers to verify the findings of the desk study assessment (as detailed in the PSSR, Arup 2016a, enclosed in Appendix 10.1, Volume 3);
- Envirocheck report (presented in Appendix 10.4, Volume 3) has been used to assess current land uses. Aerial photographs and historic plans have been used to assess recent historical land use;
 - Information from historic and recent ground investigations has been reviewed. Methodology for these ground investigations is presented in Sections 10.4.4 to 10.4.5;
 - The British Geological Survey borehole records database has been reviewed and available borehole records obtained for the local area;
 - Consultation with statutory bodies and agencies:
 - Consultation has taken place with the Pollution Control department of Powys County Council regarding potential geo-environmental issues, in addition to the Overseeing Organisation; and
 - Contaminated Land:
 - Recorded contaminated land, pollution incidents and areas of landfill have been reviewed from NRW records contained within the Envirocheck report (presented in Appendix 10.4, Volume 3).

Ground Investigation Survey Methodology

10.4.4 The intrusive ground investigations were undertaken in line with current best practice as presented in BS5930:2015 Code of Practice for Site Investigations (British Standards Institution, 2015). These investigations involved excavation of exploratory holes called boreholes and trial pits using a cable percussive rig with follow on rotary rig or a mechanical excavator, respectively. In a process of excavations, soil and rock samples were obtained, which were sent to suitably accredited laboratories for chemical and/or geotechnical testing.

10.4.5 As part of the investigations, boreholes were equipped with groundwater and ground gas monitoring installations. On completion of the field works, samples of groundwater were obtained and were sent to a suitably accredited laboratory for chemical testing. Groundwater level and ground gas concentration monitoring was also undertaken from these installations.

Baseline methodology

10.4.6 The baseline Conceptual Site Model has been based on the review of the information presented in Section 10.4.2 to 10.4.5. We do not consider it to be of a benefit to repeat the above stated

information, but shall refer back to these previous sections for greater clarity. From review of that 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 sections below.

Land Contamination Conceptual Site Model

10.4.7 The baseline Conceptual Site Model has been based on the information reviewed as part of the baseline study preparation, as detailed in Sections 10.4.2 to 10.4.3, and presents the potential pollution linkages that have been identified, i.e. the presence of sources of contamination, receptors (both human and environmental) and pathways through which the contamination could have a detrimental impact on these receptors.

Identification of Sensitive Receptors

10.4.8 Sensitive receptors have been identified based on the review of existing information and the work undertaken to inform the EIA process. Identified receptors include:

- Areas of geological or geomorphological interest;
- Soils and or groundwater;
- Sensitive human receptors on and off site;
- Controlled waters that may be affected by release of contaminants; and
- Ecological receptors that may be affected by release of contaminants.

10.4.9 Approaches adopted for the identification of sensitive ecological and hydrological receptors are considered within Chapter 9 Nature Conservation and Chapter 15 Road Drainage and the Water Environment of this ES respectively.

Identification of Sources

10.4.10 Potential sources of contamination have been identified based on the review of existing information, including the results of contamination testing from recent targeted ground investigation, and other work undertaken to inform the EIA process. These include:

- Historical industrial/commercial activities;
- Areas containing made ground; and
- Locations of past pollution incidents and sewage discharges.

10.4.11 Identification of potential contaminants associated with identified land uses has been undertaken by review of published

information, primarily the Land Contamination: Department of Environment (DOE) industry profiles.

Identification of Pathways

10.4.12 Potential pathways through which the contamination from identified sources may reach the sensitive receptors have been identified based on the review of the desk study information and ground investigation information. Relevant pathways include:

- Ingestion, inhalation or dermal contact with soils/dust originating from sources of contamination;
- Inhalation of ground gases/hydrocarbon vapours originating from sources of contamination; and
- Leaching and migration of contamination.

Methodology for Construction Impacts

10.4.13 This section outlines the methodology for the assessment of construction 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.

10.4.14 Assessment of the likely impact on the geology/geomorphology and land contamination arising from construction is undertaken by review of baseline conditions in a context of the proposed construction works. The detailed description of the Scheme is presented in Chapter 2 The Project and Figure 2.4, Volume 2. For the purpose of the assessments and to reflect the different construction activities the Scheme has been split into the following zones:

- Ch. 0+000m to 0+320m Southern Tie In and Embankment: Construction of road widening leading to an earth embankment;
- Ch. 0+320m to 0+870m: Viaduct and River Bridge: Construction of viaduct piers and river crossing with associated deep piled foundations in the central Scheme area; and
- Ch. 0+870m to 1+100m Junction and Northern Tie In: Construction of a shallow cutting and piled abutment on the northern river bank and construction of side roads within cuttings, and shallow embankment widening in the northern Scheme area.

10.4.15 A review of the baseline data described in Section 10.4.1 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.

10.4.16 The baseline Conceptual Site Model has 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.

10.4.17 Interrelationships have been identified between the Geology and Soils, Materials, Road Drainage and the Water Environment, Air Quality, Nature Conservation, Landscape and Visual and Cultural Heritage chapters. The assessment of effects has taken these interrelationships into account in Section 10.13.

10.4.18 The assessment of the construction effects is presented in Section 10.7 and the identified mitigation measures are presented in Section 10.9.

Issues Scoped Out

10.4.19 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 Figure 10.1, Volume 2.

Methodology for Assessment of Potential Effects

10.4.20 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 11 Geology and Soils, whilst the detailed assessment on the magnitude of impacts and significance criteria for effects has been undertaken using the methodology outlined in DMRB Volume 11, Section 2, Part 5, HA205/08 Principles of Environmental Assessment – Assessment and Management of Environmental Effects.

10.4.21 Assessment of effects in relation to contamination has been undertaken in accordance with industry best practice as presented in CLR11 (Environment Agency and Defra, 2004). The risk assessment process is underpinned throughout by the development of the Conceptual Site Model which provides a schematic representation of the identified contaminated linkages.

10.4.22 The process comprises a tiered approach which starts with a simple and conservative Tier 1 assessment of potential risks from possible Pollutant Linkages (Source-Pathway-Receptor). At this stage potential pollutant linkages are identified together with the required investigations to confirm whether such a linkage is viable, e.g. where there is a possibility of presence of made

ground, soil sampling and laboratory testing will be identified as the required investigation.

10.4.23 Any potential risks identified at Tier 1 have then been studied in more detail through a Tier 2: Generic Quantitative Risk Assessment (GQRA). The results of any investigations completed are reviewed at this stage and quantitative assessment is undertaken. The methodology for a GQRA is presented in Sections 10.4.25 to 10.4.32.

10.4.24 If a Tier 2 assessment identifies potential risk, i.e. the applied generic assessment criteria are exceeded, a Tier 3: Detailed Quantitative Risk Assessment (DQRA) is required. This involves derivation of site specific assessment criteria and may involve additional targeted ground investigations to refine the Conceptual Site Model. Where pollutant linkages are identified as viable on completion Tier 3 assessments remediation mitigation measures would be identified. However, the detailed design of how required mitigation would be implemented, would be completed at a detailed design stage including remedial options appraisal and remediation and verification plan. It is also acknowledged that as per any other highway scheme, further investigation work will be carried out and additional assessments will be completed as construction progresses. These however would follow the methodology set out above.

10.4.25 The assessment is on the basis of all soils that are suitable for reuse being retained on site as part of the Scheme. Geotechnical and chemical acceptability criteria shall be established for any soils proposed for reuse, with soil samples tested and screened against the acceptability criteria as the work progresses. This will ensure that the acceptability of soils for reuse is demonstrated and verified. Any soils that do not meet the chemical acceptability criteria shall be treated or disposed of to a suitably licenced facility. In addition, a discovery strategy will be developed to enable unforeseen ground conditions to be addressed if or when encountered. Any imported soils will also require verification prior to use within the Scheme. This approach to soil sampling, testing and assessment shall be defined in an earthworks specification for the construction works that shall be prepared in accordance with the Specification for Highway Works Series 600 Earthworks – that is applicable for the Scheme.

Generic Quantitative Risk Assessments Methodology – Human Health

10.4.26 Where a potential pollution linkage has been identified in relation to human health a GQRA has been undertaken. This has been done by screening available soil chemical test results against published generic assessment criteria for a suitable land use scenario, such as DEFRA Category 4 Screening Levels (C4SLs)

(Defra, 2014), and where these are not available, the LQM/CIEH Sutable 4 Use Levels (S4ULs) (LQM/CIEH, 2015).

- 10.4.27** The screening criteria in relation to human health are presented in Appendix 10.5, Volume 3. The applied assessment criteria, as per paragraph 10.4.27, have been derived using the Environment Agency Contaminated Land Exposure Assessment (CLEA) model. This model defines Age Classes for receptors within a number of generic end use scenarios. The end use scenario applied within the Tier 2 quantitative risk assessment identifies adult workers as the most sensitive receptors. The age class for this scenario is for 16 to 65 year old individuals.
- 10.4.28** Where a potential pollution linkage has been identified in relation to human health from direct exposure to groundwater, the GQRA involves screening of the groundwater chemical testing results against Drinking Water Standards (DWS), as presented in Appendix 10.5, Volume 3.
- 10.4.29** Where, the exposure would comprise inhalation of hydrocarbon vapours, the GQRA involves a review of groundwater chemical testing results for the presence of hydrocarbon compounds.

Generic Quantitative Risk Assessments Methodology – Controlled Waters

- 10.4.30** Where a potential pollution linkage is identified in relation to controlled waters a GQRA is undertaken. This is achieved by screening available water chemical testing results against the Environmental Quality Standards (EQS) (Defra, 2015) for annual average inland surface water (freshwater) values.
- 10.4.31** For hardness dependent determinands e.g. cadmium, the EQS value has been set at Class 2 hardness range. This is based on Water Hardness Map (Drinking Water Inspectorate, 2001).
- 10.4.32** Where the EQS is dependent on bioavailability, which is the case for copper, manganese and zinc, for the purpose of the assessments, it has been conservatively assumed that the measured concentrations reflect the bioavailable dissolved metals.
- 10.4.33** The screening criteria are presented in Appendix 10.5, Volume 3.

Ground Gas Risk Assessment Methodology

- 10.4.34** Where a potential pollution linkage is identified in relation to ground gas a review of the available ground gas monitoring data is undertaken and assessment of risk is carried out based on the published guidance on assessing risks posed by ground gases (Ciria 665, CIRIA, 2007). Due to the nature of the Scheme, i.e. no buildings are included within the development, the

assessment involves only derivation of Gas Screening Values (GSVs) based on recorded maximum concentrations of methane and carbon dioxide, and the measured maximum gas flow. The derived GSV are then compared to GSV thresholds to obtain a risk classification.

Methodology for Operational Impacts

- 10.4.35** Potential receptors have been identified for the operational phase of the Scheme, such as maintenance workers who may carry out excavation works in the area and adjacent water bodies. Where there are potential sources of contaminated land, and pathways to any receptors, assessment of potential impacts to the receptors has been carried out. This comprised a Tier 1 and Tier 2 contamination risk assessment in accordance with industry best practice, including CLR11 (Environment Agency and Defra, 2004). Remedial strategies would be developed at detailed design stage, for locations where significant contamination is present.
- 10.4.36** The assessment is on the basis of all soils that are suitable for reuse being retained on site for reuse within the Scheme. It is on the basis of measures being taken to establish acceptable reuse criteria and procedures for the Scheme to ensure that suitability of material for reuse can be demonstrated and verified. For this approach, a discovery strategy would be developed to enable unforeseen ground conditions to be addressed if or when encountered. This approach is in line with the Specification for Highway Works, Series 600 – Earthworks that is applicable for the Scheme, and standard practice for earthwork. Inter-relationships with Chapter 11 Materials would be captured relating to soil re-use.
- 10.4.37** The baseline Conceptual Site Model has been revised to include 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.
- 10.4.38** For land contamination, potential impacts due to operation shall be determined through the identification of potential sources of contamination and pathways introduced is undertaken in line with methodology set out in 10.4.11 to 10.4.35.
- 10.4.39** The assessment of the operational effects is presented in Section 10.8 and the identified mitigation measures are presented in Section 10.9.

Significance Criteria

Environmental Value (or Sensitivity) of Resource/Feature

10.4.40 The significance of impacts have 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 10.1, and the magnitude of impact in accordance with Table 10.2. It should be noted that the descriptions of the sensitivity of each receptor has been adapted for geology/mineral resources, groundwater, surface water, land contamination and UXO. 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 10.3.

Table 10.1: Criteria and DMRB Definitions of Sensitivity or Value HA205/08 (Highways Agency, 2008)

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, public open space).</p> <p>UXO Human health</p>
High	<p>Geology/ Mineral Resources: 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:</p>

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

Table 10.2: Criteria and DMRB Definitions of Impact Magnitude
HA205/08 (Highways Agency, 2008)

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> <p>Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).</p>
Moderate	<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> <p>Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).</p>
Minor	<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:</p>

Magnitude of Impact	Typical Criteria Descriptors
	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)
	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).
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	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Significance of Effect

10.4.41 The criteria for assessing the significance of the impact takes account of the following factors:

- The value of the resource (international, national, regional and local level importance);
- The magnitude of the impact;
- The duration involved;
- The reversibility of the effect; and
- The number and sensitivity of receptors.

10.4.42 The level of significance that merits further consideration / mitigation has been determined following the procedures set out in Chapter 4, section 4.5. In terms of the EIA Regulations, significant effects are generally those where the significance of the effect is 'moderate' or greater.

10.4.43 The significance criteria used are summarised in Table 10.3.

Table 10.3: Approach to Evaluating Significance of Effect HA205/08
(Highways Agency, 2008)

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

Consultation

10.4.44 Information in relation to land contamination issues and private water supplies has been requested from Powys County Council, however no information has been received at the time of writing. The Contaminated Land Officer of the Environmental Health Department by email and phone, however no information was received.

Limitations and Assumptions

10.4.45 It is assumed that pollution control measures based on best working practices would be implemented during construction. The assessments have been based on the assumption that management of environmental issues arising during construction e.g. groundwater management during piling operations or dust generation as a result of transport of materials will be undertaken in line with best practice as outlined in the Construction Environmental Management Plan (CEMP) presented in Chapter 17 and as such will not have an impact on identified receptors. Nonetheless, to reinforce the requirement for particular environmental management measures, these will be outlined within Section 10.9 Construction Mitigation.

- 10.4.46** In addition, the following principles have been applied:
- 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.
 - As detailed in Section 10.4.24, 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 would be acceptable for construction works.
- 10.4.47** Professional judgement has been applied where necessary in assignment of sensitivity and magnitude of effects in line with definitions provided in Table 10.1 and Table 10.2.
- 10.4.48** The 2015 investigations provide only preliminary information on ground conditions and detailed information would be obtained at Key Stage 6 detailed design stage.
- 10.4.49** 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 would form basis for a detailed design of the Scheme.
- 10.4.50** Prior to completion of construction, the areas adjacent to the Scheme used for access, egress, piling and other associated construction works are to be reinstated with turf and topsoil in keeping with the original land use. Vehicular access would be required along a strip of land immediately adjacent to the viaduct for occasional maintenance in the future. This strip of land is to be reinstated with turf and topsoil, as per the surrounding areas. Post construction, it will be offered back to the land owner, but with a lesser interest in or rights to the land, including restrictions on activities that could block this route, and on uses that could present risks of damage to the viaduct. Therefore, it is assumed that access for inspections during the Scheme operation would have no impact on either geology or land contamination aspects.
- 10.4.51** The assessment of pollution release as a result of operational or construction activities is covered in Chapter 15 Road Drainage and the Water Environment.
- 10.4.52** Notwithstanding the limitations, sufficient information has been available for completion of assessment of geology, geomorphology and contaminated land.

10.5 Baseline Environment

- 10.5.1** The methodology for identification of baseline conditions is presented in Section 10.4.
- 10.5.2** A Preliminary Sources Study Report (Arup, 2016a) has been prepared for the Scheme, which documents the findings of the desk study.
- 10.5.3** The sections below present a summary of relevant findings of the desk study, supplemented by information identified through a data gap analysis.

Site Topography

- 10.5.4** The Scheme lies in the Dyfi Valley to the east of Cardigan Bay in mid-Wales. From the northern outskirts of Machynlleth, the proposed construction corridor traverses relatively flat ground associated with the floodplain of the Afon Dyfi. Much of this flat ground comprises grass pasture used mainly for grazing of sheep and cattle. Field boundaries are delineated by fences, hedgerows and trees. Refer to Chapter 8 Landscape and Visual with respect to details on the quality of the boundary features, are the hedgerows and trees maturity.
- 10.5.5** In the vicinity of the Scheme, the construction route crosses the National Cycle Network, a relatively new public footpath, bridleway and cycleway that runs for the most part along the south bank of the river. The Scheme then crosses the Afon Dyfi.
- 10.5.6** On the north bank of the river, the proposed route traverses a steep wooded slope, approximately 10m high, and continues on higher ground where bedrock outcrops in a roadside cutting of the existing A487.
- 10.5.7** The elevation of the floodplain varies between 5m and 10m Above Ordnance Datum (AOD), although typically between 8m and 9mAOD, whereas the valley side to the north of the Scheme rises steeply to above 200mAOD.

Published Geology and Ground Conditions

- 10.5.8** The site geology has been reviewed in detail in the PSSR (Arup, 2016a; enclosed in Appendix 10.1, Volume 3) and is summarised below together with findings of the ground investigations undertaken within the Scheme area.

Completed Ground Investigations

- 10.5.9** To inform the initial stages of the Scheme optioneering and design, two intrusive ground investigations were completed:

- CJ Associates 2001: A ground investigation and interpretative report were completed by CJ Associates in 2001 (CJ Associates, 2001). This work was carried out for a range of possible highway alignments that were under consideration for the Scheme at the time; and
- CC Geotechnical Ltd 2015: Further ground investigation was completed by CC Geotechnical Ltd in 2015 (CCG, 2016). This investigation was to provide preliminary data for an outline Scheme design.

10.5.10 The factual information obtained from these investigations together with the interpretation in line with the DMRB requirements is presented in the Arup PSSR (Arup 2016a, enclosed in Appendix 10.1, Volume 3) and the Arup GIR (Arup 2016b, enclosed in Appendix 10.2, Volume 3). The exploratory hole locations are presented on Figure 10.2, Volume 2. The study methodology is presented in Sections 10.4.4 and 10.4.5.

10.5.11 The 2001 site investigation comprised 21 boreholes, to depths of between 9.5 and 29m below ground level and 17 trial pits, to depths of between 0.5 and 3m below ground level. In situ sampling and geotechnical testing was undertaken. Laboratory testing included geotechnical and contamination tests.

10.5.12 The 2015 investigation included five boreholes to depths of between 19.5 and 30m below ground level and 25 trial pits, to depths of between 1.7 and 3.2m below ground level. In situ soil sampling and geotechnical testing was undertaken. Laboratory testing comprised geotechnical and contamination testing.

Encountered ground conditions

10.5.13 The encountered ground conditions are summarised in Table 10.4 and discussed in detail below. A graphical representation of the encountered ground conditions is shown on Figure 4 of the GDR (Arup 2016c, enclosed in Appendix 10.3, Volume 3).

Table 10.4: Summary of encountered ground conditions

		Embankment	Viaduct and southern bridge support	Cutting and northern bridge support
		Estimated thickness (m)		
Superficial Deposits of Quaternary age	Topsoil	absent to 0.50	0.20 - 0.30	0.10 – 0.6
	Made Ground	absent to 0.90	absent	absent to 8.6
	Cohesive Alluvium	1.60 to a maximum identified depth of 3m	0.80 to a maximum identified depth of 3m	absent
	Head Deposits	absent	absent	absent to 1.1
	Glacial Sand and Gravel	at least 23.0	at least 28.4	absent to 4.00
Solid Geology of Silurian age	Weathered Bedrock			0.30 – 0.9
	Estimated depth to rockhead (m) / thickness of superficial deposits			
	Bedrock	at least 25.0	20.4 – at least 30.0	1.5 - 9.2

Superficial deposits

10.5.14 The published geological information (refer to Section 10.4.2 for references) indicates the Scheme area to be underlain by poorly defined superficial deposits comprising fluvial alluvium associated with the floodplain overlying glacial deposits:

- The glacial deposits have frequently been modified by periglacial action and in places have been entirely removed by erosion. Typically, these deposits comprise heterogeneous grey-brown clays with poorly sorted and locally derived gravel and boulders; and
- Valley-fill and mixed alluvium of the floodplain include coarse to fine-grained gravels with impersistent interbedded sandy clays, clays and silts.

10.5.15 The superficial deposits encountered by ground investigation surveys (as detailed in Section 10.5.9 to 10.5.12) along the road alignment across the floodplain to the south of the river can be generally summarised as very soft to soft silty clay / clayey silt present at depths ranging from approximately 1m to 3m over medium dense becoming very dense sand and gravel, with occasional sand and silt/clay horizons, overlying moderately

strong to strong siltstone or shale or mudstone bedrock. South of the Afon Dyfi, the depth to bedrock has generally not been confirmed. Various boreholes have however been advanced to depths of up to 30m, and confirmed the presence of sands and gravels to these depths.

- 10.5.16** Published geology (refer to Section 10.4.2 for references) indicates the presence of deposits of alluvial fan materials and head on the north bank of the river and within the route corridor. The alluvial fan materials consist mainly of crudely stratified debris, typically sub-angular to rounded pebbles and boulders with discontinuous lenses of gravelly and silty clay. In addition, River Terrace Deposits, are reported elsewhere within the Dyfi Valley. These comprise alluvial material placed on benches on the side of the valley, deposited at a geological time when the river flowed at a higher level, prior down-cutting to the current level of the floodplain. These deposits mainly consist of gravels, and have not been identified in the immediate vicinity of the Scheme. Topsoil was encountered in the majority of the exploratory hole locations between 0.1 and 0.3m thick, typically described as brown clayey silty topsoil. No sub-soil has been distinguished on the exploratory hole logs. Refer to Chapter 14 Community and Private Assets with respect to Agricultural Land Classification.
- 10.5.17** Ground investigations undertaken within the Scheme area (as detailed in Sections 10.5.9 to 10.5.12) encountered made ground materials within the southern Scheme area, possibly associated with a field track, and in the northern Scheme area associated with the construction of the Wales Millennium Cycle Bridge and/or the former Corris Railway Bridge.
- 10.5.18** Made ground encountered in the southern end of the Scheme, at chainages from 0+200 to 0+260, typically comprised clayey silty gravel as well as brick fragments at one location. Thicknesses comprised between 0.3m and 0.5m underlying topsoil.
- 10.5.19** In the northern end of the Scheme, at chainages from 0+920 to 0+980, made ground typically comprised clayey silty sands and gravel and fragments of man-made materials, including in places, plastic, glass, ceramic, brick, mortar, glass, tarmac, concrete, slate, roofing tile, coal and cinders - in particular, on the northern bank of the river from surface to 8.6m. No clarification on the origin of the cinders has been provided on the exploratory logs.
- 10.5.20** The quality of encountered made ground is presented in detail in Sections 10.5.69 to 10.5.74.

Solid geology

- 10.5.21** The published geology (refer to section 10.4.2 for sources of information) shows the Scheme area to be underlain by bedrock comprising grey mudstones and siltstones of the Borth Mudstone Formation of Silurian (Llandovery) age.
- 10.5.22** An anticlinal (arch shape) axis passes through the centre of the tie in with the existing A487 at the northern end of the site. Generally, the bedrock strata strike north-northeast and dip at moderate to steep angles.
- 10.5.23** The nearest significant fault is the Pennal Fault which runs east-west through the valley some 500m to the south of the river.
- 10.5.24** The ground investigations undertaken within the Scheme area (as detailed in Sections 10.5.9 to 10.5.12) encountered bedrock comprising grey turbiditic mudstones and siltstones of the Borth Mudstone Formation of Silurian (Llandovery) age. The mudstone beds range from 0.2m to 0.6m thick and include a few thin sandstone and siltstone interbeds.
- 10.5.25** The bedrock crops out in a roadside cutting on the A487 in the vicinity of the tie-in at the north-western end of the Scheme. The bedrock can be seen towards the base of the northern bank of the Afon Dyfi at various locations close to the proposed river crossing. The best exposures are visible in nearby quarries, for example at Llwyngwern (NG: SH 759 044). Generally, the bedrock strata strike north-northeast and dip at moderate to steep angles.
- 10.5.26** The ground investigation records indicate that rockhead level dips to depths greater than 30m a short distance south of the river, at the approximate Scheme chainage of 0+500m, with rockhead level continuing to lie at depth across the full length of the floodplain to the south.

Hydrology and Hydrogeology

- 10.5.27** The baseline hydrology and hydrogeology for the Scheme is presented in Chapter 15 Road Drainage and the Water Environment of this ES.
- 10.5.28** In summary, Natural Resources Wales (NRW) classifies the Afon Dyfi as a 'Main River'. It generally flows in a south-western direction to the coast where it enters Cardigan Bay. The Envirocheck Report, presented in Appendix 10.4, Volume 3, records that it had a General Quality Assessment (GQA) Grade: River Quality A (Very Good). GQA grades are a historical method of assessment, however, this past assessment is informative and considered relevant to the environmental reporting for the Scheme. Chapter 15 Road Drainage and the Water Environment

presents the WFD baseline for the Afon Dyfi, with an overall 'moderate' status, with 'good' ecological status and failing to achieve 'good' chemical status.

- 10.5.29** The superficial deposits present at and below the ground surface across the majority of the Scheme area, comprise alluvium and are classified as a Secondary A aquifer. The head deposits present on the northern river bank are classified as a Secondary Undifferentiated aquifer. Underlying these are Glacial Deposits, predominantly comprising high permeability sands and gravels. The bedrock beneath the entire Scheme area is classified as a Secondary B aquifer. Refer to Sections 10.4.2 and 10.4.3 for references with respect to the aquifer classification contained within groundwater vulnerability plans.
- 10.5.30** Secondary A aquifers are described as permeable layers capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers. Secondary B aquifers are predominately lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.
- 10.5.31** The groundwater vulnerability map in the Envirocheck report, presented in Appendix 10.4, Volume 3 indicates the soil on site as having a high leaching potential (H1) – soils which readily transmit liquid discharges because they are either shallow, or susceptible to rapid by-pass flow directly to rock, gravel or groundwater.
- 10.5.32** In the valley floor, to the south of the Afon Dyfi, groundwater levels have typically been identified as lying close to the ground surface, with ground investigation records indicating groundwater as having frequently been encountered within 2m depth of the surface. The floodplain is frequently flooded, and it is considered likely that groundwater levels rise in general continuity with surface water levels during flood events.
- 10.5.33** On the northern bank groundwater strikes were recorded at depths between 6.5 and 9m below ground level within the granular superficial deposits and underlying bedrock.
- 10.5.34** Two surface water abstractions are located within 1km of the Scheme area. Both are located upstream of the Scheme, on the Afon Dyfi and the Dulas River. The licences are for the purpose of pipe pressure testing at Machynlleth and aquaculture purposes, respectively. These are unlikely to be impacted by the Scheme.
- 10.5.35** Groundwater sampling and testing was undertaken as part of the 2015 ground investigations for the Scheme. The results are

presented in the Arup Ground Investigation Report (GIR), in Appendix 10.2, Volume 3.

- 10.5.36** The assessments of construction and operational effects on surface water and groundwater quality as a result of the presence of potential contamination are presented in Sections 10.7 and 10.8 respectively.

Geomorphology

- 10.5.37** The Scheme lies in the middle reaches of the Afon Dyfi with the active channel and the flat floodplain being the most important features. During walkover surveys (refer to the PSSR for details, as enclosed in Appendix 10.1, Volume 3) no evidence has been found of the river terrace levels and little indication of former channel alignments (palaeochannels) were observed. Surface features including reedy marsh, ponds and patches of wet ground are potential indications of the existence of palaeochannels which are understood to have become obscured over time.
- 10.5.38** A study of recent and historical aerial photographs for the Scheme (refer to Section 10.4.2 and 10.4.3 for references) revealed several geomorphological features along the present river channel including gravel bars and eroding banks. In addition, several short curvilinear patterns were noted on the surface of the floodplain that could indicate the presence of buried channels (palaeochannels) beneath the floodplain at Ch. 0+780m and between Ch. 0+650m and 0+680m.
- 10.5.39** An area at lower elevation has been recorded between Ch. 0+750m and 0+820m, understood to correspond to an area flooded on a regular basis since 1953. The possible extents of a historical pond dating from 1946 are present approximately 50m east of the Ch. 0+630m.

Historical Development

- 10.5.40** The historical development of the Scheme area is presented in detail in the PSSR (see Appendix 10.1, Volume 3) and summarised below.
- 10.5.41** No significant development of the Scheme area has historically occurred. In 1863 the Machynlleth Railway Station was constructed with associated sidings occupying the land directly to the south of the Scheme area and by 1889 a single narrow gauge railway track running from the station to the northern end of the Scheme area.
- 10.5.42** Historical plans show a single rail track running from the station in the south, which headed in a north-eastern direction, across

the river and then in cutting until it joined the proposed alignment at around Ch. 1+080m. The Coflein database indicates this to have been the Corris narrow gauge railway which was constructed in 1889 and was on a 500m long embankment. By 1974 the Corris railway was dismantled. By 1995, the railway lines and associated works at the southern end of the site had been removed and the area occupied by a garden centre and a garage (currently occupied by the Dyfi Eco Park). As detailed in Section 10.5.68 railway land is considered a potential source of contamination.

- 10.5.43** In 2001, the Millennium Cycle Bridge and a public footpath were opened. Both the bridge and the footpath were constructed on the historic alignment of the northern section of the Corris railway. The public footpath crosses the Scheme alignment at Ch. 0+830m and connects with the approach to the Millennium Cycle Bridge some 45m to the east. The Millennium Cycle Bridge is located some 40m to the east of the Scheme.
- 10.5.44** Historic plans show changes to the river course and width, with the shingle bars shown in different locations between 1889 and 1901 and later in 1974/75 and 1995.
- 10.5.45** Quarries were shown some 350m to the south and 200m to the north-west of the Scheme.
- 10.5.46** By 1974, a flood alleviation bund, approximately 220m long, had been constructed along the southern bank of the river. The 1995 OS plan shows a large pond at the eastern end of the flood bund at approximately Ch. 0+780m to Ch. 0+800m. Recent aerial photography shows the pond to be overgrown.

Mineral Resources

- 10.5.47** The BGS Mineral Resources Map for Wales shows the Scheme to be located within the identified resources area for sand and gravel, along with the whole of the Dyfi valley.
- 10.5.48** These resources are not currently included within Powys County Council's existing mineral sites as presented in the Powys Local Development Plan Deposit (Powys County Council, 2015). The Council policy is not to permit new exploration sites unless these are very small workings for local distinct stone or borrow pits.
- 10.5.49** There is one BGS recorded mineral site within 250m of the Scheme. An opencast site ceased in operation in 1992 and was located 180m to the south.

Ground Hazards

Mining Related Instability Hazards

- 10.5.50** The Coal Authority online viewer indicates that the study area is not within a coal mining area. A shaft is indicated in the town of Machynlleth approximately 1km to the south of the Scheme. An adit is located some 750m to the south of the Scheme, trending in a southerly direction away from the site. There are seven BGS recorded mineral sites within approximately 500m of the Scheme, all of which have ceased operation. Most are recorded as having been extracted through open cast methods, with two recorded as underground extraction – one is confirmed to have been for the extraction of Slate from the Devil’s Bridge Formation. The two underground mines are located approximately 500m to the southeast of the proposed route. Due to the distance, these are not deemed to be of relevance to the Scheme.
- 10.5.51** There are no known records of former mining activity within or in the immediate vicinity of the proposed development. No surface indication of mining operations have been noted during the site walkover survey. Therefore, mining related instability is not considered to be of relevance to the Scheme.

Compressible Ground Stability Hazards

- 10.5.52** A “moderate hazard potential” in relation to future development has been identified within the Envirocheck report for the area in which the Scheme lies, in particular within the floodplain due to the presence of alluvial deposits.
- 10.5.53** This is due to the presence of soft alluvial deposits which are compressible under applied load.

Landslide Ground Stability Hazards

- 10.5.54** A “very low to moderate hazard potential” for landslide ground instability has been identified within the Envirocheck report for the area in which the Scheme lies, in particular for the northern river bank.
- 10.5.55** This is due to the presence of poorly sorted superficial deposits overlying the bedrock on steep slopes at the northern bank of the Afon Dyfi.

Geological Designated Areas

Statutory Sites

- 10.5.56** The study area does not lie within, or within close proximity to any geological statutory designated sites.
- 10.5.57** The northern end of the Scheme is located within the Snowdonia National Park. The Snowdonia National Park is of national

importance due to its geology, which creates its unique landscape and character. The geology and geomorphology play a significant part in reasons why this area has been designated as a statutory site.

10.5.58 However, the area of the park where the Scheme is located comprises an existing road and agricultural land. Therefore, the sensitivity of the park area within the Scheme is considered to be low.

10.5.59 Dyfi Estuary SSSI is located some 4km south-west downstream of the Scheme. It covers an area of estuary, sand dunes and also unmodified, actively growing raised bog. Whilst the Dyfi Estuary is not a geologically designated SSSI, it is designated by virtue of the special interest regarding the ecosystems contained within. Therefore it is an indirect sensitive receptor to any land contamination effect that the Scheme may have directly on the quality of the Afon Dyfi.

Non-Statutory Sites

10.5.60 The study area does not lie within, or within close proximity to any geological non-statutory designated sites such as Regionally Important Geological Sites (RIGS).

10.5.61 The Scheme is located within the Dovey Geological Landscape Area (GLA) and the northern end encroaches on the Moel Maesywerngoch GLA (Natural Resources Wales website) evaluated by a team of experts on behalf of the Countryside Council for Wales (CCW), now NRW, in relation to local geological importance.

10.5.62 The Dovey GLA comprises lowland hills and valleys, lowland river and drainage, and an active lowland river floodplain system. It has been evaluated as being of 'high importance' due to the well-developed major river system with minimal intervention, which also includes part of Afon Dyfi ger Mallwyd SSSI located some 19km upstream of the Scheme area.

10.5.63 The northern study area encroaches on the Moel Maesywerngoch GLA. This area comprises mountain and upland valleys, glaciated mountain terrain and glacial mountain valleys. It has been evaluated to be of 'high importance' due to the upper Ordovician and lower Silurian stratigraphy, and also disused mines and slate quarries.

10.5.64 The above GLA sites are considered to be of low sensitivity due to their local importance.

Unexploded Ordnance

- 10.5.65** The possible presence of Unexploded Ordnance (UXO) has been considered and a preliminary risk assessment has been undertaken in line with published guidance (namely Ciria Report C681, Ciria, 2009). This concluded that there were no indicators for the potential presence of UXO, and that a detailed UXO risk assessment is not necessary.

Land Contamination

- 10.5.66** 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

- 10.5.67** The potential sources of contamination identified in relation to the study area are summarised in Table 10.5. A review of chemical testing of soils and groundwater, and ground gas monitoring is presented in sections below.

Table 10.5: Summary of identified potential sources of contamination

Potential sources	Potential Contaminants
On site	
Historical single railway track from Ch. 1+080m to Ch. 1+180m.	Metals, hydrocarbons (PAHs), asbestos, sulphates.
Made ground associated with the Millennium Cycle Bridge construction and historical railway bridge/track at Ch. 0+930m to Ch. 1+180m.	Metals, hydrocarbons, asbestos, ground gas
Made ground encountered from Ch. 0+240m to Ch. 0+280m associated with the field track	Metals, hydrocarbons, asbestos, ground gas
Off site	
Historical single railway track running on an embankment 100-150m to the east of the Scheme.	Potential for migration of groundwater impacted by metals and hydrocarbons into the Scheme area.
Railway station with associated historical sidings located directly to the south of the Scheme. The information on the Dyfi Eco Park development in relation to remedial measures has been requested from Powys Council. It is anticipated that remedial action has been undertaken to reduce contamination to the levels acceptable for commercial end use.	Potential for migration of groundwater impacted by metals and hydrocarbons into the Scheme area.
Possible made ground utilised for the construction of the flood defences located 220m to the west of the Scheme.	Fill of unknown origin. Potential contaminants can include metals, hydrocarbons, sulphates, pH

Potential sources	Potential Contaminants
Commercial activities and a garage within the Dyfi Eco Park.	Potential for migration of groundwater impacted by metals and hydrocarbons into the Scheme area.
Former Household Waste Amenity Site (now closed) with a licenced site drainage discharge to groundwater located some 40m to south-west of the site	Potential for migration of groundwater impacted by waste related contaminants (mainly metals and hydrocarbons) into the Scheme area
Petrol filling station located some 180m to south-west and also the location of an inactive garage.	Potential for migration of petroleum hydrocarbon impacted groundwater into the Scheme area
Minor incident to controlled waters occurred in 1994 some 120m to the south-west of the Scheme. Discharge of unknown substance.	Unknown.

Soil Quality

- 10.5.68** Ground investigations undertaken along the proposed route encountered Made Ground in the south, possibly associated with a field track, and in the north associated with the Millennium Cycle Bridge and the former Corris Railway bridge.
- 10.5.69** Made Ground encountered in the southern end of the proposed route typically comprised clayey, silty gravel as well as brick fragments at one location. Thicknesses were between 0.3m and 0.5m beneath the topsoil.
- 10.5.70** Made Ground typically comprising clayey, silty sands and gravel and fragments of man-made materials, including plastic, glass, ceramic, brick, mortar, glass, tarmac, concrete, slate, roofing tile, coal and cinders were encountered on the northern bank of the Afon Dyfi from the ground surface to maximum proven depth of 8.6m, although a 5m depth was used for design due to its density.
- 10.5.71** Inclusions of tarmac, coal and cinders present potential sources of metals or hydrocarbons contamination, primarily of Polycyclic Aromatic Hydrocarbons (PAHs). The measured levels of PAHs did not indicate elevated levels of these contaminants. Inclusions of concrete and bricks may indicate the presence of demolition materials, a potential source of asbestos. No other obvious evidence of contamination (including hydrocarbon or asbestos) was encountered during the fieldwork.
- 10.5.72** The results of the laboratory chemical testing indicate the presence of some contaminants within the made ground including metals, PAHs and TPH within the soils at maximum recorded concentrations as follows:
- Arsenic at 21.3 mg/kg in TP3 at 0.4m;
 - Beryllium at 1.2 mg/kg in TP2 at 0.4m;

- Cadmium at 0.9 mg/kg in TP14 at 0.6m;
- Chromium at 43.1 mg/kg in TP19 at 0.4m;
- Copper at 128 mg/kg in TP5 at 0.25m;
- Lead at 718 mg/kg in TP14 at 0.6m;
- Nickel at 52 mg/kg in TP19 at 0.4m;
- Vanadium at 42.6 mg/kg in TP20 at 0.3m;
- Zinc at 258 mg/kg in TP6 at 0.3m;
- Total Petroleum Hydrocarbons at 343 mg/kg in TP20 at 0.3m;
- Total PAHs at 6.08 mg/kg in TP01 at 0.4m; and
- No asbestos has been identified within the analysed samples.

10.5.73 The full soil testing results are presented in the Arup GIR (Arup, 2016b), in Appendix 10.2, Volume 3.

Groundwater Quality

10.5.74 A total of two rounds of groundwater sampling were undertaken. The samples were obtained from boreholes BH2, BH3 and BH4, all located in the central Scheme area to the south of the river and to the north of the proposed embankment. Refer to Figure 10.2, Volume 2 for borehole locations. No groundwater sampling was undertaken on the northern river bank as at the time of the investigations the Scheme proposals did not require deep excavations. In order to inform the changed proposals, further groundwater monitoring will be undertaken at the detailed design stage. No groundwater sampling was also undertaken in the area of the proposed embankment, as similarly no deep excavation are proposed in that part of the Scheme.

10.5.75 The testing results for metals and inorganic compounds obtained from the first round of testing met the quality assurance requirements and therefore are considered representative. However, the results of chemical analyses of organic compounds such as petroleum hydrocarbons or Polycyclic Aromatic Hydrocarbons (PAHs) can only be used as indicative. This is due to the holding time being exceeded resulting in the sample deterioration and the measured concentrations potentially being lower than those present within the original sample.

10.5.76 All results of the second round of testing meet the quality assurance requirements.

10.5.77 No evidence of contamination such as hydrocarbon sheen or odours was observed during obtaining the samples.

10.5.78 In summary, the following determinands were detected:

- Calcium at between 4.31 and 14.6 mg/l (Round 1 and 2);
- Magnesium at between 2.34 and 7.84 mg/l (Round 1 and 2);
- Zinc at between 15 and 29 ug/l (Round 1 and 2);
- Total Petroleum Hydrocarbons was measured in all monitored locations at concentrations up to 260 ug/l. The identified compounds comprised of aromatic compounds with carbon banding measured C21 to 35 at between <5 and 39.5 ug/l in Round 1, and aliphatic compounds C8 to C10 and C16 to 21 at between 108 and 260 ug/l and of aromatic compounds C16 to 35 in Round 2. The source of these hydrocarbons is unclear but the range of the detected hydrocarbon fractions indicate a possible ongoing off-site source of hydrocarbon contamination;
- Total Polycyclic Aromatic Hydrocarbons (PAHs) at between 0.4 and 1.59 ug/l (Round 1) and 0.37 and 2.11 ug/l (Round 2); and
- pH was measured at between 5.3 and 5.4, which is slightly below the neutral levels.

10.5.79 The full groundwater testing results are presented in the Arup GIR (GIR, 2016b), in Appendix 10.2, Volume 3.

Ground Gas

10.5.80 Four rounds of ground gas monitoring was undertaken between January and March 2016 in three monitoring wells, BH2, BH3 and BH4 with response zones within the glacial sand and gravels. Refer to Figure 10.2, Volume 2 for borehole locations. No sufficient thickness of made ground was encountered during the 2015 investigation to undertake ground gas monitoring. No ground gas monitoring was included within the 2013 investigation.

10.5.81 The measured gases included methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide. Gas flow rate was also obtained. A summary of measured concentrations is summarised in Table 10.6 below. The full ground gas monitoring results are presented in the GIR (Arup, 2016b; enclosed in Appendix 10.2, Volume 3).

Table 10.6: Summary of ground gas monitoring results

BH ID	Methane, % w/w	Carbon dioxide, % w/w	Oxygen, %w/w	Carbon monoxide, ppm	Hydrogen sulphide, ppm	Flow rate, l/hr
BH2	Nil	<0.1-0.8	19.7-20.2	Nil	Nil	<0.1
BH3	Nil	<0.1-0.5	19.7-20.1	Nil	Nil	<0.1
BH4	Nil	<0.1-4.6	10.4-20	Nil	Nil	<0.1

10.5.82 The assessment of potential risk from ground gas was undertaken in line with the methodology presented in Section 10.4.33. The GSV were calculated using the maximum measured concentration of methane (0.0% w/w) and of carbon dioxide (4.6% w/w) with the maximum measured flow rate of 0.1 l/hr. The derived GSVs are 0.0 l/hr for methane and 0.0046 l/hr for carbon dioxide. This indicates a very low risk from ground gases.

Potential Receptors

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

- Human receptors:
 - Residents and workers of the farm located some 100m to the north of the Scheme;
 - Workers and visitors of the Dyfi Eco Park commercial area (adjacent to the southern part of the Scheme);
 - Workers and visitors of the commercial premises located some 50m to the south of the Scheme;
 - Users of the agricultural land (central part of the Scheme only);
 - Maintenance workers of the existing A487 (adjacent to the northern part of the Scheme);
 - Users of the existing A487 road (northern part of the Scheme only), including motorised and non-motorised users (such as cyclists, pedestrians, horse riders, etc);
- Environmental receptors:
 - The Afon Dyfi;
 - The pond at chainage 0+720m; and

- Groundwater beneath the site (secondary aquifers).

10.5.84 Residents and workers of the farm, maintenance and commercial 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.

10.5.85 Both the Afon Dyfi and the underlying groundwater are considered to be potential environmental receptors. Refer to Sections 10.5.29 to 10.5.31 for details on designation and quality ratings.

Potential Pathways

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

- Human health:
 - Ingestion of soils and dust;
 - Inhalation of dust, gases and volatile hydrocarbon contamination;
 - Dermal contact with soils, dust and groundwater;
 - Gas migration from made ground or alluvium into near surface;
- Controlled waters:
 - Vertical and lateral and migration of contaminants released to the ground through spillage or leaks; particularly from the previous site uses such as railway land or current commercial park, and the potential for vertical or lateral migration through the underlying strata;
 - Soil leachate generation and migration from made ground materials; and
 - Made ground materials that remain on site may leach contaminants into the underlying groundwater (within made ground, alluvium and bedrock) resulting in contamination. The groundwater may flow towards the Afon Dyfi in the north-east. There is potential therefore for the contamination present within the made ground materials to impact the Afon Dyfi 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

10.5.87 The plausible pollution linkages are summarised in Table 10.7 below.

Table 10.7: Identified Baseline Source-Pathway-Receptor Linkages within the study area

Sources	Pathways	Receptors	Comments
On-site (within the Scheme alignment including temporary land take) sources			
Railway land Made ground in the south and north of study area Made ground materials associated with the construction of the Millennium Cycle Bridge in the north Potentially impacted groundwater	Direct exposure to soil and/or soil dust via ingestion, dermal contact and inhalation	Human health: A487 maintenance workers and users; Agricultural land users	Maintenance workers and highway users may be directly exposed to soil and dust generated from made ground in areas of soft landscaping for example, the ground investigation showed evidence of elevated concentrations of Poly-Aromatic Hydrocarbons at localised positions. Risk of exposure to ground gas is considered to be low, as no elevated levels of ground gas were measured during the ground investigations.
	Inhalation of gas and volatile contamination		
	Leaching and migration	Controlled waters: the Afon Dyfi, and groundwater (secondary aquifers)	Potential contaminants within the identified sources may leach to groundwater and via lateral migration have potential to impact the river quality.
Off-site (outside the Scheme alignment including temporary land take) sources			
Groundwater beneath railway land (incl. track), activities at the Dyfi Eco Park including the historic garage, household amenity site, petrol filling station, flood alleviation bund and the historic pollution incident.	Inhalation of volatile contamination from potentially impacted groundwater	Human health: Farm residents, Dyfi Eco Park and other commercial park workers, agricultural land users	The identified receptors outside the Scheme alignment are unlikely to be exposed to the sources within the Scheme alignment due to the distance. However, they may be exposed to sources identified in their vicinity such as the activities at the Dyfi Eco Park as detailed in the sources column to the left. Groundwater entering the central part of the Scheme area was found impacted by contamination arising from historic/current activities and consequently impacting the groundwater quality beneath the site.
	Leaching and migration	Controlled waters: groundwater (both secondary aquifers) beneath the site	The risk to the agricultural land users is considered to be very low due to the short-term exposure and absence of confined/enclosed spaces. Made ground used for flood defences is not considered of concern due to down-gradient location in relation to the Scheme. The identified potential off-site sources are only present to the south of the Afon Dyfi and therefore no impact on the A487 related receptors is foreseen.

10.6 Summary of Baseline

- 10.6.1** The Scheme is located within a floodplain of the Afon Dyfi. The southern and central parts of the study area comprise relatively flat grass pasture with the northern section rising steeply to the existing A487 carriageway. The National Cycle Network, a footpath and a bridge are located in the vicinity of the Scheme.
- 10.6.2** The Scheme area is generally underlain by poorly defined superficial deposits of fluvial alluvium and glacial till over mudstones of the Borth Mudstone Formation. The northern part of the Scheme is underlain by head deposits.
- 10.6.3** Historical aerial photography and site walkover indicated the potential for the presence of former channel alignments (palaeochannels) within the study area.
- 10.6.4** The superficial deposits and the bedrock are classed as secondary aquifers. The Afon Dyfi is classed as a major river.
- 10.6.5** No significant historical development of the study area has been identified with the narrow gauge railway track (present from 1889 to 1974) encroaching on the northern end of the Scheme, at the location of the Millennium Cycle Bridge that was constructed in 2001. The area directly to the south of the Scheme, used as railway sidings until 1995, has been redeveloped into a commercial area, Dyfi Eco Park. No hazards in relation to historical mineral exploration have been identified within or in the vicinity of the Scheme area. The ground within the study area has a potential for compressible stability and landslide stability hazards.
- 10.6.6** The study area is identified as a potential source of sand and gravel, however these resources are not currently explored and in accordance with the local policy no new exploration permits will be granted.
- 10.6.7** Two ground investigations have been completed within the study area, which have provided information on ground and groundwater conditions and chemical properties of the soils.
- 10.6.8** There are no statutory or non-statutory geological sites within the study area, such as SSSIs or RIGS. The north of the site lies within the Snowdonia National Park, which is of national importance, in part due to its geology. The Scheme is located within two Geological Landscape Areas (GLA) of local importance. The Scheme lies within the Dovey GLA and the northern part of the Scheme encroaches on the Moel Maesywerngoch GLA.

10.6.9 There are some minor rock exposures along the existing A487 in the north. These are considered to be of low to negligible value, due to the abundance of such features on a local scale.

10.7 Potential Construction Effects - Before Mitigation

10.7.1 This section presents assessment of impact that the construction may have on geology and geomorphology and land contamination. The potential effects of construction works on agricultural land take has been considered as part of Chapter 14 Community and Private Assets and Chapter 11 Materials of this Environmental Statement. Issues associated with flooding are considered in Chapter 15 Road Drainage and Water Environment.

Geology and Geomorphology

Assessment of Potential Impact of Construction of the Approach Embankment Ch. 0+000m to 0+320m and flood alleviation bunds

10.7.2 The construction of the embankment would result in consolidation of the soils due to the applied load of the embankment materials. This would result in a slight reduction in permeability of the alluvium that is present in the upper 1.5 m to 4 m of the ground, with limited potential for localised changes to the groundwater movement. Slight seepages of groundwater as a result of ground consolidation may occur for a short duration immediately after placement of the embankment fill and these would be collected by a temporary drainage. The underlying soils which form the primary aquifer for groundwater movements in the area, comprise overconsolidated glacial deposits, and no significant changes to the permeability are anticipated within this material.

10.7.3 The proposed embankment covers a limited area (30m x 120m) and therefore any impact would be minimal.

10.7.4 The sensitivity of the impacted geology is considered low due to the localised area of impact with a minor magnitude of impact. Consequently the effect of the construction of the embankment on the geology is considered to be **neutral to slight adverse**.

10.7.5 The construction of the flood alleviation bund would result in minimal consolidation of the soils due to the low load of the utilised materials. Therefore the magnitude of impact would be no change with a **neutral** significance of effect.

10.7.6 Consequently the effect of the construction of the embankment on the geomorphology is considered to be **neutral to slight adverse**.

Assessment of potential Impact of Viaduct Construction and River Crossing Ch. 0+320m to Ch. 0+870m

- 10.7.7** The construction of the viaduct would require construction of deep piled foundations. The foundation works will result in localised excavations for the piles, and where proposed, the pile caps. This would result in removal of soils from the location of the pile. This will not result in changes to groundwater flows within the wider Scheme area.
- 10.7.8** The viaduct piers would generally contain pairs of piles around 10m apart, with the pairs of piles spaced at typical distances of 34m. These are therefore unlikely to significantly alter geological conditions within the Scheme area.
- 10.7.9** The sensitivity of the geological resources is considered to be low with the piling works having a negligible impact on the site geology. Consequently, the effect of piling works on the geology is considered to be **neutral to slight adverse**.

Assessment of potential Impact of Earthworks on the North River Bank Ch. 0+870m to Ch. 1+100m

- 10.7.10** The construction of the bridge on the northern river bank would require preparation of a construction platform to allow for safe construction of piles. This would involve cutting into the existing made ground and underlying soils. The superficial deposits above the working platform would be graded back to achieve stable slope angles.
- 10.7.11** The desk study identified moderate hazard potential for landslides. As the construction works would be designed to resist potential instability of the slope, depending on the design that is taken forward, there is potential for the measures to increase slope stability and therefore reduce the potential for landslides. This would have a minor beneficial impact. The construction of the farm access road would comprise creation of a cutting of up to around 7m into the existing ground. This is likely to result in rock exposures along the cutting. Rock exposures are of geological interest, and the exposures proposed to be created are considered to have a low value, with the creation of this feature presenting a minor beneficial magnitude of impact.
- 10.7.12** The sensitivity of the local geology within this area of the Scheme is low. Therefore, overall the construction works are considered to have a **slight beneficial** significance effect on the Scheme geology.

Soils

- 10.7.13** The potential effects of construction works on agricultural land take has been considered as part of the Community and Private

Assets Chapter 14 and Materials Chapter 11 of this Environmental Statement.

Land Contamination

- 10.7.14** 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 10.8. The assessment of individual pollution linkages is presented in sections below.
- 10.7.15** The assessment of effects of construction works on the environment and human health has been undertaken based on following requirements (as detailed in Sections 10.4.44 to 10.4.45):
- 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 Chapter 17 and as such will not have an impact on identified receptors;
 - 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 with respect to surface water; and
 - 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 construction works.
- 10.7.16** 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

- 10.7.17** The potential baseline sources of contamination identified in relation to the study area are presented in Section 10.5.68 and Table 10.5. The construction works would introduce the following additional sources as a result of construction activities:
- Areas of unexpected contamination that would be encountered and excavated as a result of construction works;
 - Imported and site won construction materials e.g. for the construction of the temporary access track or embankment;
 - Dust derived from areas of made ground created during construction; and

- Groundwater removed as a result of piling operations impacted by cement (viaduct and bridge foundations) and dewatering (cutting into northern embankment).

Potential Receptors

10.7.18 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in Section 10.5.88 and Table 10.7. The construction works would introduce the following additional receptors:

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

Potential Pathways

10.7.19 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 10.5.88 and Table 10.7. The construction works would introduce the following additional pathways:

- Direct discharge of groundwater removed from ground as a result of piling and dewatering operations;
- Direct exposure to soils or groundwater (such as ingestion, dermal contact and/or inhalation of vapours) during excavation and piling works; and
- Contamination of groundwater and surface waters by concrete, cement paste or grout as a result of piling activities.

Plausible Pollution Linkages

10.7.20 The plausible pollution linkages are summarised in Table 10.8 below.

Table 10.8: Identified Source-Pathway-Receptor Linkages during Construction within the study area

Sources	Pathways	Receptors	Comments
On-site (within the Scheme alignment) sources			
<u>Baseline sources:</u> Railway land Made ground in the south and north of study area Made ground materials associated with the construction of the Millennium Cycle Bridge in the north Potentially impacted groundwater	Direct exposure to soil and/or soil dust via ingestion, dermal contact and inhalation Inhalation of gas and volatile contamination	Human health Baseline: A487 maintenance workers and users Agricultural land users Additional during construction works: Construction workers	Construction workers, and also the existing A487 maintenance workers and highway users may be directly exposed to soil and potentially contaminated dust generated from made ground during construction. For example, the ground investigation showed evidence of elevated concentrations of Polycyclic Aromatic Hydrocarbons at localised positions. Risk of exposure to ground gas is considered to be very low, as no elevated levels of ground gas were measured during the ground investigations.
<u>Additional sources during construction</u> Unexpected contamination Imported and site won construction materials Dust created during construction Groundwater removed from ground during piling or dewatering	Leaching and migration; Piling operations	Controlled waters: the Afon Dyfi, and groundwater (secondary aquifers)	Potential contaminants within the identified sources may leach to groundwater and via lateral migration have potential to impact the river quality. During piling operations groundwater will require removal from pile location. This groundwater will require discharge, which may impact the quality of the river. Cement used to form piles may escape and locally impact the groundwater or surface water receptors.

Sources	Pathways	Receptors	Comments
Off-site (outside the Scheme alignment) sources			
Groundwater beneath railway land (incl. track), activities at the Dyfi Eco Park including the historic garage, household amenity site, petrol filling station, flood alleviation bund and the historic pollution incident.	Inhalation of volatile contamination from potentially impacted groundwater	Human health Baseline: Farm residents, Dyfi Eco Park and other commercial park workers, agricultural land users	The potential human health baseline receptors in addition to the baseline sources, may be exposed to potentially impacted dust generated during the Scheme construction, Groundwater entering the central part of the Scheme alignment was found impacted by contamination arising from historic/current activities and consequently impacting the groundwater quality beneath the site. The risk to the agricultural land users is considered to be very low due to the short-term exposure and absence of confined/enclosed spaces. Made ground used for flood defences is not considered of concern due to down-gradient location in relation to the Scheme. The identified potential off-site sources are only present to the south of the Afon Dyfi and therefore no impact on the A487 related receptors is foreseen.
	Leaching and migration	Controlled waters: groundwater (both secondary aquifers) beneath the site	

Across the Scheme

- 10.7.21** There is a risk of encountering unexpected localised contamination during the construction works even in areas previously covered by intrusive investigations. This may pose a risk to the construction workers and controlled waters.
- 10.7.22** The sensitivity of the receptor is considered to be medium (adult construction worker) and medium (Secondary aquifer). 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 effect is considered to be ***slight adverse***.

Assessment of Potential Impact of Construction of the Approach Embankment Ch. 0+000m to 0+320m and flood alleviation bunds

- 10.7.23** The construction works in the area of the embankment would introduce new pollution linkages into the baseline conceptual site model as shown in Table 10.8 above.
- 10.7.24** Site operatives would be present on site for the duration of the construction works. They are likely to be exposed to potential sources of contamination identified within the baseline model, i.e. the area of railway land and associated made ground, and groundwater potentially impacted by contamination originating from the off-site sources.
- 10.7.25** Site won (from across the Scheme area) and imported materials are likely to be used within the construction works and therefore, in addition to sources already identified within that part of the Scheme, the construction workers, could also be exposed to any potential contamination contained within the construction materials. However, as detailed in Section 10.4.24, for the purpose of the assessments, 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 construction works. Consequently, construction materials are not considered to be a viable source of contamination and therefore their application in the Scheme construction would result in no change to the baseline scenario with a ***neutral*** significance effect.
- 10.7.26** No significant excavation works are proposed within the area of the embankment and therefore the receptors are likely to only be exposed to the dust generated from the potentially impacted existing soils, including potential made ground associated with the former railway land. The exposure pathways would include direct exposure of the construction workers to the soils and dust via ingestion, inhalation and dermal contact.

10.7.27 Similarly, as no excavations would take place, no direct exposure to groundwater would occur. However, the construction workers could be exposed to hydrocarbon vapours from the groundwater should it be impacted by hydrocarbon contamination and to ground gases. No groundwater sampling or testing, or ground gas monitoring have been undertaken in that part of the Scheme. Refer to Sections 10.5.69 to 10.5.83 for the baseline conditions. Considering that no excavations will take place and hence in the absence of confined spaces, and that the construction works would be taking place in an open air, the risk of gas/vapours accumulation and significant impact on human health is considered to be very low and therefore this pollution linkage will not be considered further. Consequently, ground gas or hydrocarbon vapours are not considered to be a viable source of contamination and therefore would result in no change to the baseline scenario with a **neutral** significance effect.

10.7.28 The Scheme neighbours, in particular, the workers of the Dyfi Eco Park, also have potential to be exposed to potentially impacted dust generated during the construction works via ingestion, inhalation and dermal contact. Note that effects of dust generation during construction is assessed by Chapter 6 Air Quality.

10.7.29 The above indicates that the works associated with the construction of the embankment approach and flood alleviation would create new potential plausible pollution linkages such as:

- Construction workers direct exposure to made ground materials encountered in the area of the proposed embankment; and
- Scheme neighbours exposure to potentially contaminated dust generated during the construction works.

Therefore, a GQRA has been carried out to assess the risks in more detail.

Generic Quantitative Risk Assessment (GQRA)

10.7.30 Following the methodology set out in Section 10.4, a GQRA has been carried out to assess the risks posed by the construction works, as presented below. This has taken into account the results obtained from two ground investigations completed within the Scheme area, presented in the Arup Ground Investigations Report (Arup, 2016b), in Appendix 10.2, Volume 3.

10.7.31 Considering the identified receptors, construction workers and the Dyfi Eco Park workers, the available soil testing results from the area of the proposed embankment, have been screened against the assessment criteria for a residential end use scenario. This scenario is considered the most conservative with

respect to potential exposure pathways during construction. The assessment criteria are presented in Appendix 10.5, Volume 3.

10.7.32 This indicated no exceedances of the applied assessment criteria within the embankment construction area and therefore the identified potential sources of soil contamination are unlikely to pose a risk to the identified receptors.

10.7.33 The sensitivity of the receptor is considered medium due to the receptor being an adult and the exposure duration being short-term (only duration of the construction works). 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 effect of the construction of the embankment on land contamination is **neutral**.

Assessment of potential Impact of Viaduct Construction and River Crossing Ch. 0+320m to Ch. 0+870m

10.7.34 The construction works in the area of the viaduct would introduce a new receptor and new pathways into the baseline conceptual site model.

10.7.35 The construction of the viaduct would require boring into the soils to form deep piled foundations. The piles are standard bored piles of 1.5m diameter with the casing pushed into the ground in sections and the soils and groundwater removed from within the casing. The piles are to be founded in sands and gravels along the viaduct, and down to the rock for the river crossing. Subject to the detailed design, the casing is likely to remain while the full length of the pile is concreted and then the casing would be removed.

10.7.36 A detailed foundations works risk assessment has been completed and is presented in Appendix 10.6, Volume 3. This identified a number of risks to human health and controlled waters during construction, which were assessed in more detail. The assessments concluded:

- Direct contact with contaminated soil arisings and groundwater that have been brought to the surface:

Groundwater potentially impacted by contamination originating from the off-site sources in the central Scheme area and soils in the area of piling operations (central and northern Scheme areas) have been identified as potential sources of contamination in this part of the Scheme. The assessment of risk to human health and surface water (due to discharge) is required. See Sections 10.7.38 to 10.7.40 for a more detailed review of potential pollution linkages;

- Contamination of groundwater and subsequently surface waters by concrete, cement paste or grout:

The piles would be cased due to the ground comprising permeable sands and gravels, therefore the migration is likely to be limited to the base of the pile only. As the migration may only occur until setting of the concrete occurs (set in terms of potential for migration of concrete constituents), which would generally occur on a timescale of a few minutes, the impact is likely to be very localised and unlikely to impact the groundwater quality significantly. Therefore, no further action is required.

There is however an increased risk of concrete spillages during pile formations, particularly in a vicinity of the river. The assessment of risk surface water is required.

10.7.37 The potential for made ground to be present at the locations of viaduct piling works is considered to be limited to the northern abutment only. However, some of made ground materials would be removed to facilitate the piling operations. Therefore, the conclusions of the assessment carried out for the assessment of effects of the works undertaken at the northern abutment (detailed in Sections 10.7.59 to 10.7.62 below), which considered the impacts of excavating this material and the potential exposure to site operatives is also valid for the piling works. This concluded that the excavation works would result in a **slight adverse** significance effect on the site operatives. The assessment of potential impact from soils within the central Scheme area is presented below.

10.7.38 The piling operations would also require dewatering of pile locations. The construction workers may be exposed to any potential contamination contained within that groundwater, that identified at baseline and also that introduced as a result of application of wet concrete. The exposure pathways would include direct exposure of the construction workers to the groundwater via ingestion, inhalation and dermal contact, inhalation of vapours from groundwater.

10.7.39 The removed potentially contaminated groundwater will also require discharge, possibly to the river, following monitoring and if needed, treatment to ensure it is of acceptable quality. Any such discharge will only be carried out with appropriate approval from NRW. The Scheme neighbours i.e. the agricultural land users, are unlikely to be exposed to the identified sources and therefore are not considered further.

10.7.40 A temporary access track will be required for the duration of the piling works, with the ground surface subsequently reinstated with topsoil for return to its current use. The access track shall

comprise either imported or site won crushed stone that will be verified as acceptable for reuse from a contamination point of view. The materials used within the construction of the temporary access track will be verified in terms of their quality in line with the approach outlined in Section 10.4.24. On this basis, the risk of these materials impacting the quality of groundwater beneath the Scheme or human health is considered to be very low and therefore this pollution linkage is not considered further. Consequently, materials used for the construction of the temporary access track are not considered to be a viable source of contamination and therefore their application in the Scheme would result in no change to the baseline scenario with a **neutral** significance effect.

10.7.41 The above indicates that the construction works would create new potential plausible pollution linkages during piling operations:

- Construction workers direct exposure to the soils and potentially contaminated groundwater (central part of the Scheme only);
- Construction workers direct exposure to made ground materials (northern abutment only; scenario considered in the northern abutment Scheme area, refer to Sections 10.7.60 to 10.7.62 below for the assessment));
- Direct discharge of the groundwater arising from the piling works to the river; and
- Potential impact on surface water receptors due to concrete overspill during piling operations;

10.7.42 Therefore a GQRA has been completed.

Generic Quantitative Risk Assessment (GQRA)

10.7.43 Following the methodology set out in Section 10.4, a GQRA has been carried out to assess the risks posed by the construction works, as presented below. This has taken into account the results obtained from two ground investigations completed within the Scheme area, presented in the Arup GIR (Arup, 2016b), in Appendix 10.2, Volume 3.

10.7.44 The review of the baseline groundwater chemical testing results (refer to Sections 10.5.75 to 10.5.80) indicates the presence of hydrocarbon contamination. These concentrations were measured above the applied assessment criteria with respect to human health.

10.7.45 No evidence of hydrocarbon contamination, such as sheen or odours, was noted during the sampling events. The testing results however indicated the water to be impacted by heavy

(with very low volatility) fractions of petroleum hydrocarbons at concentrations exceeding the applied assessment criterion in relation to human health. Consequently, there is a potential that hydrocarbon impacted groundwater may pose a risk to human health as a result of ingestion.

- 10.7.46** Considering the identified receptors, construction workers, the available soil testing results from the area of the proposed viaduct, have been screened against the assessment criteria for a residential end use scenario. This scenario is considered the most conservative with respect to potential exposure pathways during construction. The assessment criteria are presented in Appendix 10.5, Volume 3.
- 10.7.47** This indicated two exceedances of the applied assessment criteria within the viaduct construction area. Lead was identified above the applied assessment criterion at two locations, in TP04 at 0.6m and TP14 at 0.6m, both within the alluvial deposits. Therefore there is a low risk to the identified receptors.
- 10.7.48** The sensitivity of the receptor is considered to be medium due to the receptor being an adult and the exposure duration being short-term (limited to the duration of the construction works). Based on the GQRA the magnitude of impact presented by the identified sources of potential contamination is considered to be minor adverse. Consequently, the significance effect of the construction of the viaduct on land contamination is *slight adverse*.
- 10.7.49** The review of the baseline groundwater chemical testing results (refer to Sections 10.5.75 to 10.5.80) indicates the presence of elevated levels of metals (nickel and zinc), Polycyclic Aromatic Hydrocarbons (benzo(a)pyrene and fluoranthene) and petroleum hydrocarbons in relation to the applied assessment criteria with respect to surface water environment. In addition, the groundwater removed from the pile locations is likely to be impacted by cement.
- 10.7.50** This indicates that this groundwater has a potential to impact the quality of the receiving waters, should the discharge to surface water be considered. However, as stated in Section 10.4.45, 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. Measures may include bunding around working areas to contain any overspill and use of settlement lagoons, settlement tanks and/or silt busters. In addition, there is an absolute requirement to meet the chemical Environmental Quality protective of surface water.
- 10.7.51** Based on these requirements and considering the medium sensitivity of the river as a receptor, it is considered that a discharge of removed groundwater to the river and other piling

operations would have a negligible adverse impact on the river quality. Consequently, this activity would result in a *slight adverse* significance effect.

Assessment of potential Impact of Earthworks on the North River Bank Ch. 0+870m to Ch. 1+100m

10.7.52 The construction works in the area of the north river bank would include:

- Cutting into the existing ground to create a platform for the construction of the deep piled foundations and grading the slopes back. This would result in the removal of made ground and natural superficial deposits;
- Construction of deep piled foundations from the platform; and
- Cutting into the existing ground for the construction of the farm access road.

10.7.53 These construction activities would introduce a new receptor and a new pathway into the baseline Conceptual Site Model.

10.7.54 Site operatives would be present on site for the duration of the construction works. They are likely to be exposed to sources identified within the baseline model, i.e. the area of made ground associated with railway track and the construction of the Millennium Cycle Bridge, primarily during the earthworks activities and piling works.

10.7.55 The exposure pathways would include direct exposure of the construction workers to the soils and dust via ingestion, inhalation and dermal contact, inhalation of vapours from groundwater.

10.7.56 The maintenance workers of the existing A487 may be exposed to the potentially impacted dust generated as a result of the construction works, primarily the excavation of made ground materials via ingestion, inhalation and dermal contact. Note that effects of dust generation during construction is assessed by Chapter 6 Air Quality.

10.7.57 The users of the A487 are unlikely to be impacted by the identified sources during the construction works due to the very short-term exposure and therefore are not considered further.

10.7.58 The proposed earthworks may encounter groundwater during the excavation of superficial deposits, and therefore dewatering measures would be required. The removed groundwater would require discharge, possibly to the river, following monitoring and if needed, treatment to ensure it is of acceptable quality. Any such discharge will only be carried out with appropriate approval from NRW.

10.7.59 In addition, as the excavation works within the made ground would be taking place directly next to a river, there is also a risk of surface water run-off impacting the quality of the river. This requires further assessment, which is presented in Sections 10.7.60 to 10.7.65 below

10.7.60 The above indicates that the construction works would create new potential plausible pollution linkages as follows:

- Construction workers direct exposure to made ground materials;
- The existing A487 maintenance workers exposure to dust generated during excavation into the made ground;
- Direct discharge of groundwater to the river; and
- Surface water run-off to the river from areas of made ground;

Therefore a GQRA has been completed. The potential pollution linkages associated with piling activities are presented and assessed in the Viaduct Construction and River Crossing section above.

Generic Quantitative Risk Assessment (GQRA)

10.7.61 Following the methodology set out in Section 10.4, a GQRA has been carried out to confirm the existing risks resulting from the construction works.

10.7.62 Considering the identified receptors, construction workers and the maintenance workers and users of A487, the available soil testing results for materials removed from the areas of cutting have been screened against the assessment criteria for a residential end use scenario.

10.7.63 This indicated no exceedances of the applied assessment criteria. However, on account of the presence of ash and cinders, there is a low risk to the identified receptors.

10.7.64 The sensitivity of the receptor is considered medium due to the receptor being an adult and the exposure duration being short-term (only duration of the construction works). Based on the detailed assessment the identified sources of potential contamination are unlikely to pose a risk to human health and therefore the magnitude of impact is likely to be minor adverse. Consequently, the significance effect of the excavation works on the northern abutment on land contamination is *slight adverse*.

10.7.65 No data on groundwater quality on the northern bank is available. Refer to the baseline groundwater quality review, presented in Sections 10.5.75 to 10.5.80. Therefore a risk of potential impact on the river resulting from the discharge of groundwater into the river cannot be fully assessed at this stage. However, based on

the assumption made, as detailed in Section 10.4.45, any discharge to the river will only be carried out with appropriate approval from NRW, following monitoring and if needed, treatment to ensure it is of acceptable quality. Based on that and considering the medium sensitivity of the river as a receptor, it is considered that a discharge of removed groundwater to the river would have a negligible adverse impact on the river quality. Consequently, this activity would result in a *slight adverse* significance effect.

- 10.7.66** No data on soil leachate quality on the northern bank is available. Therefore a risk of potential impact on the river resulting from the surface run-off or groundwater seepages into the river during construction cannot be fully assessed at this stage. Appropriate measures would be implemented to ensure that any discharges comply with the particulate and chemical requirements that would be agreed with NRW prior to construction. These may include the use of bunded enclosures, settlement lagoons, settlement tanks and or silt busters. Based on these requirements and considering the medium sensitivity of the river as a receptor, it is considered that a discharge of the drainage water to the river would have a negligible adverse impact on the river quality. Consequently, this activity would result in a *slight adverse* significance effect.

10.8 Potential Operational Effects - Before Mitigation

Geology and Geomorphology

Assessment of Potential Impact of the Approach Embankment Ch. 0+000m to 0+320m and flood alleviation bunds

- 10.8.1** During the operational phase the embankment would result in continued minor consolidation of the soils due to the applied load of the embankment materials. This is unlikely to result in further significant reduction of the soils permeability and consequent localised changes to the groundwater movement. The proposed embankment covers a small area and therefore the impact would be limited.
- 10.8.2** The sensitivity of the impacted geology is considered low due to the localised area of impact with no change. Consequently the significance effect of the operation of the embankment on the geology is considered to be *neutral*.
- 10.8.3** The construction of the flood alleviation bund would result in minimal consolidation of the soils due to the low load of the utilised materials and would have no impact on the permeability and groundwater flow characteristics of the ground beneath the

bund. Therefore the magnitude of impact on operation would be no change with a **neutral** significance effect.

10.8.4 Consequently the overall significance effect of the operation of the embankment and the flood alleviation bund on the geomorphology is considered to be *neutral*. However, the embankment may have an impact on water flow during flooding events. Issues associated with flooding are considered in Chapter 15 Road Drainage and the Water Environment.

10.8.5 The introduction of the embankment would also locally bury the mineral resources present within the embankment area. As discussed in Section 10.5, the sensitivity of these resources is low. The magnitude of impact of the embankment on the resources would be negligible due to the relative small area covered by the embankment. Consequently, the significance effect of the operation of the embankment is considered to be *neutral to slight adverse*.

Assessment of potential Impact of Viaduct and River Crossing Ch. 0+320m to Ch. 0+870m

10.8.6 The presence of the viaduct piers would limit access to the mineral resources present within the Scheme area. As discussed in Section 10.5, the sensitivity of these resources is low. The magnitude of impact of the viaduct on the resources would be negligible due to the relative small area covered by the Scheme. Consequently, the significance effect of the operation of the viaduct is considered to be *neutral to slight adverse*.

Assessment of potential Impact of the Scheme on the North River Bank Ch. 0+870m to Ch. 1+100m

10.8.7 During the operational phase of the Scheme, works completed to the northern bank would not have effects on the geology or geomorphology.

Soils

10.8.8 The potential effects of operational phase on land take has been considered as part of the Community and Private Assets Chapter 14 and Materials Chapter 11 of this Environmental Statement.

Land Contamination

10.8.9 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 10.9. The assessment of individual pollution linkages is presented in sections below.

10.8.10 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

10.8.11 The potential baseline sources of contamination identified in relation to the study area are presented in Sections 10.5.68 and Table 10.5. The operation of the Scheme would introduce the following additional sources:

- Imported and site won construction materials e.g. for the construction of the embankment.

10.8.12 The assessment of pollution release as a result of operation is covered in Chapter 15 Road Drainage and the Water Environment.

Potential Receptors

10.8.13 Potential baseline receptors to the identified sources of potential contamination within the study area are presented in Section 10.5.88 and Table 10.7. The operation of the Scheme would introduce the following additional receptors:

- Maintenance workers; and
- Road users, including motorised and non-motorised users (such as cyclists, pedestrians, horse riders, etc.).

Potential Pathways

10.8.14 The preliminary potential baseline pathways between identified sources of contamination and receptors are presented in Section 10.5.88 and Table 10.7. The construction works would introduce the following additional pathways:

- Direct exposure to soils or dust (such as ingestion, dermal contact and/or inhalation of vapours);
- Inhalation of hydrocarbon vapours from groundwater;
- Leaching of contaminants from materials used for the construction;
- Creation of preferential pathways, through a low permeability layer, to cause contamination of groundwater in an aquifer due to the insertion of piles;
- Creation of preferential pathways to allow migration of ground gas or contaminated vapours to surface due to the insertion of piles; and
- Direct contact with contaminated soil or leachate causing degradation of pile materials.

Plausible Pollution Linkages

10.8.15 The plausible pollution linkages are summarised in Table 10.9 below.

Table 10.9: Identified Source-Pathway-Receptor Linkages during Scheme Operation within the study area

Sources	Pathways	Receptors	Comments
On-site (within the Scheme alignment) sources			
<u>Baseline sources:</u> Railway land Made ground in the south and north of study area Made ground materials associated with the construction of the Millennium Cycle Bridge in the north Potentially impacted groundwater	Direct exposure to soil and/or soil dust via ingestion, dermal contact and inhalation Inhalation of gas and volatile contamination Vertical upward gas migration along the piles.	Human health Baseline: A487 maintenance workers and users Agricultural land users Additional during Scheme operation: Maintenance workers Scheme users	Maintenance workers, and also the existing A487 maintenance workers and highway users may be directly exposed to soil and dust potentially contaminated dust generated from made ground during maintenance works. For example, the ground investigation showed evidence of elevated concentrations of Poly-Aromatic Hydrocarbons at localised positions. There is a potential risk of ground gas upward migration along the inserted piles. 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.
<u>Additional sources during Scheme operation</u> Imported and site won construction materials	Leaching and migration Contamination vertical migration along the piles	Controlled waters: the Afon Dyfi, and groundwater (secondary aquifers)	Potential contaminants within the identified sources may leach to groundwater Similarly, there is also a risk of contamination migration along the piles towards the groundwater. Both have potential to impact the river quality via lateral migration.
	Direct contact with potentially aggressive ground environment	Pile materials	Pile materials would be directly exposed to surrounding soils and groundwater. These may impact the integrity and durability of the piles due to low pH or high content of sulphates, which may create an aggressive environment.

Sources	Pathways	Receptors	Comments
Off-site (outside the Scheme alignment) sources			
Groundwater beneath railway land (incl. track), activities at the Dyfi Eco Park including the historic garage, household amenity site, petrol filling station, flood alleviation bund and the historic pollution incident.	Inhalation of volatile contamination from potentially impacted groundwater	Human health Baseline: Farm residents, Dyfi Eco Park and other commercial park workers, agricultural land users	Due to the distance to the Scheme, the potential human health baseline receptors are unlikely to be exposed to other sources than the baseline sources during the Scheme operation. The remaining pollution linkages are likely to return to the baseline conditions.
	Leaching and migration	Controlled waters: groundwater (both secondary aquifers) beneath the site	

Assessment of Potential Impact of the Approach Embankment Ch. 0+000m to Ch. 0+320m and flood alleviation bunds

- 10.8.16** The operation of the embankment would introduce potential pollution linkages into the baseline Conceptual Site Model.
- 10.8.17** Maintenance workers would undertake regular maintenance works within the embankment area. They may therefore be exposed to sources identified within the baseline model, i.e. the area of railway land and associated made ground. The exposure pathways would primarily include exposure to potentially impacted soil dust via ingestion, inhalation and dermal contact. Note that nuisance caused by dust generation during construction is assessed by Chapter 6 Air Quality.
- 10.8.18** In addition, the construction workers would be exposed to any site won materials used for the construction of the embankment. The use of the site won materials within the construction of the embankment could also potentially result in leaching and migration of mobile contaminants into the underlying groundwater as a result of rainwater infiltration. However, as detailed in Section 10.4.24, for the purpose of the assessments, 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. Consequently, construction materials are not considered to be a viable sources and therefore this pollution linkage will not be considered further. Consequently, construction materials are not considered to be a viable source of contamination and therefore their application in the Scheme construction would result in no change to the baseline scenario with a *neutral* significance effect.
- 10.8.19** As regular maintenance works would not involve deep excavations, no direct exposure to groundwater would occur. However, the maintenance workers could be exposed to hydrocarbon vapours from the groundwater should it be impacted by hydrocarbon contamination, and also ground gas. No groundwater sampling or testing, or ground gas monitoring has been undertaken in that part of the Scheme. Refer to Sections 10.5.69 to 10.5.83 in baseline conditions. Considering that no excavations will take place and hence in the absence of confined spaces, and the construction works would be taking place in an open air, the risk of significant impact on human health is considered very low and therefore this pollution linkage will not be considered further.
- 10.8.20** The Scheme users are unlikely to be impacted by any potential contamination within the Scheme area due to a very short-term exposure and therefore are not considered further.

10.8.21 The Scheme neighbours such as residents of the farm, workers and visitors of the commercial premises located in the Scheme vicinity are unlikely to be exposed to sources within the Scheme area due to their distance from the sources and therefore are not considered further. The above indicates that the operation phase of the Scheme would create new potential plausible pollution linkages such as:

- Maintenance workers direct exposure to made ground materials located outside the Scheme footprint, for which a GQRA has been completed.

Generic Quantitative Risk Assessment (GQRA)

10.8.22 Following the methodology set out in Section 10.4, a GQRA has been carried out to assess the risks to operation resulting from the Scheme. This is presented in the following sections.

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

10.8.24 This 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 high due to the receptor being an adult and the exposure duration being long-term. 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 effect of the construction of the embankment on land contamination is *slight adverse*.

Assessment of potential Impact of the Viaduct and River Crossing Ch. 0+320m to 0+870m

10.8.25 The construction works in the area of the viaduct would introduce a new pathway into the baseline Conceptual Site Model.

10.8.26 The viaduct piers foundations, subject to a selected piling technique, may introduce a preferential flow path for potentially impacted groundwater and/or ground gas. A detailed foundations works risk assessment has been completed and is presented in Appendix 10.6, Volume 3. This identified a number of risks to human health and controlled waters during Scheme operation, which were assessed in more detail. The assessments concluded:

- Creation of preferential pathways, through a low permeability layer, to cause contamination of groundwater in an aquifer

The proposed piling technique has a potential to create a preferential flow path for contamination migration through the alluvial layer encountered across the majority of the viaduct area (refer to Section 10.5.13 for details on ground conditions). The alluvial deposits were found to contain lead, which may leach into the underlying groundwater. However, considering that these are likely to represent background concentrations and the majority of the alluvial materials would be excavated to form a pile cap in the pile location, the risk to groundwater is considered to be very low. Where the piles extend into the bedrock, i.e. within the area of the river crossing, there is a potential for impacted groundwater migration into the bedrock along the piles. However, considering that the bedrock comprises materials of low permeability and that the concrete would be placed directly within the rock without creating voids, the risk is also considered very low. Therefore, no further action was considered required.

- Creation of preferential pathways to allow migration of ground gas or contaminated vapours to surface.

As above, the proposed piling technique has a potential to create a preferential flow path for ground gas through the alluvial layer. However, the ground gas risk assessment undertaken for the baseline conditions, as presented in Sections 10.5.81 to 10.5.83, indicated a very low risk from ground gas. In addition, the results of groundwater testing indicated the presence of hydrocarbon contaminants within the groundwater, vapours of which might also migrate along the pile to the ground surface. The review of the identified hydrocarbon compounds indicated that these compounds are not highly volatile, and therefore unlikely to pose a significant risk to human health. Moreover, providing that no confined spaces are included within the design, the risk of ground gas migration along the piles was considered to be very low. No further action was considered required.

- Direct contact with contaminated soil or leachate causing degradation of pile materials.

There is a risk of the pile materials to be impacted by the surrounding soils and groundwater on removal of the casing. The assessment of ground aggressivity on concrete has been undertaken and is presented in the Arup GIR (Arup, 2016, enclosed in Appendix 10.2, Volume 3). This identified a suitable concrete class to be applied within the piles construction. Therefore the risk to the piled foundations materials was considered to be very low. No further action was considered required.

- 10.8.27** The above indicates that the operational phase of the viaduct section of the Scheme would be unlikely to create new potential plausible pollution linkages.

Assessment of Potential Impact of the North River Bank Ch. 0+870m to 1+100m

- 10.8.28** The proposed earthworks to be undertaken as part of the construction works would result in some of the made ground materials to be exposed at surface and consequently exposed to the increased rainfall infiltration during the Scheme operation. This may result in an increase in leaching of contaminants from the exposed made ground.

- 10.8.29** Groundwater has been encountered in this part of the Scheme. However, considering the proximity to the Afon Dyfi, the rainwater is likely to discharge to the river as a result of either surface water runoff or as perched groundwater flows within the shallow superficial deposits. These flows would be collected by the highway drainage system and discharged, possibly to the river.

- 10.8.30** The above indicates that the construction works may create a new plausible pollution linkage:

- Surface water run-off and leaching of contaminants into the river, and therefore a GQRA is required.

Generic Quantitative Risk Assessment (GQRA)

- 10.8.31** No data on soil leachate quality on the northern bank is available. Therefore a risk of potential impact on the river resulting from the discharge of collected surface run-off or groundwater seepages into the river cannot be fully assessed at this stage. However, based on the assumption made, as detailed in Section 10.4.45, any discharge to the river will only be carried out with appropriate approval from NRW, following monitoring and if needed, treatment to ensure it is of acceptable quality. Based on that and considering the medium sensitivity of the river as a receptor, it is considered that a discharge of the drainage water to the river would have a negligible adverse impact on the river quality. Consequently, this activity would result in a *slight adverse* significance effect.

10.9 Mitigation and Monitoring

Construction Mitigation

- 10.9.1** The assessment of impact that the construction of the Scheme may have on geology and land contamination identified a number of effects as summarised in Table 10.10.

Table 10.10: Summary of construction effects

Scheme element	Effect	Significance
Geology and Geomorphology		
Approach Embankment and flood alleviation bunds	Soils consolidation	Neutral to slight adverse
Viaduct Construction	Piling works	Neutral to slight adverse
Earthworks on the North River Bank	Increased slope stability and reduction in landslides.	Slight beneficial
	Rock exposures	Slight beneficial
Land contamination		
Across the Scheme	Impact on human health and controlled waters due to localised unexpected contamination	Slight adverse
Approach Embankment and flood alleviation bunds	Impact on human health (construction workers and the Dyfi Eco Park workers) due to exposure to soils and groundwater impacted by contamination	Neutral
	Use of site and/or imported materials for construction	Neutral
Viaduct Construction	Impact on human health (construction workers) due to exposure to soils and groundwater impacted by contamination	Slight adverse
	Discharge of groundwater to surface water and general impact on surface water	Slight adverse
Construction of temporary access track	Impact on human health and water environment due to placement of site won/ imported materials	Neutral
Earthworks on the North River Bank	Impact on human health (construction workers and the A487 maintenance workers) due to exposure to soils impacted by contamination	Slight adverse
	Impact on the river quality due to groundwater discharge and surface run-off	Slight adverse

Geology and Geomorphology

10.9.2 The completed assessments identified a number of effects with respect to geology and geomorphology as summarised in Table 10.10. The assessment indicated the overall *neutral to slight adverse to slight beneficial* significance of effect of construction works on site geology and geomorphology. Therefore, no mitigation measures are considered necessary.

Land Contamination

10.9.3 The completed assessments identified a number of effects with respect to land contamination as summarised in Table 10.10. 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.

10.9.4 The absence of the requirement for mitigation is based on the following as detailed in Sections 10.4.45 to 10.4.50):

- 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 Chapter 17 and as such will not have an impact on identified receptors. See Section 10.9.5 for more details;
- 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; and
- 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 construction works.

10.9.5 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.

10.9.6 The applied best environmental management practice as a minimum would include the following considerations (refer to Chapter 17 Environmental Management Plan for details):

- Discovery of unexpected contaminated land would require appropriate measures to limit the risk to construction workers and controlled waters;
- Dust control measures to ensure that dust generation and off-site migration is minimum. 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 6 Air Quality;

- Water impacted by chemical contamination and cement would require application of mitigation measures before discharge. Measures may include bunding around working areas to contain any overspill and use of settlement lagoons, settlement tanks and/or silt busters. In addition, there is an absolute requirement to meet the chemical Environmental Quality protective of surface water;
- 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 works. This is in addition to the approval requires with respect to the quality of the discharge water to the river;
- 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 and groundwater quality and would be consulted regarding monitoring programmes; and
- 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

10.9.7 The assessment of impact that the operation of the Scheme may have on geology and land contamination identified a number of effects as summarised in Table 10.11.

Table 10.11: Summary of operational effects

Scheme element	Effect	Significance
Geology and Geomorphology		
Approach Embankment and flood alleviation bunds	Continued soils consolidation and potential impact on groundwater movement	Neutral
	Localised burial of mineral resources	Neutral to slight adverse
Viaduct Construction	Limitation of access to mineral resources	Neutral to slight adverse
Earthworks on the North River Bank	None	
Land contamination		
Approach Embankment and flood alleviation bunds	Impact on human health (maintenance workers) due to exposure to soils and groundwater impacted by contamination	Slight adverse
	Leaching of contaminants from soils reused in construction of the embankment to groundwater	Neutral
Viaduct Construction	None	
Earthworks on the North River Bank	Surface run-off and leaching of contaminants from soils exposed at surface as a result of construction works to surface water	Slight adverse

Geology and Geomorphology

10.9.8 The completed assessments identified a number of effects with respect to geology and geomorphology as summarised in Table 10.11. The assessment indicated the overall *neutral to slight adverse* effect of the Scheme operation on site geology and geomorphology. Therefore, no mitigation measures are considered necessary.

Land Contamination

10.9.9 The completed assessments identified a number of effects with respect to land contamination as summarised in Table 10.11. The assessment indicated *neutral to slight adverse* effect of the Scheme operation presented by land contamination. Therefore, no mitigation measures are considered necessary.

10.9.10 The absence of the requirement for mitigation is based on Sections 10.4.46 i.e. 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 construction works.

- 10.9.11** In addition, the available soil and groundwater chemical testing results would be used to inform health and safety risk assessments for the maintenance works.

10.10 Construction Effects - With Mitigation

- 10.10.1** No mitigation measures have been proposed over and above the current design proposals and therefore the construction effects, as summarised in Table 10.10, remain unchanged.

10.11 Operational Effects - With Mitigation

- 10.11.1** No mitigation measures have been proposed over and above the current design proposals and therefore the construction effects, as summarised in Table 10.11, remain unchanged.

10.12 Assessment of Cumulative Effects

- 10.12.1** No other developments have been identified which could generate cumulative effects with the Scheme during the construction phase or operation of the Scheme.

10.13 Inter-relationships

Dust during construction – nuisance

- 10.13.1** Construction activities would result in dust emissions. Inhalation of dust derived from potentially contaminated materials during construction and maintenance works has been considered as one pollution linkages identified for the Scheme. The assessments indicated that the risk of exposure to elevated levels of contaminants is very low with significance effect of neutral to slight adverse.

- 10.13.2** Therefore, no additional mitigation measures specific to exposure to contaminated soils are proposed. Note that effects of dust generation during construction is assessed by Chapter 6 Air Quality.

Reuse of soils – materials

- 10.13.3** Construction of the embankment would involve reuse of site won materials. Impact on Scheme users and neighbours as well as water environment was considered as part of the land contamination effects. The assessments indicated that the risk of

exposure to elevated levels of contaminants is very low with significance effect of neutral to slight adverse.

- 10.13.4** Therefore, no additional mitigation measures specific to exposure to contaminated soils are proposed.

Impact on quality of groundwater

- 10.13.5** The assessment of potential effects of land contamination identified potential risks to groundwater during construction and maintenance works. These would include encountering areas of unexpected contamination, leaching of contaminants from soils reused in the construction of the embankment and piling activities creating preferential pathway for contamination migration towards groundwater.

- 10.13.1** The assessments indicated that the risk of exposure to elevated levels of contaminants is very low with significance effect of neutral to slight adverse.

- 10.13.2** Therefore, no additional mitigation measures specific to exposure to contaminated soils are proposed.

10.14 Summary

- 10.14.1** This chapter of the ES presents the potential effects that the proposed development would have on geology and soils with a particular emphasis on land contamination. Consideration of potential impacts on agricultural land take has been considered within Chapter 14 of this report, relating to Community and Private Assets.

- 10.14.2** The baseline review indicated the site to be located in a floodplain of the Afon Dyfi with the underlying geology comprising poorly defined superficial deposits of fluvial alluvium and glacial till over the bedrock of the Borth Mudstone Formation.

- 10.14.3** The key geological/geomorphological features include:

- Potential presence of former channel alignments in the central part of the Scheme; and
- Some minor rock exposures present in the northern Scheme area along the existing A487.

These are considered to be of low sensitivity.

- 10.14.4** There are no statutory or non-statutory geological sites within the study area, with the northern end of the Scheme located within the Snowdonia National Park. However, the Scheme lies within the Dovey GLA and the northern part on the Moal Maesywerngoch GLA. Due to their local importance these are considered to be of low sensitivity.

- 10.14.5** The Scheme lies within an area identified as a potential source of sand and gravel, however these resources are currently not explored and in accordance with the local policy no new exploration permits will be granted.
- 10.14.6** No hazards relating to past mineral exploration have been identified. The ground within the study area has a potential for compressible soils and landslide stability hazards have been identified at the northern end of the Scheme.
- 10.14.7** The assessments indicate that the construction activities associated with the construction of the embankments, viaduct and general earthworks would have a *neutral to slight adverse* effect on the underlying geology and geomorphology. The earthworks in the northern end of the Scheme would have a *slight beneficial* significance of impact on the underlying geology due the increased slope stability and creation of rock exposures along the cutting.
- 10.14.8** Generally, the construction works would have a *neutral to slight adverse* effect on land contamination issues in relation to the identified human and environmental receptors. Although no mitigation measures would be considered necessary, the risk to the identified receptors could be further limited by implementation of best practice environmental management measures in line with the Pre-CEMP and through obtaining appropriate approvals from NRW with respect to monitoring/treatment of any water discharged into the river.
- 10.14.9** Generally, the operation of the Scheme would also result in a *neutral to slight adverse* significance effect on the underlying geology and geomorphology and land contamination. As with the risks arising from the construction activities, no mitigation measures would be considered necessary during the Scheme operation.