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A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

ENVIRONMENTAL STATEMENT
VOLUME 3B: TECHNICAL APPENDICES

July 2019

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Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

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PART A

1 The Project

1.1 Context

1.1.1 The Welsh Government have appointed Arup and RML as their technical advisors, to develop the design of the proposed A40 Llanddewi Velfrey to Penblewin Improvements up to publication of draft Orders.

1.1.2 In February 2017, the Welsh Government appointed Carillion, with Arup and RML as their technical advisors. In January 2018 Carillion went into liquidation. In August 2018, Arup and RML were contracted to recommence development of the Scheme.

1.1.3 The contract was awarded on the basis of a northern bypass for Llanddewi Velfrey from Gwyndy Farm to Ffynnon Wood and an offline improvement from Ffynnon Wood to Penblewin. The contract required the team to build on the previous work, and to carry out a WelTAG Appraisal in accordance with the new 2017 draft Guidance. The WelTAG appraisal approach has been applied to identify the problems on the existing A40, Scheme objectives and some solutions to be incorporated within the Scheme.

Changes to the draft Scoping Report

1.1.4 As a consequence of the delays to the project in early 2018, the decision was made to update the Screening Report, Scoping Report and the full Environmental Statement (ES) to take account of the most recent 2014 Directive (as amended) 2014/52/EU. The latter amendments were recognised in the publication of The Environmental Impact Assessment (Miscellaneous Amendments Relating to Harbours, Highways and Transport) Regulations 2017 (EIA Regulations 2017). This Scoping Report has therefore been rewritten since a draft ES was completed and so is informed by the information included in that draft ES.

The WelTAG appraisal

1.1.5 Welsh Government adopted the Welsh Transport Planning and Appraisal Guidance (WelTAG) in 2008. This appraisal uses a methodology for assessing proposed strategies, plans and schemes. The Appraisal is intended to provide information about significant economic, environmental and social impacts from proposals so that decision makers can judge the merits of proposals using a consistent approach.

1.1.6 The options for the A40 Llanddewi Velfrey to Penblewin Improvements were compared against the Transport Planning Objectives and the criteria of Welsh Impact Areas (the 'three pillars of sustainability' that underlie policy in Wales: the economy, the environment and society (including legal requirements and the desire to protect and enhance the condition of the built and natural environment).

1.1.7 The WelTAG Stage 1 Report recommended further consideration of an offline (2+1) option taking a route north of Llanddewi Velfrey and reflecting previous public opinion, along with an offline improvement between Ffynnon Wood and Penblewin Roundabout. Options that were rejected included a 'Do Minimum' option; a Public Transport Improvements option; and a route west of Ffynnon Wood that would require only limited interventions.

1.1.8 WelTAG Stage 2 study considered three different variations of junction arrangements for the route.

1.2 Project History

1.2.1 The need for the improvement of the A40 west of St Clears was identified during a 2001 study into a range of transport options. The findings were published in the Transport Framework for Wales (2001). Following a subsequent A40 West of St Clears study in 2004, Welsh Government announced the outcome of consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest.

1.2.2 In December 2004 the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvements would use the 2+1 configuration allowing overtaking in the two-lane direction, with overtaking prohibited in the one lane direction, and would be delivered in the following phases:

A. A40 Penblewin - Slebech Park

B. A40 Llanddewi Velfrey - Penblewin.

1.2.3 From 2006 onward, a range of routes for the improvements were considered between Bethel Chapel and Penblewin Roundabout, including a route that closely followed the existing road, a bypass option to the north of Llanddewi Velfrey and on and offline improvements from Ffynnon Wood to Penblewin

1.2.4 The first of these projects, Penblewin - Slebech Park, was completed in March 2011.

1.2.5 In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

> *"Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements."*

1.2.6 On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary:

> *"In terms of transport links, I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey."*

1.2.7 In June 2015, in a written statement on the A40 Improvement Study the Minister noted *"It is my intention to progress delivery of the A40 Llanddewi Velfrey to Penblewin Scheme as soon as possible…"*

1.3 The problems

1.3.1 Consultation with key stakeholders, including the Local Authority, Welsh Government Departments and the Regional Transport Planner has identified the following problems:

a) Limited overtaking opportunities which lead to poor journey time reliability and driver frustration, risky manoeuvres and collision incidents.

b) Inconsistency in the level of overtaking provision between the eastbound and westbound directions. Existing provision gives a total of 5.5km in the westbound direction and 3.2km in the eastbound, so that 13% of the total 32.5km length remains well below the 30% ratio advised for this type of route in the Design Manual for Roads and Bridges (DMRB) TD9/93 [1].

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[1] Design Manual for Roads and Bridges, Volume 6 Section 1 Part 1, TD 9/93, Highway Link Design, The National Assembly for Wales, June 1993

c) Where overtaking provision does exist, it is currently not spread along the length of the A40 such as there are long lengths in each direction with no overtaking opportunities. This is the case for vehicles travelling east for at least 19km from Robeston Wathen towards St Clears roundabout and for vehicles travelling west for 9.5km from Canaston Bridge to Haverfordwest roundabout.

d) Occasional convoys of heavy goods vehicles from the ferry ports and slow-moving agricultural vehicles, both of which contribute to periods of platooning and journey time unreliability when combined with limited overtaking opportunity.

e) Seasonal spikes in traffic volumes along the A40 and during the summer months. This leads to slow moving tourist traffic causing journey time unreliability when combined with limited overtaking opportunity.

f) Community severance at Llanddewi Velfrey owing to the current A40 alignment.

g) Conflict between vehicle traffic and Non-Motorised Users (NMUs), particularly along sections where footways are substandard.

h) Substandard sections of existing road, especially at Llanddewi Velfrey.

i) Numerous side road junctions and the high number of direct accesses to property and fields.

j) A mix of traffic types using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents.

k) A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.

1.4 Scheme objectives

1.4.1 A number of transport planning objectives were developed iteratively during previous development work and engagement on the A40 project, aiming to address one or more of the identified problems. During the early stages of Key Stage 3 the problems and objectives were refreshed during a focused workshop event with key stakeholders to take into account the WelTAG 2017 guidance and Well-being of Future Generations (Wales) Act well-being goals. The Scheme objectives are:

a) To improve health and safety on the road and reduce collisions.

b) To improve the resilience of the A40 as an important trade and tourist route through provision of safe, unambiguous overtaking opportunities in both directions using the wide single 2+1 standard.

c) To improve the cohesiveness of communities on the line of the A40, reducing severance effects and taking traffic out of the village communities.

d) To improve capacity, reliability and journey times along the east-west road corridor as a key gateway into Pembrokeshire for local connectivity, access to services, trade and tourism.

e) To improve regional accessibility and mobility.

f) To improve prosperity through better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard and Milford Haven.

g) To maintain and promote cycling, horse riding and walking and provide opportunities for healthy lifestyles.

h) Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.

i) Deliver a project which offers resilience through minimising future maintenance and disruption to the network.

j) To deliver a scheme that integrates with the local transport network and better connects local communities to key transport hubs.

k) To deliver a scheme which opens up legacy opportunities, delivering health and amenity benefits through opportunities to connect to the wider environment.

l) To improve prosperity through opportunities for skills training and employment for local people.

m) Ensure all of these objectives are met with due consideration given to the impact on the environment and opportunities for enhancement.

1.5 Purpose of this Report

1.5.1 Scoping seeks to decide which environmental topics[2] (Factors) are to be examined within a Statutory Environmental Impact Assessment (EIA). The scoping exercise should inform the assessment process and determine the appropriate assessment levels. Scoping can also be used to inform and activate discussion with the statutory consultees (through Environmental

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[2] The revised Design manual for Roads and Bridges requires the term ‘topic’ in this context to be replaced with ‘Factor’. In this report the term ‘Factor’ is used with a capital letter to highlight the change.

Liaison Group meetings) with respect to defining the assessment activities. For this project, the Scoping process has become an iterative activity that has been reactivated at key stages in the project planning process to reflect the changing knowledge and regulatory context.

1.5.2 The purpose of this Scoping Report is to request a Scoping Opinion from Welsh Government, under the framework of the Highways Act 1980, Highways (Assessment of Environmental Effects) Regulations 1999 and The Highways (Environmental Impact Assessment) Regulations 2007 (as amended to transpose Council Directive No. 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, and subsequent Council Directive No. 97/11/EC M2 and Directive No. 2003/35/EC M3 of the European Parliament and Council), 2011 European Directive 2011/92/EU, and the most recent 2014 Directive (as amended) 2014/52/EU. The latter amendments were recognised in the publication of The EIA Regulations 2017.

1.5.3 Guidance outlined in the DMRB also provides relevant direction in relation to the EIA process and subsequent ES.

1.6 Structure and Contents of this Scoping Report

1.6.1 Because considerable detail is required in this Scoping Report to address the specialist topics, a decision has been taken to provide a summary of the specialist topics in PART A, with the full scoping for each topic set out in PART B. Any reference to a chapter is referring to the proposed chapter in the Environmental Statement.

PART A	
Section 1	This introduction
Section 2	Sets out a description of the Scheme.
Section 3	Identifies the administrative process in terms of the policy context.
Section 4	Identifies the consultation requirements in a legislative context, previous consultations undertaken to date and provides a list of statutory and non-statutory consultees that the project team proposes to engage with.
Section 5	Identifies the proposed content and structure of the EIA, in the form of chapter layout.
Section 6	Summary of Chapters 7 to 16 in PART B covering potential impacts and proposed mitigation
PART B	
Section 7 - 16	Identifies the proposed technical chapter structure and assessment methodology. Identifying those matters which may have a potentially significant environmental effect and should be subject to EIA i.e. those topics to be 'Scoped in' to the EIA.
Drawings	Provides a site location plan and illustrative Scheme masterplan

1.7 Assessment of Implications for European Sites (AIES)

1.7.1 Under the contract, the project team are required to undertake an AIES which includes Natura 2000 sites identified previously and newly designated and candidate sites. The assessment is carried out in stages which commence with a Stage 1 Statement to Inform an Appropriate Assessment (SIAA) Screening Report. If required, a Stage 2 SIAA is prepared. The AIES screening is being undertaken in parallel with this EIA Scoping exercise.

1.7.2 A list of relevant European sites is provided in Section 9, Table 7.

2 Proposed Development

2.1 Description of the Scheme

2.1.1 A 4.3km length of the A40 Trunk Road would be improved. Currently the road is a single carriageway with few places for overtaking. The road has poor visibility and has a large number of accesses to fields, farms and private property opening straight onto the road. During the summer, the amount of traffic can increase considerably compared to the winter. This road A40 runs through the village of Llanddewi Velfrey, splitting the community in two.

2.1.2 The proposed improvements include a 2.2 km northern bypass to the village of Llanddewi Velfrey and a 2.1 km improvement that continues west to Penblewin roundabout on an alignment that is parallel and close beside the existing road. The Scheme would provide overtaking opportunities in both directions.

2.1.3 Starting in the west, at the existing Penblewin Roundabout, the Scheme would require an enlarged roundabout to accommodate the necessary 5 arms connecting with the A478 and the existing detrunked A40 connecting with the existing service area. The Improvement Scheme would leave the roundabout immediately to the north of the existing A40 and extend, in parallel, westward on an embankment and then almost at grade, for a distance of 1.2 km. The existing road would be detrunked to provide local access to properties to the south. A number of private means of access (PMA) and field gates would be severed on the north side, so a single lane road would be constructed to carry local traffic to these PMAs and fields. A balancing pond would be required at around chainage 300 to receive road drainage for discharge into a minor watercourse which flows south.

2.1.4 The landscape is gently undulating hedged pastureland rising to the north and sloping southwards towards a minor water course to the south.

2.1.5 At chainage 1,200, there is a junction on the existing A40 with a minor county road on the south side. There is a small former gate lodge which is of some heritage value, although not designated. On the north side, there is a PMA and bridleway. The proposed improvement would close both routes. In mitigation, the existing detrunked road would connect to the southern local road at the former junction, while the proposed new single lane local road would link to the northern PMA. An equestrian underpass would be constructed to carry the bridleway under the proposed A40.

2.1.6 From chainage 1,200 to 1,900, the proposed Scheme would use the line of the existing A40, although the improved alignment would deviate to north and south of the existing carriageway, which is on embankment as it passes through the small settlement of Ffynnon and through Ffynnon Wood. Construction is likely to require the felling of some woodland trees. Watercourses cross the existing road here, but the proposed Scheme would not require any changes to the existing culverts.

2.1.7 A new staggered junction would be required between chainage 1,900 and 2,100 to allow access on the north side to Ffynnon and to several more isolated properties on the north side of the road. The south arm of the junction would provide a link to the detrunked A40 through the village of Llanddewi Velfrey. A balancing pond would be required on the south side to receive highway drainage for discharge into a minor watercourse which flows west.

2.1.8 From chainage 2,100, the proposed road would continue in a straight alignment, leaving the line of the old A40, which curves southwards to along the crest of a prominent ridge to pass through Llanddewi Velfrey. The new road would traverse the north side of the ridge, with gradient of the slope steepening to the east. To maintain the vertical and horizontal alignment the carriageway would require a cutting up to 4m deep and then embankment up to 8m high. A farm underpass would be required to link farms on the north with severed land to the south. The underpass would also carry a public footpath.

2.1.9 Further east the ridge is increasingly deeply incised with small wet, wooded valleys and intervening pastureland. The bypass curves southwards as it continues to traverse the ridge first into a cutting to pass under a county road which links Llanddewi Velfrey to Llanfallteg to the north. The road would be carried over the bypass on a new bridge.

2.1.10 Continuing eastwards the bypass crosses several small wooded valleys on a major embankment of up to 15m height and would require the clearance of woodland and the construction of culverts to cross minor watercourses. Mammal underpasses are proposed along the route to mitigate for the severance of the woodland wildlife corridors. An underpass would also be required to carry several diverted public footpaths under the Scheme. A balancing pond would be required on the north side to receive highway drainage for discharge into a minor watercourse which flows north.

2.1.11 Continuing east the new carriageway would pass into a deep cutting and then return to the alignment of the existing A40. This would require a new four-arm roundabout, connecting with the detrunked A40 serving Llanddewi Velfrey and a Private Means of Access to Bethel Chapel and a number of properties to the north. The southern link would tie-in to the detrunked A40 through Llanddewi Velfrey. Eastwards, a 500m length of improved carriageway would tie-in with the existing A40. A balancing pond would be required on the south side to receive highway drainage for discharge into a minor watercourse which flows north.

2.1.12 Attenuation ponds are proposed in four locations to receive highway drainage and release this water to watercourses, at rates agreed with Natural Resources Wales.

2.1.13 A plan of the Scheme is available in Appendix B.

3 Policy Context

3.1 European and National Legislation and Policy

3.1.1 This section of the Scoping Report outlines the relevant legislative and policy framework with an overview of guidance and strategy documents. These documents are considered as part of the 'Legislative and Policy Context' chapter of the ES.

3.1.2 Consideration of European and national legislation is a requirement of the EIA regulations so that the Scheme can be seen in the policy context and any problems caused, conflicts created and benefits to be derived can be identified and understood. DMRB Volume 11 states that the ES should *'indicate briefly the degree to which transport and environmental policies, and related transport appraisals, Environmental Reports published in accordance with the requirements of the SEA Directive and the Overseeing Organisation, and other relevant policies would be supported by the project.'. The ES will refer to matters such as predicted economic benefits or safety improvements.*

3.1.3 Specific policy considerations and methods are further considered on a topic by topic basis in the ES.

EIA Legislation

3.1.4 The EIA legislative framework in Wales originates from European Council Directive 85/337/EEC as amended by EC Directive 97/11/EC and the Public Participation Directive 2003/35/EC.

3.1.5 Then came the 2011 European Directive 2011/92/EU, and the most recent 2014 Directive (as amended) 2014/52/EU. These are known, collectively, as the EIA Directive. The Directive requires EIA to be undertaken in support of an application for development consent for certain types of scheme.

3.1.6 The most recent Directive (2014/52/EU) requires Member States to transpose its requirements into national law by 16 May 2017 and sets out arrangements for a transitional period from the regime laid down by Directive 2011/92/EU.

3.1.7 These transitional measures require that the provisions of Directive 2011/92/EU should apply to schemes for which the EIA process has been initiated within the transitional period.

3.1.8 For highways schemes, the requirements of the EIA Directive are currently transposed by the Highways Act 1980, as amended by The Highways (Assessment of Environmental Effects) Regulations 1999 and The Highways (Environmental Impact Assessment) Regulations 2007 and The EIA Regulations 2017.

3.1.9 The 2017 regulations come into effect on the 5 December 2017 and change the information that is required in the screening of Schedule 2 developments, and in what should be included in an ES. A minimum period for public consultation of 30 days has been included.

Environment (Wales) Act 2016

3.1.10 The Environment (Wales) Act primary purpose is as follows:

a) To promote sustainable management of natural resources

b) To require the Welsh Ministers to meet targets for reducing emissions of greenhouse gases from Wales.

c) To ensure Waste is processed separately and effectively.

Well-being of Future Generations (Wales) Act 2015

3.1.11 The Well-being of Future Generations Act requires public bodies in Wales to think about the long-term impact of their decisions, to work better with people, communities and each other, and to prevent persistent problems such as poverty, health inequalities and climate change.

Planning (Wales) Act 2015

3.1.12 The Planning (Wales) Act makes provision about sustainable development in the exercise of functions relating to development planning and applications for planning permission.

Active Travel Act, 2013

3.1.13 The Active Travel (Wales) Act requires local authorities in Wales to map and plan suitable routes for active travel, and to build and improve their infrastructure for walking and cycling every year. It creates new duties for highways authorities to consider the needs of walkers and cyclists and make better provision for them. It also requires both the Welsh Government and local authorities to promote walking and cycling as a mode of transport so that local communities rely less on cars when making short journeys.

Planning Policy Wales

3.1.14 Planning Policy Wales (Edition 9 – November 2016) Chapter 5, refers to EIA and the thresholds for implementing an assessment. Chapter 8 refers to Planning for roads and outlines the Governments commitments to reducing the use of trunk roads for short journeys.

Green Corridors

3.1.15 In July 2018, the Minister introduced a new policy and announced a programme of work and activities to improve the landscape and environmental quality of the urban and rural transport network. The initiative is to deliver against the Economic Action Plan 'Prosperity for All'.

Technical Advice Notes

3.1.16 Welsh Government have prepared a number of Technical Advice Notes to provide guidance on specific technical considerations within the consenting process. These are referenced where applicable under the relevant topics within the ES and would include:

a) Technical Advice Note 5 Nature Conservation and Planning, 2009

b) Technical Advice Note 11 Noise, 1997

c) Technical Advice Note 18 Transport, 2007

d) Technical Advice Note 23 Economic Development, 2014

Wales Transport Strategy, 2008

3.1.17 Published by Welsh Assembly Government, the overarching aim of the Wales Transport Strategy is to promote sustainable transport networks that safeguard the environment while strengthening the country's economic and social performance. The strategy has been prepared in the context of the One Wales Programme, which is a progressive agenda for Wales.

National Transport Finance Plan, 2015

3.1.18 Published by Welsh Government, the National Transport Finance Plan lists the schemes the Welsh Government plan deliver across the different areas of transport policy for which it is responsible. The Plan is not a policy document in itself but provides a framework of schemes pursuant to policy aims set out in the Wales Transport Strategy 2008. Improvements to the A40 are included within the Plan.

Trunk Road Forward Programme, 2002, 2004 and 2008

3.1.19 Published by Welsh Government, the Trunk Road Forward Programme seeks to improve the economic and social conditions in Wales, through increasing efficiency and accessibility in all areas. The Forward Programme indicated the Welsh Government's intentions for road schemes that were expected to cost £1m or more. The A40 St Clears to Haverfordwest was identified in the Forward Programme within the 'East – West (south) strategic corridor'.

3.2 Regional Policy

Joint Transport Plan for South West Wales 2015-2020

3.2.1 The Joint Transport Plan for South West Wales 2015-2020 is the culmination of collaborative working between Carmarthenshire County Council, Neath Port Talbot County Borough Council, Pembrokeshire County Council and the City and County of Swansea. This collaborative working is closely linked with wider initiatives under the Swansea Bay City Region concept. The plan provides the framework for improving connectivity to, from and within the region for the period 2015 – 2020.

South West Wales Tourism Strategy, 2004-2008

3.2.2 The South West Wales Tourism Strategy presents a plan to provide an inclusive and common focus along with a set of shared objectives which can help guide the future development and promotion of tourism throughout the region. A major component of supporting tourism within the region is the improvement of the strategic highway network serving it.

3.3 Local Policy

Pembrokeshire County Council Local Development Plan, 2013

3.3.1 Pembrokeshire County Council Local Development Plan- 'Planning Pembrokeshire's Future' was adopted on 28 February 2013 and provides the framework for town and country planning decisions to be made up until 2021 on how land is used and developed. The development plan is amplified by supplementary planning guidance which is also referenced, where relevant, and includes: Biodiversity: How biodiversity can be protected and enhanced in the development process, 2014.

Pembrokeshire Coast National Park Local Development Plan, 2010

3.3.2 Pembrokeshire County Council Local Development Plan is the adopted Development Plan for the area. The Plan was adopted on 29 September 2010 and provides the framework for town and country planning decisions to be made up until 2021 on how land is used and developed.

Pembrokeshire Destination Management Plan, 2013-2018

3.3.3 Published in 2013, by Destination Pembrokeshire Partnership, the Pembrokeshire Destination Management Plan is designed to act as a development guide for all Pembrokeshire based organisations, businesses and employees in tourism related roles. The plan aims to improve the tourist offer in the region in order to stave off competition from elsewhere in the UK.

3.4 Habitat Regulations Assessment

3.4.1 The UK is bound by the terms of the EC Habitats Directive, EC Birds Directive and the Ramsar Convention. The aim of the Habitats Directive is to conserve natural habitats and wild species across Europe by establishing a network of sites known as Natura 2000 sites.

3.4.2 Under Article 6 (3) of the Habitats Directive, an ‘Appropriate Assessment’ is required where a plan or project is likely to have a significant effect upon a European site, either individually or in combination with other projects.

3.4.3 In preliminary consultations, it was identified that the Scheme could have significant effects in relation to Natura 2000 sites. Subsequently, as part of the ecological impacts, a separate document is prepared as part of the Habitat Regulations Assessment (HRA) under the Conservation of Habitats and Species Regulations 2010 and in consultation with NRW.

3.4.4 The HRA would assess potential impacts of the Scheme on the relevant Natura 2000 sites and the need for an Appropriate Assessment is assessed during the EIA in consultation with the relevant statutory consultees.

3.5 Previous Studies

3.5.1 Extensive studies were undertaken over the course of the last decade, to assess the options for improving the A40. These studies include (but not exhaustively) the following documents:

a) Mott MacDonald Ltd, December 2015: A40 Llanddewi Velfrey to Penblewin Statement of Intent;

b) Welsh Government, June 2015: A40 St Clears to Haverfordwest Study Executive Report;

c) WSP Parsons Brinckerhoff, June 2015: A40 St Clears to Haverfordwest Study Design Options Report Volume 1 and 2, Final;

d) Parsons Brinckerhoff Ltd, July 2006: Welsh Assembly Government A40 West of St Clears

e) Llanddewi Velfrey to Penblewin Addendum to Technical Appraisal Report Volume 1 R9;

f) Parsons Brinckerhoff Ltd, August 2006: Llanddewi Velfrey Stage 2 Scheme Assessment Report v2;

g) Parsons Brinckerhoff Ltd, September 2006: Welsh Assembly Government A40 West of St Clears

h) Llanddewi Velfrey to Penblewin Addendum to Technical Appraisal Report Volume 2;

i) Parsons Brinckerhoff, December 2004: Welsh Assembly Government A40 West of St Clears Route Options Report Volume 1 Rev 10;

j) Parsons Brinckerhoff Ltd, December 2004: Welsh Assembly Government A40 West of St Clears

k) Technical Appraisal Report Volume 1 Rev 7 and 2; and

l) Parsons Brinckerhoff, December 2003: A40 West of St Clears Economic Assessment Report.

3.6 The Need for an Environmental Impact Assessment

3.6.1 The potential environmental effects of a project must be understood to:

a) Satisfy legal obligations

b) Inform option choices;

c) Aid the planning and design process; and

d) Inform transport appraisals.

3.6.2 The EIA regulations require that a new road project should be screened to determine if a formal ES should be prepared. An ES is a document that is written to report on the process and findings of this EIA.

3.6.3 In accordance with the EIA regulations (paragraph 3.1.3-) and under Section 105 of the Highways Act, the Welsh Government must provide a formal Screening Opinion to determine if the project proposals fall within Annex I or II of the aforementioned EC Directives. A Screening has been undertaken and a Notice of Determination will be published. The screening process identified that the Scheme would be below the threshold for Annex I 7(c) of the Directive but would be of sufficient size (over 1 hectare) to be considered under Annex II 10(e). Under Annex III the Scheme is likely to have significant impacts near or within sensitive areas and so will require an ES. The details are set out in a Record of Determination.

3.7 The Purpose of Scoping in the EIA Process

3.7.1 A formal Scoping Opinion is not a requirement under the Highway EIA Regulations[3] but it is seen as best practice to ensure the relevant topics and information which the EIA is to be based on, are included within the final report – the ES.

3.7.2 The DMRB (Volume 11, Section 2, Part 4, para.1.8) states that;

> *'The statutory environmental bodies, local authorities, and other public authorities with environmental responsibilities, and other key stakeholders are likely to have views on the scope of the environmental impacts assessment and it is good practice, particularly in the case of EIA, to consult with these interests to ensure that the issues to be addressed are appropriate. In addition, the local community and other non-statutory consultees may initially be more knowledgeable about local conditions that those responsible for the assessment.'*

3.7.3 Therefore, the Scoping stage, provides an opportunity to consult all relevant statutory and non-statutory consultees, who have an interest in the Scheme and/or area where the development would take place.

3.7.4 The following information is required in a scoping request:

a) a plan sufficient to identify the land;

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[3] The Highways (Environmental Impact Assessment) Regulations 2007

b) a brief description of the nature and purpose of the development and of its possible effects on the environment;

c) other information or representations as the person making the request may wish to provide or make.

3.7.5 Appendix B provides a plan of the Scheme. Section 1 and 2 provides the reason for the Scheme and the proposed description. Sections 5, 6 and 7 provide information on the content, structure and scope of the EIA and more detailed scoping of environmental topics is included in Appendix A.

4 Consultation

4.1 Previous consultations

4.1.1 A public consultation was held in 2006 as part of the process to develop the preferred route. Statutory Consultees, including Countryside Council for Wales and Pembrokeshire County Council and several non-statutory organisations were also consulted. A second Public Information Exhibition was held in April 2017. A Public Consultation was carried out in autumn 2017 and as part of that a further exhibition was held in October of that year. Questionnaires were available for those who were consulted to respond. The results of the responses were taken into consideration.

4.1.2 Pembrokeshire businesses were engaged during the 2015 study and were consulted again in February 2017.

4.1.3 Meetings were held with Natural Resources Wales in 2016/2017 February 2016 and January 2017.

4.1.4 In February 2017, a meeting with Welsh Government and Pembrokeshire County Council was held to develop Transport Planning Objectives (TPO) for the project

4.1.5 A programme of Environmental Liaison Group (ELG) meetings is planned to happen approximately every three months. The first meeting was held on the 12 April 2017 in Haverfordwest. The ELG meetings will continue through the duration of the current contract, although the frequency might change to suit circumstances.

4.1.6 The primary purpose of the ELG is to advise on mitigation and construction procedures, restoration and habitat management measures and raise any concerns relating to the construction of the development. Members of the ELG are involved with the Scoping Report, through recommendation of content and methodology.

4.1.7 ELG meetings were held as follows:

a) April 2017 (introductory meeting)

b) August 2017

c) September 2018

d) Further meetings will be programmed for later phases of the project, as required.

4.2 Other proposed consultations

4.2.1 It was proposed to consult the following statutory organisations and the non-statutory bodies organisations, as required, within each technical aspect during Key Stage 3 (Section 7.0):

Statutory bodies	
Welsh Government;	
Pembrokeshire County Council and Carmarthenshire County Council;	
Natural Resources Wales (NRW)	
CADW	
Non-statutory bodies	**Completed**
South Wales Trunk Road Agent (SWTRA)	March 2017 (for ELG)
Utilities Infrastructure Providers	Location and routing data required under contract for highways design
Dyfed Archaeological Trust	From commencement of contract to carry out curatorial role
Parish/Community Councils	From commencement for Project Information Exhibition
Local Community and Interest Groups	March 2017 for Project Information Exhibition October 2017 Public Exhibition

4.2.2 Meetings were held throughout the contract period during 2017 and 2018 with local councils, landowners and businesses, as well as a series of presentations to local interest groups. Two public exhibitions were held for the local community in the village hall in Llanddewi Velfrey. In Spring 2017, a Public Information Exhibition was held, while in Summer 2017 a Public Consultation Exhibition was held. At the latter, those who attended the exhibition, or received the information documents, were able to give their opinion on the route options under consideration.

5 Proposed Content and structure of the EIA

5.1 Content

5.1.1 The content of the EIA will include environmental Factors in the list set out in Table 1. This range of Factors that were addressed as part of this scoping exercise are those topics set out in the DMRB Volume 11 published in 2008 and The EIA Regulations 2017 (collectively referred to hereafter as the EIA Regulations. The list below includes the subjects which are recommended in the guidance[4] as well as utilising previous experience, baseline studies and EIA best practice.

5.1.2 The 2017 EIA Regulations require an assessment to consider the following additional environmental Factors:

a) Biodiversity – with attention to species and habitats protected under the Birds and Habitats Directive;
b) Population and human health;
c) Land, soil, water, air and climate;
d) Material assets, cultural heritage and the landscapes;
e) Vulnerability of the Project to the risk of Major Accidents and/or Disasters which may cause environment effects;
f) Heat and Radiation;

5.1.3 The EIA will assess the potential significant impacts associated with the proposal. The individual EIA subjects/Chapters and the proposed order are listed in Table 1.

5.1.4 Volume 1: Main text, will be supported by Volume 2: Figures and Volume 3: Technical Appendices (where appropriate). A Non-Technical Summary (NTS) will also be provided.

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[4] Welsh Transport Planning and Appraisal Guidance - WelTAG - June 2008

Table 1 Factor Chapters in the proposed ES

Chapter	Factor (*new Factors added since previous draft of this report)
1	Introduction
2	Scheme Description
3	Assessment of Alternatives
4	EIA Methodology
5	Legislation and Policy Context
6	Geology and Soils
7	Road Drainage and Water Environment
8	Nature Conservation (Biodiversity)
9	Landscape and Visual
10	Archaeology and Cultural Heritage
11	Community and Private Assets (excluding agriculture)
12	Community and Private Assets: Agricultural Assessment
13	Air Quality
14	Noise and Vibration
15	All Travellers
16	Materials
17	Population and Human Health*
18	Climate Change*
19	Heat and Radiation*
20	Risk of Major Accident and Disaster*
21	Introduction to Cumulative Effects
22	Same scheme cumulative effects
23	Cumulative effects of multiple schemes
24	Management of Environmental Effects
25	Conclusions

5.2 Proposed Structure of the environmental topic chapter

5.2.1 The sections below describe the proposed structure and content of the technical ES chapters, along with the proposed methodologies for defining proposed mitigation measures and assessing impacts.

Section #.1 – Introduction

5.2.2 Brief section stating the name of the organisations responsible for undertaking the impact assessment and the scope of the topic being considered.

5.2.3 To Include a list of figures and appendices.

Section #.2 – Potential Effects

5.2.4 A brief section outlining in what ways the development may affect the environment. This will set a background for the methodology and is not part of the impact assessment. This section will provide a summary of the types of impact that will then be assessed within the chapter.

Section #.3 – Assessment Methodology

5.2.5 This section will set out the methodology by which the impacts were assessed. It will include references to published standards, guidance, best practice and the outcome of consultations (including where consultees' comments were addressed in the ES).

5.2.6 Where detailed methodologies are provided, these will be included as Appendices, to ensure the main ES is proportionate.

5.2.7 This section will also state the relevant assumptions made in undertaking the assessment and/or identify if/where information gaps exist (if any).

5.2.8 The methodology will include tables that explain how the magnitude of impact and sensitivity of receptor are defined within the chapter as these vary by topic. Where possible, these will be based on best practice guidance and use appropriate terminology.

5.2.9 Impact significance is then based on a combination of the impact magnitude and sensitivity of receptor. There is no statutory definition of significance, but the guidance set out in DMRB Volume 11 Section 2 Determining Significance of Environmental Effects (2008) will be used:

5.2.10 The determination of significance will be based on best practice, which can be topic-specific, but will use the standard terms listed above. It is important that the ES chapter is able to justify the determined levels of impact significance. Therefore, it is recommended that the significance matrix from DMRB guidance is used (where appropriate) to ensure that it is clear to the reader how significance has been derived, based on the stated levels of impact magnitude and receptor sensitivity.

5.2.11 Table 2 includes descriptors of effects, for the environmental value of an environmental resource. These descriptors will be used throughout the EIA process, providing a uniform approach environmental value (sensitivity).

Table 2 Environmental Value (or Sensitivity) and typical descriptors

Value (sensitivity)	**Typical Descriptors**
Very High	Very high importance and rarity, international scale and very limited potential for substitution.
High	High importance and rarity, national scale, and limited potential for substitution.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.
Low (or Lower)	Low or medium importance and rarity, local scale.
Negligible	Very low importance and rarity, local scale.

5.2.12 The outlined assessment methodology seeks to ensure that the following questions, where relevant, should be considered in evaluating the significance of potential effects:

a) Which receptors/resources would be affected and in what way?

b) Is the receptor/resource of a local, regional, national or international importance, sensitivity or value?

c) Does the effect occur over the long or short term; is it permanent or temporary and increase or decrease with time?

d) Is the change reversible or irreversible?

e) Are environmental and health standards (e.g., local air quality standards) being threatened?

f) Are feasible mitigating measures available?

5.2.13 For each topic, the likely environmental change arising from the Scheme would be identified and compared with the baseline (the situation without the Scheme). Impacts are divided into those occurring during the construction and operation phases and the size, or Magnitude of the impact assessed. As a general guide, the definitions set out in Table 2.2 of HA205/08 would been taken into account (except where topic guidance requires otherwise). This includes a five-point scale for assigning impact magnitude as shown in Table 3.

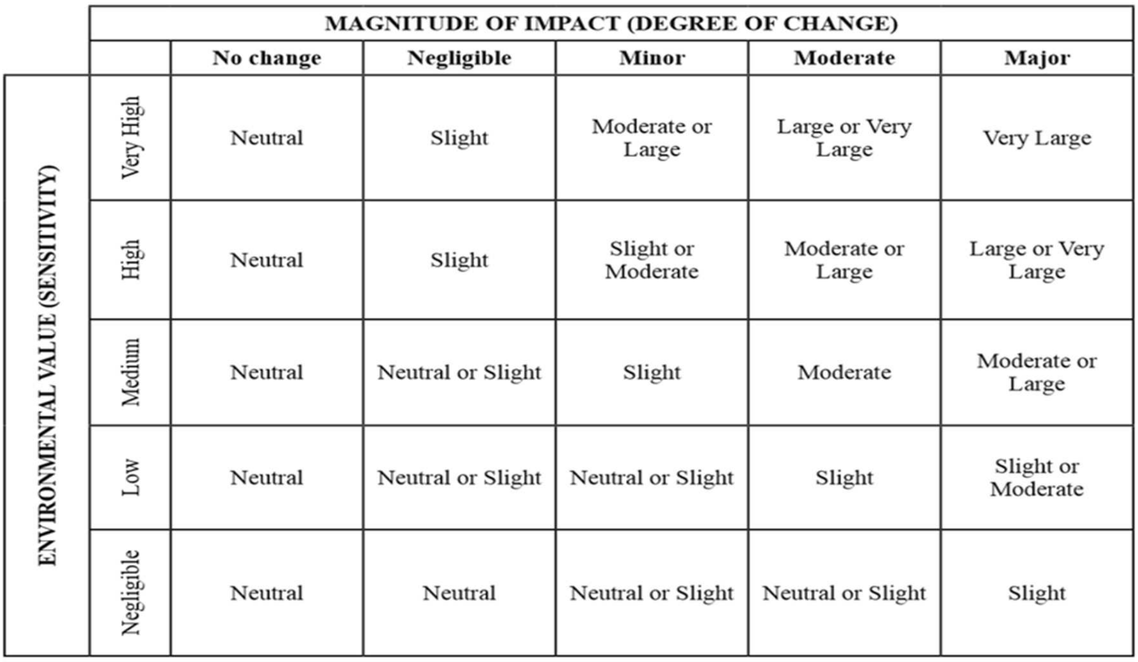
Table 3 The five-point scale for assigning impact magnitude

Magnitude of Impact	Typical descriptors
Major	Adverse: loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements ().
	Beneficial: large scale or major improvement of resource quality, extensive restoration or enhancement; major improvement of attribute quality
Moderate	Adverse: loss of resource but not adversely affecting integrity; partial loss or damage to key characteristics, features or elements.
	Beneficial to, or addition of key characteristics, features or elements; improvement of attribute quality.
Minor	Adverse: some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to key characteristics, features or elements.
	Beneficial: minor benefit to or addition of one or more key characteristics, features or elements; some beneficial impact on attribute, or a reduced risk of negative impact occurring.
Negligible	Adverse: very minor loss or detrimental alteration to one or more characteristics, features or elements.
	Beneficial: very minor benefit or positive addition of one or more characteristics, features or elements.
No change	Adverse/beneficial: no loss or alteration of characteristics, features or elements, no observable impact in either direction.

Based on Table 2.1 of HA205/08 (Highways et al., 2008e)

5.2.14 The DMRB Table ‘Arriving at the Significance of Effect Category’ is given in Table 4.

Table 4 Arriving at the Significance of Effects Descriptors



		MAGNITUDE OF IMPACT (DEGREE OF CHANGE)				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
ENVIRONMENTAL 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

5.2.15 The following terms will also be used to aid the description of the impact:

Beneficial – positive impacts;

Adverse – negative impacts;

Short/Medium/Long Term – length of the impact;

Permanent – impact cannot be reversed;

Temporary – impact can be reversed;

Direct – are effects that are a direct result of the proposed development;

Indirect – are effects that may be ‘knock-on’ effects of direct effects.

Section #.4 – Baseline Conditions

5.2.16 This section will include a topic-specific description of the existing environment which will provide the basis against which the impacts of the indicative development will be assessed. National or local policies will be referred to, where necessary or appropriate.

Section #.5 - Mitigation Measures

5.2.17 Mitigation is proposed where significant effects are identified, with the aim of avoiding, reducing, or compensating for potential adverse effects and maximising potential beneficial effects. The most effective form of mitigation measures are those that are ‘designed in’ to the Scheme, leading to the avoidance of identified impacts or a reduction in impact magnitude.

5.2.18 EIA is an iterative process that develops in parallel with the design so that the Scheme can, where feasible, be modified and adjusted to avoid, minimise and mitigate for environmental impacts. The proposals for the development are generally designed and updated to incorporate mitigation measures and their delivery is therefore, more certain. Measures to mitigate impacts associated with construction are normally based on accepted industry standards, resulting in a high degree of certainty over their delivery.

5.2.19 The approach is to present the mitigation measures in Section 5 of each technical chapter, prior to the assessment of impacts (Section 6). The purpose of this is to avoid the ES describing numerous potential impacts that have actually been designed out of the Scheme or will be avoided through standard construction measures. This reduces the length of the ES, avoids confusion and demonstrates the benefits of any mitigation.

5.2.20 Section 5 will cover each site separately and be split into:

Standard mitigation measures – e.g. construction mitigation with a high degree of certainty over delivery i.e. measures to be included in a draft Construction Environmental Management Plan (CEMP).

Actionable mitigation measures - those that require a controlling mechanism or legal undertaking to be implemented but are under the control of the ‘applicant’ and therefore, have a good certainty over delivery.

Enhancement Measures – those that are over and above the requirements of mitigating the impacts. Net benefits that can be incorporated into the Scheme but isn’t required to reduce an impact.

5.2.21 Standard mitigation measures will be included in a draft CEMP and a Register of Environmental Actions and Commitments (REAC) will also be produced.

5.2.22 A REAC will be prepared and included in the ES as an appendix to Chapter 2, Scheme Description. The REAC is a record of matters that were agreed with consultees and other stakeholders where some specific activity or mitigation measure is required during preconstruction, construction or operation of the road. The REAC also indicates who is responsible for the commitment and provides a reference to where, in the various documents that were produced, there is a record of what is required and is to be achieved.

Section #.6 - Assessment of Environmental Impacts

5.2.23 The purpose of an EIA is to identify and evaluate the environmental effects associated with the proposed development. These effects are assessed based on their magnitude (following mitigation) and the sensitivity of the receiving environment as described in Section 3 of the ES chapter.

5.2.24 The determination of impact significance will be undertaken against the environmental baseline and be based on the significance matrix included in Section 3 of the ES chapter. The section will then be presented under sub-sections:

Impact Assessment - with inherent and standard mitigation measures implemented;

Residual Impact Assessment – with inherent/standard and actionable mitigation measures implemented.

Cumulative Impacts – those effects of the proposed Scheme that may interact in a positive or negative way with other developments that are not currently in existence but may be by the time the development is implemented.

Section #.7 – Summary

5.2.25 A brief summary of the chapter.

6 Proposed Scoping: topic summaries

6.1 Technical Chapter Summaries

6.1.1 The full technical scope for each EIA topic chapter is included in PART B of this document, with a brief summary of each topic included in this Section 6. This approach has been taken to allow Sections 1 to 6 to be read by all who need to have a general understanding so that they can then proceed to their specialist topic in PART B to refer to the full Scoping Report for that topic.

6.1.2 Mitigation and enhancement measures will be discussed with the statutory consultees through the ELG and commitments made will be recorded in the REAC.

6.2 Geology and Soils (Chapter 6)

6.2.1 This section covers ground conditions, as well as geology and soils, with a particular emphasis on land contamination. Potential impacts of the Scheme on groundwater due to the geology and soils are included.

6.2.2 The assessment will consider potential land contamination, where there could be risks presented to human health and controlled waters in construction and operational phases of the Scheme. Where pollutant linkages dictate, additional assessments will be prepared as necessary, including remedial options appraisals.

6.2.3 The baseline conditions will be determined through a review of published information gathered in the Preliminary Sources Study Report prepared for the proposed Scheme and site-specific data obtained through the 2016 ground investigations. No protected areas of geological importance were identified within the proposed Scheme area, however, mineral resources of local values underlie the Scheme. The construction of the Scheme may limit access to these resources.

6.2.4 Isolated areas of made ground that are likely to be encountered during the Scheme construction are present within the vicinity and would be associated with the existing roads, infilled quarries or agricultural activities. The potential effects with respect to human health and controlled waters would be assessed but no significant contamination is anticipated.

6.2.5 Typical pollution control and health and safety practice during construction should be sufficient to mitigate any potential effects from the presence of made ground during construction. The reuse of site won or import of materials would be managed to verify that the Specification for Highway Earthworks Series 600 is being complied with. Suitability for use would be assessed based on potential risk posed to end users and controlled waters during and post-construction.

6.2.6 The design has been developed on the basis that most soils would be retained on site for reuse, however, some areas of the completed Scheme would not require topsoiling and so there could be some surplus. Measures would be taken to establish acceptable reuse criteria and procedures defined for ensuring that the suitability of material can be demonstrated and verified. A discovery strategy would be developed to enable unforeseen ground conditions to be addressed if or when encountered during construction. Inter-relationships with the Materials chapter relating to soil reuse will be considered.

6.3 Road Drainage & Water Environment (Chapter 7)

6.3.1 New roads would intersect a number of surface and groundwater features and create pollution sources or pathways that are not present under existing conditions. Potential direct and indirect short, medium, long term or permanent effects on the water environment occur as a result or construction and/or operation. The assessment will consider the following potential effects on the water environment during construction and operation:

a) Pollution of receiving waters as a result of accidental spillage or the runoff during construction and routine and accidental road runoff during operation;

b) Changes in the flow or levels of surface and groundwater features (private water supplies, springs and wetlands;

c) Changes in flood risk and conveyance of drainage.

d) In channel sediment transfer or movement, often as a result of modification to the existing surface water network;

e) Fluvial flooding as a result of increased surface water runoff and changes to surface water and floodplain capacities.

6.4 Nature Conservation (Chapter 8)

6.4.1 The assessment of the effects of the Scheme will include those likely to arise from the permanent land take required for the Scheme during construction and operation. These would primarily arise from habitat loss which, as well as resulting in the loss of habitat of intrinsic value in its own right, would reduce the area available for foraging and nesting animals.

6.4.2 The assessment will be undertaken in accordance with the DMRB, and will take account, and follow guidance set out by, the Chartered Institute of Ecology and Environmental Management (CIEEM) in their Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal (CIEEM, 2016).

6.4.3 The Welsh Government has particular responsibilities with respect to the protection of biodiversity and so the ES will include both mitigation and enhancement measures for the Scheme to address these obligations. The needs of biodiversity will be incorporated into the design of the road and the associated soft estate. The mitigation and enhancement measures are likely to include, but are not limited to,

a) The design of the Scheme, its drainage and construction will take into account amphibians and also ensure the potential for these species becoming trapped in the drainage system is minimised;

b) Measures to reduce the potential to cause harm to species during construction

c) Measures to mitigate for habitat loss and for loss of connectivity;

d) Barriers, in the form of otter and badger fencing, to reduce the risk of the relevant mammal species entering the road corridor;

e) Measures to manage or eradicate invasive plant species on the site in accordance with existing guidelines such as the relevant Environmental Agency guidance.

f) A five-year aftercare scheme for the soft estate to ensure establishment and undertake maintenance of ecological measures.

6.5 Landscape and Visual (Chapter 9)

6.5.1 The study area for the assessment of landscape effects will cover the proposed improvement site and the wider landscape context within which the proposed Scheme might influence landscape character. The baseline study will include desk work based on LANDMAP and field survey. Landscape character classification will involve the sorting of the landscape into areas of consistent and recognisable character. The study area of the assessment of visual effects will extend to the whole area from which the proposed improvement could be visible, which will be determined through the application of a Zone of Theoretical Visibility (ZTV).

6.5.2 Mitigation and enhancement will be developed to integrate the road, earthworks and other environmental mitigation with the landscape setting and to address visual impacts on key viewpoints such as residential buildings, footpaths and other public areas. Planting of trees and shrubs to form woodland, scrub and hedgerows would provide visual screening and landscape integration in combination with replacement habitat. The mitigation design will give consideration to whole life costs and to minimising waste.

6.6 Archaeology and Cultural Heritage (Chapter 10)

6.6.1 This chapter of the ES will address the potential impact on designated sites and on known non-designated archaeological sites. A list of known heritage sites in the setting of the Scheme is provided in the cultural heritage chapter 10 in PART B.

6.6.2 The assessment will also use survey techniques to try to identify previously unknown sites so that the impact and the need for mitigation on these can be better understood. Field surveys and geophysical surveys will be carried out, followed by trial trenching, if required, and the results interpreted to enhance knowledge of the archaeological resource. Depending upon the significance of the sites, it is possible that the Scheme design could be modified to avoid an impact. Based around the final Scheme design an assessment of the impact on all these known heritage sites will be completed and the likely impact, and scheme of mitigation, including detailed investigation and recording, will be proposed and the residual effects described.

6.6.3 Impacts identified include physical impact on heritage features, damage and indirect impacts on buried archaeological features, change in visual perception and noise in specific heritage locations. There is the potential for unknown and known sites to be affected by the Scheme.

6.6.4 A scheme of mitigation will include recording of above ground heritage, stripping of soil and recording and if required, more detailed investigation. Where required, the impact of the Scheme on the settings of designated sites will be considered and a scheme of mitigation included in the environmental masterplan.

6.7 Community and Private Assets (Chapter 11 and 12)

6.7.1 The assessment will also address the effects of the Scheme on development land and on community receptors such as the village hall and cricket ground in Llanddewi Velfrey, the filling station, shop and public house, as well as more distant facilities such as hospitals. This assessment will be in Chapter 11 of the ES.

6.7.2 The assessment on Agricultural Land and Farm Businesses will cover the loss of land and soil resources, the type of land management and farming practices currently operated and the potential impacts on these, and matters such as severance, disturbance, disruption, farm size, use of buildings and equipment, surface water and land drainage. Using the existing Stage 2 Agricultural land classification, which showed that most land is sub-Grade3b used as pastureland, farm interviews will be completed. Using the designed Scheme, a calculation of land take per grade will be completed.

6.7.3 The assessment will address the impact on farm business and on the 'best and most versatile' land resources. For the purposes of this technical assessment, and to assist in its interpretation, common assessment criteria and terminology were developed and agreed with Welsh Government for the analysis of predicted impacts. This agricultural assessment will be included in Chapter 12 of the ES.

6.7.4 A scheme of mitigation will be considered and incorporated within the design or will be considered as Accommodation Works, to be recorded in the REAC and will be described in the relevant ES chapter 11 or 12.

6.8 Air Quality (Chapter 13)

6.8.1 Fugitive dust arising from construction and demolition activities generally has a particle size greater than the PM10 fraction (which can potentially affect human health). It is noted that construction activities can contribute to an increase in local PM10 concentrations. During construction fugitive dust emissions arising would arise from a range of activities and the magnitude would vary depending upon soil type and moisture content, and the conditions of weather and road surfaces. Periods of dry weather combined with higher wind speeds have the potential to generate more dust. An assessment of the likely effects during construction would be undertaken using the risk-based approach published by the IAQM in which sensitive receptors are identified within 350m of construction activities. An assessment of effects from machinery and vehicles used during the construction phase has been scoped out as potential effects are considered to be negligible.

6.8.2 Appropriate measures for controlling emissions from potentially dust generating activities will be recommended to reduce or eliminate the adverse effects where sites are assessed to be at risk of generating dust effects and incorporated in the CEMP for the Scheme.

6.8.3 Concentrations of NO2 and PM10, the key pollutants of concern in the UK in relation to road traffic, will be assessed at receptors within the study area using ADMS-Roads dispersion modelling for a Baseline Scenario (2016), Opening Year (2021) both with and without Scheme scenarios, and the Future Year (2036) both with and without Scheme scenarios. This will follow the detailed level assessment methodology outlined in DMRB HA 207/07.

6.9 Noise and Vibration (Chapter 14)

6.9.1 Construction of the Scheme is likely to give rise to temporary increases in noise for sensitive receptors within around 300m of the works (this is dependent on exact location in relation to existing noise sources which would mask construction noise). The best practicable means would be used to minimize impacts. Where necessary temporary noise barriers may be recommended to reduce noise impacts further.

6.9.2 It is unlikely that piling activities would be required as part of the construction of the Scheme making it unlikely that any significant vibration impacts would occur.

6.9.3 The operation of the Scheme could give rise to increases in noise at a very small number of isolated receptors close to the Scheme, whilst there would be noise reductions at a larger number of receptors in Llanddewi Velfrey where traffic diverts from the existing A40 route onto the new bypass. Further detail on the locations of the potentially affected receptors is provided in the noise section. Where the improvements would be online, there may be noise increases or decreases at nearby receptors, dependent on predicted changes in traffic speed, movement of the traffic source lines relative to nearby receptors and future road surfacing materials (i.e. low noise surfacing).

6.10 All Travellers (Chapter 15)

6.10.1 This chapter will address the effects of the Scheme on the journeys made by both vehicular travellers (on roads) and Non-Motorised Users of roads, footpaths, cycleways and bridleways (the latter hereafter collectively referred to as NMU routes).

6.10.2 The assessment will cover the changes to journeys made by people in terms of travel distance and patterns, changes to amenity and the impact of increased or decreased severance. These will be of particular importance in Llanddewi Velfrey, where the existing road causes severance, and on several footpaths, which could be severed, although mitigation can be provided in the form of road crossings and underpasses.

6.11 Materials (Chapter 16)

6.11.1 The Scheme has the potential to generate local effects during the construction phase. Potential effects during construction include the generation of excess materials that would need to be removed to an alternative site. There would be a requirement for the import of construction materials (including primary aggregates). During the operational phase the Scheme has limited potential to generate an effect as there are no day-to-day requirements to import or export materials. Where possible locally sourced raw materials would be used.

6.12 Population and Human Health (Chapter 17)

6.12.1 The Scheme has the potential to influence local communities. It is designed to reduce journey times, improve road safety, reliability and resilience, improve air quality and reduce noise disturbance for the areas adjacent to the existing A40. It may also affect local people by affecting the community they live in, influencing health and well-being through other environmental, social and economic pathways. These could be both beneficial or adverse effects.

6.12.2 In addition, the Welsh Government has a duty under the Equality Act to determine whether there would be any disproportionate or differential effects on people within communities that have protected characteristics (as defined by the Equality Act). They also have a duty under the Well-being of Future Generations Act to assess the effects of a proposal on populations.

6.12.3 As a result of the potential for significant effects on population and human health, this topic will be scoped into the EIA.

6.13 Climate Change (Chapter 18)

6.13.1 EIA Regulations 2017 introduced the requirement to include consideration of the impact of the proposed development on climate and the vulnerability of the project to climate change. An assessment related to climate change is composed of three elements:

a) Greenhouse gas (GHG) emissions assessment – quantifies the potential GHG emissions associated with the construction and operation of the proposed development and identifies mitigation measures to reduce these emissions.

b) Climate change resilience (CCR) assessment – evaluates the effectiveness and feasibility of adaptation measures integrated into the proposed development to avoid or reduce hazards and/or increase resilience of the proposed development to climate change impacts.

c) In-combination climate change impact (ICCI) assessment – evaluates the combined effect of the proposed development and potential climate change impacts on the receiving environment during construction and operation.

6.14 Topics to be scoped out

Heat and radiation

6.14.1 The Scheme does not introduce any new sources of heat and radiation during construction or operation. In addition, there are no sensitive receptors (for example, hospitals or schools) within the route corridor. Hence the proposed Scheme would not create any new sources of heat and radiation. On that basis, with no sensitive receptors, the Scheme is not considered likely to increase the generation or release of heat and radiation.

6.14.2 With no change brought about by the Scheme there can be no significant changes in heat and radiation. It is anticipated that the generation of heat or radiation is unlikely to be relevant to the scope of this project and so has been scoped out.

Risk of Major Accident or Disaster

6.14.3 EIA Regulations 2017, require an assessment to be completed of the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project during construction and operation to risks of relevant major accidents or disasters.

6.14.4 The potential risks of major accident or disaster in the area of the Scheme were considered from a long list of those identified in the National Risk Register of Civil Emergencies 2017 edition, Cabinet Office. Those considered to be relevant to the Scheme are the effects of severe heavy snow, or transport accidents that could result in closure of the road or cause pollution events as a consequence of spillages.

6.14.5 The Scheme would be designed to current standards, so the risk of accidents is no greater than on the existing road. The procedures for dealing with heavy snowfall, major road accidents and pollution within the road are well established and the road would not be closed for long periods. On the basis that alternatives routes are available if the road is closed for a period, the consequences for the local residents, travellers and the environment is not significant, and are likely to be less than for the existing Scheme. On this basis, the Risk of Major Accident and Disaster has been scoped out.

PART B Scoping of Specialist Chapters

The following PART B of this Scoping Report identifies matters where there may be potentially significant environmental effects and the Chapters which are proposed to be ‘Scoped in’ to the EIA.

Each chapter will set out:

a) Subject Introduction

b) Policy Context

c) Consultations (undertaken and proposed)

d) Surveys undertaken to date and additional surveys required

e) Assessment Methodology

f) Study Area

g) Baseline Context

h) Potential Effects

7 Geology and Soils

7.1 Introduction

7.1.1 This chapter will cover ground conditions, as well as geology and soils, with a particular emphasis on land contamination. Potential impacts of the Scheme on groundwater due to the geology and soils are included. However, potential impacts on groundwater associated with drainage and discharge proposals are considered within Chapter 8 Road Drainage and the Water Environment. The effects on the agricultural resource of soils are considered within Section 12 Community and Private Assets. Waste and management of materials is considered in Section 15 Materials.

7.2 Policy Context

Legislation

7.2.1 Geological sites of national importance are principally afforded protection under the Wildlife and Countryside Act 1981 (as amended) or the National Parks and Access to the Countryside Act 1949 by designation as SSSI or NNR. The Joint Nature Conservation Committee (JNCC) is a public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation. On the Defra website, the JNCC state that the aim of their Geological Conservation Review (GCR) for the selection of non-statutory designated Earth Science sites was:

> *"to identify the best, most representative, earth science sites in Great Britain, with a view to their long-term conservation. Geological Conservation Review (GCR) and Earth Science Conservation Review (ESCR) sites are non-statutory sites identified by the statutory nature conservation agencies as having national or international importance for earth science conservation on the basis of their geology, palaeontology, mineralogy or geomorphology. Although GCR/ESCR identification does not itself give any statutory protection, many GCR/ESCR sites have been notified as SSSIs/ASSIs"*

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

a) Part IIA of the Environmental Protection Act (1990);

b) Contaminated Land (Wales) Regulations (2006 as amended in 2012);
c) Environment Act (1995); and
d) Environmental Permitting Regulations (2010).

7.2.3 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).

7.2.4 The Environment (Wales) Act 2016 sets out framework for the sustainable management of natural resources. An accompanying Natural Resources Policy Statement is currently awaited. In general terms, the legislation advocates the use of a risk assessment approach to assessing contamination and remedial requirements. A list of additional key legislation and guidance considered within the assessment and relating contamination and water environment include:

a) Water Resources Act 1991 as amended in Wales by the Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009;
b) EU Water Framework Directive (WFD) 2000/60/EC (as amended in 2008);
c) The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 which implement Water Framework Directive (2000/60/EC);
d) The Water Framework Directive (Standards and Classification) Directions England and Wales 2015;
e) Groundwater Regulations (England and Wales) 2009, which transpose the EC Groundwater Directive 80/68/EC into UK law;
f) Groundwater Daughter Directive (GWDD) (2006/118/EC);
g) Department for Environment Food and Rural Affairs (Defra) (2015) The Water Framework Directive (Standards & Classification) Directions (England and Wales); and
h) The Environmental Damage (Prevention and remediation) (Wales) Regulations 2009.

7.2.5 Geology and Soils chapter documents the assessments carried out in line with the requirements of DMRB Volume 11 Section 3 Part 11, which does not include assessment of waste production, disposal or management, which are included in Section 15 Materials.

National and Regional Policy

7.2.6 Planning Policy Wales[5] 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 consideration of society in the general area. Within the policy, the importance for the restoration of derelict and contaminated land is stated.

7.2.7 Planning Policy Wales[6] acknowledges that the natural heritage of Wales includes its geology and associated landforms 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, 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.

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

a) Geological Conservation Review sites (England, Scotland, Wales);
b) Geoparks;
c) Regionally Important Geological and Geomorphological Sites (RIGS);
d) Locally Important Geological and Geomorphological Sites (LIGS);
e) Sites of Importance for Nature Conservation (SINC).

7.2.9 The objectives for the conservation and improvement of natural heritage are to:

a) promote the conservation of landscape and biodiversity, in particular the conservation of native wildlife and habitats;
b) ensure that action in Wales contributes to meeting international responsibilities and obligations for the natural environment;

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[5] Planning Policy Wales, Edition 9, Welsh Government, November 2016

[6] Welsh Government, 2016 (as n.3 above)

c) ensure that statutorily designated sites are properly protected and managed;

d) safeguard protected species; and to

e) promote the functions and benefits of soils, and in particular their function as a carbon store.

7.2.10 In terms of soils, Planning Policy Wales[7] states that the Welsh Government has an objective to promote the functions and benefits of soils, and in particular their function as a carbon store.

7.2.11 Planning Policy Wales[8] also recognises that geology forms part of the natural heritage of Wales and is not constrained to statutorily designated sites, but extends across all of 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 to make ground hazards material considerations during the planning process.

Local Planning Policy

7.2.12 The Pembrokeshire County Council Local Development Plan (LDP) 2013-2021 was adopted in February 2013[9]. Pembrokeshire County Council will be undertaking a review of the LDP in May 2017.

Relevant Policies

7.2.13 Strategic Policy (SP) 1 Sustainable Development: Requires all development proposals to demonstrate how positive environmental impacts will be achieved and adverse impacts minimised.

7.2.14 SP6 Minerals: Mineral resources such as hard rock and sand and gravel will be maintained and where known to be present at outcrop locations these will be safeguarded from permanent development to ensure a continuous supply of minerals in support of local, regional and national development.

7.2.15 General Policy (GN) 1 General Development Policy: Development will be permitted on the condition that it would not cause or result in unacceptable

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[7] Planning Policy Wales, Edition 9, Welsh Government, November 2016.

[8] Ibid.

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

harm to health and safety, and would not have a significant adverse impact on water quality.

7.2.16 GN 22 Prior Extraction of the Mineral Resource: Consideration for extraction of safeguarded mineral resources from an area of a new permitted development should be made, wherever appropriate in terms of economic feasibility and environmental and other planning considerations prior to the commencement of the development. The Good Practice Guidance Note on LPD policy GN.22[10] provides a list of considerations, where no extraction of mineral resources would be required.

7.2.17 GN 23 Mineral Working: Proposals for mineral working and extensions of existing sites will be permitted where the demand cannot be met from secondary or recycled materials, or existing reserves, or there is provision for landscaping, groundwater protection, a beneficial after-use, restoration and/or post-closure management of the site.

7.2.18 GN 25 Buffer Zones around Mineral Sites: New mineral extractions will not be permitted within a Buffer Zone around mineral sites to avoid an adverse impact on one another because of their close proximity. Appendix 2 to the LDP[11] provides a list of current mineral workings with the location presented on Proposal Maps (PM). PM covers the area of the proposed Scheme.

7.3 Relevant Guidance

7.3.1 The assessment will be undertaken with due consideration of the following guidance:

a) Geotechnics and Drainage, Earthworks, Managing Geotechnical Risks DMRB Volume 4, Section 1, Part 2 HD22/08[12;]

b) Environmental Assessment, Environmental Assessment Techniques, DMRB Volume 11, Section 3, Part 11 Geology and Soils[13;]

c) Model Procedures for the Management of Land Contamination (CLR11)[14;]

d) Construction Industry Research and Information Association R132: A Guide for Safe Working on Contaminated Sites[15;]

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

[11] Pembrokeshire County Council, 2013 (as n. 7 above)

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

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

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

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

e) CIRIA SP73: Roles and Responsibility in Site Investigations[16];

f) BS5930: 2015: Code of Practice for Site Investigations including Amendment 2, issued[17];

g) BS10175:2011 + A1 2013: Code of Practice for Investigation of Potentially Contaminated Sites[18];

h) Groundwater protection principles and practice, GP3[19];

i) The Environment Agency's approach to groundwater protection [20]

j) CIRIA 552: Contaminated Land Risk Assessment, A guide to good practice[21];

k) BS 8485:2015: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings[22];

l) CIRIA 665: Assessing risks posed by hazardous ground gas to buildings[23]

m) CIRIA 681: Unexploded ordnance (UXO) A guide for the construction industry[24];

n) CIRIA 733: Asbestos in soil and made ground: a guide to understanding and managing risks[25];

o) Definition of Waste: Development Industry Code of Practice[26] sets out a framework for management of materials during construction. This is currently not obligatory for use in Wales, and therefore has not been referenced as a requirement that will be followed. Refer to Section 15 Materials for more details;

p) Eurocode 7 (BS EN 1997-1[27] & EN 1997-2[28]) and all relevant Normatives;

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

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

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

[19] Groundwater Protection: Policy and Practice (GP 3), Environment Agency, 2012

[20] The Environment Agency's approach to groundwater protection, Environment Agency, 2017

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

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

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

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

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

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

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

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

q) National 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).

7.4 Consultations (undertaken and proposed)

7.4.1 It is proposed that the following consultees will be consulted with for the purpose of the Soils and Geology assessment:

Pembrokeshire County Council, Environmental Health Department, Environmental Monitoring Team and

Natural Resources Wales.

7.5 Surveys undertaken, and further surveys required

7.5.1 A Preliminary Sources Study Report (PSSR) was prepared by Mott MacDonald in March 2016[29] for the proposed Scheme, to document the findings of the geotechnical desk study investigation.

7.5.2 A preliminary ground investigation was undertaken on behalf of the Welsh Government by WYG Environment Planning Transport Ltd in June 2016. The results are presented in their factual report[30]. The competed work included excavation of boreholes, obtaining soil and rock samples for laboratory testing and installation of groundwater monitoring instrumentation in selected locations along the proposed alignment. This work was carried out for the preliminary highway alignment that was under consideration at the time.

7.5.3 To date, three rounds of monitoring were carried out to determine groundwater levels at various locations along the alignment.

7.5.4 The 2016 investigations provide information on ground conditions sufficient for development of the design and completion of environmental reporting at Key Stage 3. More detailed information is to be obtained at Key Stage 6 shortly prior to detailed design. This approach is in line with a standard practice, where the preliminary investigations are undertaken to create a ground model and identify any required mitigation measures.

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

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

7.6 Assessment Methodology

Scope of Proposed Assessment

7.6.1 A detailed assessment is to be undertaken. The assessment will include consideration of possible effects on the geology and geomorphology, including mineral resources beneath the proposed route of the Scheme. The assessment will also consider general effects posed by potential contaminated land along the proposed route.

7.6.2 From review of the data obtained through surveys, as described in Section 7.1.4, the extent of potentially contaminated land will be identified. As part of the contamination assessment, conceptual site models (CSMs) shall be prepared for those locations identified as potentially contaminated. These shall be developed in accordance with the risk management framework provided in CLR11, Model Procedures for the Management of Land Contamination[31]. The need for further focused assessment will be considered where existing or suspected contaminated land may have an effect as a result of construction and operation, 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.

7.6.3 The conceptual site models will be used to establish the risks posed by each location and the need or otherwise for further assessment.

7.6.4 Potential interrelationships were identified between the ES chapters concerned with materials, drainage and water environment, air quality (dust), ecology, landscape and cultural heritage. The assessment of effects will take into account these interrelationships. However, the principal effects specific to these topic areas will be assessed within the relevant chapters, even where the effects are on or from geology and land contamination.

Issues Proposed to be Scoped Out

7.6.5 It is proposed that those contaminated land sites identified as being fully outside the study area will be scoped out of requiring further assessment.

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

Proposed Scope of Baseline Studies

7.6.6 A gap analysis of the information contained within the 2016 PSSR[32] will be undertaken and the existing information validated and updated where appropriate using the following sources of information:

a) Topographical maps.

b) Ordnance survey maps at scales of 1:50,000 and 1:25,000.

c) Geological maps (1:50,000 scale, and if available, 1:10,000) and available geological memoirs.

d) An Envirocheck report is available for the Scheme (contained in the 2015 PSSR[33]) that contains geological and historical plans, hydrogeological and hydrological data/features including recorded wells, springs and abstraction points.

e) Records of mines are to be reviewed through the online Coal Authority viewer[34;]

f) The Review of Mining Instability in Great Britain – Wales Regional report prepared by Arup for the Department of the Environment[35] will be consulted.

g) Mineral deposits are to be reviewed through the available mineral resources plans available through BGS online viewer[36].

h) Historic OS plans will be used to identify the potential presence of historic quarries.

i) The potential for natural cavities will be assessed from geological maps and memoirs.

j) A site walkover and the Envirocheck report (contained in the 2015 PSSR[37]) will be used to assess current land use. Current and historic aerial photographs will be used to assess recent historical land use.

7.6.7 Existing and proposed ground investigation information shall be reviewed from the following sources:

a) The British Geological Survey borehole records database.

b) Factual reports on previous ground investigations for the Scheme.

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

[33] Ibid.

[34] Coal Authority Interactive Map, http://mapapps2.bgs.ac.uk/coalauthority/home.html

[35] Department of the Environment, The Review of Mining Instability in Great Britain, Volume 1/iii – Wales Regional report, Arup, 1991.

[36] British Geological Survey website http://www.bgs.ac.uk

[37] Mott MacDonald, 2015 (n. 32).

c) The Welsh Assembly Geotechnical Data Management System.

d) Consultation with statutory bodies and agencies (NRW and Pembrokeshire County Council Pollution Control team) including information on designated contaminated land sites, private water supplies, local authority managed historical landfill sites;

e) Recorded contaminated land, pollution incidents and areas of landfill will be reviewed from NRW data contained within the Envirocheck report scheme (contained in the 2015 PSSR[38]).

f) Assessment of the soil resource value is not proposed as part of this chapter; refer to Section 12 Community and Private Assets for further details.

Identification of Sensitive Receptors

7.6.8 Sensitive receptors will be identified based on the review of existing information, as detailed above. Receptors relevant to this topic area may include:

a) Areas of geological or geomorphological interest;

b) Soils;

c) Sensitive human receptors;

d) Controlled waters that may be affected by release and migration of contaminants; and

e) Ecological receptors that may be affected by release of contaminants.

7.6.9 Identification of receptors and consideration of their sensitivity will be undertaken in accordance with the DMRB Volume 11, Section 3, Part 11[39] and Volume 11, Section 2, Part 5[40]. The assessment applied in relation to potentially contaminated land will be in accordance with the risk management framework provided in CLR11, Model Procedures for the Management of Land Contamination[41].

7.6.10 Approaches adopted for the identification of sensitive hydrological and ecological receptors are considered within Section 9.2 and 9.3 of this Scoping Report respectively.

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

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

[40] Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5, HA205/08, Highways Agency, 2008.

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

Assessment of Potential Effects

7.6.11 The overall assessment of the environmental effects on geology and soils for the Scheme will be carried out in accordance with the guidance set out in DMRB Volume 11, Section 3, Part 11[42], whilst the detailed assessment on the magnitude of impacts and significance criteria for effects will be undertaken using the methodology outlined in DMRB Volume 11, Section 2, Part 5[43].

7.6.12 Assessment of effects in relation to contamination will be undertaken in accordance with industry best practice, comprising CLR11[44] and CIRIA 552[45].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). Any potential risks identified at Tier 1 are then studied in more detail through a Tier 2: Generic Quantitative Risk Assessment (GQRA) and, if deemed necessary in accordance with the guidance, a Tier 3: Detailed Quantitative Risk Assessment (DQRA) will be carried out. Consideration shall be given to whether risks may be presented to human health and/or the environment in both the construction and operational phases of the Scheme. This shall be determined on a location specific basis as part of the environmental impact assessment.

7.6.13 The risk assessment process is underpinned throughout by the development of the Conceptual Site Model (CSM) which provides a schematic representation of the identified Contaminated Linkages.

7.6.14 Where pollutant linkages dictate, additional assessments will be prepared as necessary, including remedial options appraisals and piling risk assessments (if required).

Study Area

7.6.15 The study area for the contaminated land assessment will cover the construction land take and permanent land take. The baseline study area will include all potential contaminated land sites that intersect the Scheme and those site that have plausible pollutant linkages that may be intercepted by the proposed alignment, typically within approximately 250m[46] of the route

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

[43] Design Manual for Roads and Bridges (DMRB) Volume 11, Section 2, Part 5, HA205/08, Highways Agency, 2008.

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

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

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

corridor, although potential pollutant linkages will be considered on a case by case basis.

7.6.16 The geology and geomorphology study area will be determined on the basis of the published information on geology for the area and the site-specific data gathered during investigations along the Scheme. The detailed study area for geology is therefore based along a corridor following the route.

Baseline Context

7.6.17 The 2016 PSSR[47] provides an overview of the historical development and geology underlying the proposed Scheme. An overview of the hydrology and hydrogeology in a Scheme context is also provided.

7.6.18 The PSSR describes the historical development of the Scheme area as follows:

> *"There has been little development either on or off the proposed alignment route since 1888, the earliest historical mapping reviewed. An unnamed road is identified corresponding with the existing A40 alignment. Open fields, field boundaries and woodland areas have remained unchanged since 1888, being consistent with current status. Several quarries are labelled near the alignment, most notably 2 no. quarries near Ffynnon Chapel, approximately 30m to the north of Ffynnon Woods, and 1 no. quarry located near to the proposed Bethel Chapel roundabout, approximately 50m south west. All the aforementioned have ceased activity. 1 no. gravel pit is also noted at the current location of Maes-y-Rhos. None of the aforementioned quarries or gravel pits are located within 50m of the proposed alignment."*

7.6.19 The proposed Scheme area is reported to be underlain by localised superficial deposits comprising glacial or fluvioglacial deposits (clay, sands ad gravels) over mudstones and conglomerates of the following formations:

Slade and Redhill Formation (mudstone)*: blue grey mudstone with frequent thin micaceous sandstone and calcareous bands; and*

Portfield Formation (mudstone) and Haverford Mudstone Formation (conglomerate): *shale, sandstone and conglomerates which grade up into dark green mudstones into thinly bedded green mudstone with occasional bands of sandstone.*

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

7.6.20 The reviewed geological plans did not indicate the presence of made ground. However, from review of the historical development there is potential for localised areas of made ground to be present within the proposed Scheme alignment, primarily associated with the existing road infrastructure.

7.6.21 The PSSR further reports as follows:

> *"Two faults are identified crossing the alignment; both are northeast trending at Llanddewi Velfrey and at Penblewin. The area has undergone various stages of folding and faulting, as a result the regional and local strata dip in various directions. Recorded strata dips in the vicinity of the Scheme vary from 48 degrees north to 50 degrees south south-west."*

7.6.22 No protected areas of geological or geomorphological significance at national, regional or local scale are located within the study area, however the Scheme transects areas identified by the local authority as mineral resources of hard rock and sand and gravel[48].

7.6.23 The desk study review undertaken as part of the PSSR, identified the underlying bedrock to be classed as a Secondary B aquifer, whereas the superficial deposits were generally identified as unproductive strata except for a small section approximately 500m east of Penblewin Roundabout which was identified as a Secondary A aquifer. Groundwater level monitoring was undertaken as part of the 2016 ground investigation.

7.6.24 The PSSR reports that:

> *multiple small rivers are identified both to the north and south of the existing A40 and proposed alignment*

and:

> *the proposed alignment crosses 4 no. 'main rivers'. At Ffynnon Bridge an unnamed 'Primary River' is crossed by the A40, this river progressing via 2 no. extended culverts, draining to the northeast and northwest of Ffynnon Wood. Between Pen-troydin-fach and Pen-troydin-fawr (approximate Ch.2650) the proposed alignment crosses an unnamed tertiary river which flows from the southwest to the northwest. An unnamed secondary river is located within the valley to the east of Pen-troydin-fawr, along the proposed alignment*

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

> *(approximate Ch. 3000), with a second unnamed tertiary river located approximately 300m to the southeast.*

7.6.25 Further details on the hydrological and hydrogeological baseline for the Scheme are presented in Section 8 Road Drainage and Water Environment.

7.6.26 As part of the 2016 ground investigation, five soil samples were obtained from localised areas of the made ground encountered along the proposed alignment. These samples were sent for laboratory testing. The results are presented in the WYG Environment Planning Transport Ltd factual report[49]. In addition, it is expected that groundwater sampling and testing would be undertaken as part of the ongoing 2016 investigations. The results of these investigations will inform the baseline conditions for the ES.

7.6.27 The geological plans show the central part of the proposed Scheme alignment to be underlain by Glacial Till deposits, with the remainder of the Scheme alignment directly underlain by bedrock. The bedrock is shown to comprise mudstones of the Portfield Formation and Heverford Mudstone Formation (undifferentiated) and Slade and Redhill Mudstone Formation, and limestones of the Mydrim Shales Formation and Llandeilo Flags Formation.

7.6.28 In addition, the Supplementary PSSR reports that

> *"No alluvial deposits are shown on the geological maps but these are likely to be present due to the watercourse crossing the proposed route.*
>
> *Although the site appears relatively undeveloped apart from agricultural industry, there is the potential for Made Ground to be encountered. Particularly as there are numerous historic quarries in the local vicinity, some of which may have been infilled."*

7.6.29 Made Ground associated with the exiting road infrastructure is also anticipated.

7.6.30 With respect to geomorphology, the PSSR states:

> *"The topography of the area with valley features and watercourses, as well as presence of glacial till indicates the area has been affected by glaciation."*

7.6.31 The Supplementary PSSR identifies five watercourses ('tertiary rivers') within 100m of the proposed Scheme, two of which cross the alignment. In

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[49] Welsh Government, A40 Llandewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016.

addition, a well and two ponds are located near the Scheme alignment. The Supplementary PSSR reports, "*the presence of ponds highlights the potential for unknown historic quarrying and other extractive industries in the immediate vicinity which have since been infilled.*" No source protection zones are located within 1km of the Scheme alignment.

7.6.32 The Supplementary PSSR did not identify any mines or mineral deposits.

7.6.33 The Supplementary PSSR identifies a number of potential sources of contamination. These include agricultural uses (accidental spillages of fuel, waste storage), use of the existing road infrastructure (accidental spillages of fuel) and potential made ground associated with the road infrastructure or agricultural use of land.

Future Baseline Conditions

7.6.34 Consideration will be given to the potential for changes in the baseline conditions in the medium to long-term as a result of climate change. The Climate Change Risk Assessment for Wales[50] will be reviewed, together with other climate change prediction tools. However, it is considered unlikely that there would be significant change in the geological conditions. With respect to soils, the Change Risk Assessment for Wales identifies the following:

a) reduction in soil moisture and lower river flows, and an increase in the frequency and magnitude of droughts;

b) changes in soil organic carbon, although the ways in which this might be affected are not adequately understood at present;

c) increases in soil erosion in drier summers;

d) wetter soils and increased waterlogging in wetter winters.

7.6.35 It is anticipated that the key areas of existing contaminated land would remain in the future, as there are no other plans for their remediation.

7.7 Potential Effects

Geology and Geomorphology

7.7.1 No protected areas with respect to geology or geomorphology were identified within the study area, and therefore no potential effects on such features were

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[50] Welsh Government, A climate change risk assessment for Wales, HR Wallingford, January 2012

identified. Rock exposures as a result of cuttings in the eastern part of the proposed Scheme may have beneficial effect.

7.7.2 The introduction of the Scheme would limit access to the mineral resources beneath the proposed alignment. Some embankments are proposed in the northern offline bypass section of the Scheme, which will prevent future access to the underlying rock, which is considered a mineral resource. The proposed cuttings in the eastern offline bypass section would result in removal and effective use of mineral resources, in line with the LPD requirements[51].

Soils

7.7.3 The potential effects on the agricultural use of soils are considered within Section 12 Community and Private Assets.

Land Contamination

7.7.4 The published geology does not indicate the presence of made ground, however, a review of the current land use, historical development and existing ground investigation indicates there is a potential for localised areas of made ground within the proposed Scheme alignment. These would primarily be associated with the existing road infrastructure in particular the proposed Llanddewi Velfrey Roundabout), agricultural activities, and/or historical infilled quarries and gravel pits (at various locations along the Scheme alignment). The made ground materials are possible sources of contamination.

7.7.5 The potential effects with respect to human health and controlled waters would be assessed based on the results of the 2016 investigations. No significant contamination is however anticipated. Subject to the assessments, typical good pollution control and health and safety practice is likely to be sufficient to mitigate any potential effects from the presence of made ground during construction. In addition, the reuse of site won or import of materials to the Scheme will be managed by a verification system applied through the Specification for Highway Earthworks Series 600.Only materials found suitable for use would be used for construction. Suitability for use would be assessed based on potential risk posed to end users and controlled waters during construction and operation.

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

7.8 Mitigation Measures

7.8.1 The design is being progressed on the basis that all soils would be retained on site for reuse where feasible. Measures would be taken to establish acceptable reuse criteria and procedures defined for ensuring that the suitability of material can be demonstrated and verified. A discovery strategy would be developed to enable unforeseen ground conditions to be addressed if or when encountered during construction. Inter-relationships with the Materials chapter relating to soil reuse will be considered.

8 Road Drainage and Water Environment

8.1 Introduction

8.1.1 The section describes and characterises the existing surface and ground water resources in the vicinity of the proposed widening of the A40 from Penblewin to Llanddewi Velfrey (the Scheme). It sets out the methodology to be used by Arup for the assessment of potential impacts to water bodies, surface water drainage and flood risk due to the Scheme during the construction and operational phases. Potential impacts to groundwater due to the Scheme, including changes in groundwater level or resource and pollution as a result of road runoff, accidental spillage or construction activities will be considered in this chapter. Potential impacts on groundwater due to the mobilisation of existing pollutants are considered within Section 7.1 Geology and Soils of this Scoping Report.

8.1.2 The assessment methodology follows the guidance set out in the DMRB Volume 11, Section 3, Part 10: HD 45/09 Road Drainage and the Water Environment (November 2009), subsequently referred to in the report as HD 45/09.

8.2 Policy Context

European Legislation

8.2.1 **Water Framework Directive (WFD) 2000/60/EC**: the WFD provides a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater. The Directive requires Member States to establish river basin districts and for each of these a river basin management plan (RBMP), which are prepared, implemented and reviewed every six years. The current period from 2015-21 is Cycle 2 of these RBMPs.

8.2.2 **Groundwater Daughter Directive 2006/118/EC**: a daughter directive of the WFD, the Groundwater Directive establishes a regime which sets groundwater quality standards and introduces measures to prevent or limit inputs of pollutants into groundwater. Amended by Directive 2014/80/EU to clarify groundwater information to be provided to the European Commission. Member States must provide information on groundwater bodies classified as being at risk and threshold values for the respective pollutants and indicators established.

8.2.3 **Floods Directive 2007/60/EC**: the Floods Directive requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. The Directive requires that flood risk management plans be prepared, implemented and reviewed every six years for each river basin district, in coordination with RBMPs prepared under the WFD.

8.2.4 **Habitats Directive 92/43/EEC & Birds Directive 2009/147/EC**: the Habitats Directive and Birds Directive ensure the conservation of a range of rare or threatened species. They establish the EU wide Natura 2000 ecological network of protected areas to safeguard against potentially damaging developments.

8.2.5 **Priority Substances Directive 2013/39/EU**: the Priority Substances Directive amends WFD 2000/60/EC and the Directive on Environmental Quality Standards (Directive 2008/105/EC) by updating the list of priority substances that would apply to WFD assessment.

8.2.6 **Urban Wastewater Treatment Directive 91/271/EEC (as amended) (UWWT Directive (consolidated)):** This Directive concerns the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. The objective of the Directive is to protect the environment from the adverse effects of the above mentioned waste water discharges.

National Legislation

8.2.7 **Environmental Protection Act 1990**: the Act makes provision to control pollution arising from industrial and other processes for waste management.

8.2.8 **Water Industry Act 1991**: The Water Industry Act relates to water supply and the provision of wastewater services in England and Wales.

8.2.9 **Land Drainage Act 1991 (as amended)**: The Land Drainage Act 1991 requires that a watercourse be maintained by its owner. The Act provides functions to internal drainage boards and local authorities to manage watercourses and provide consenting powers for proposed works to watercourses associated with development.

8.2.10 **Water Resources Act (England and Wales) 1991 (Amended 2009):** The Water Resources Act 1991 (WRA) (as amended) sets out the responsibilities of Natural Resources Wales (NRW) and the Environment Agency (EA) in relation to water pollution, resource management, flood defence, fisheries, and navigation.

8.2.11 **Environment Act 1995**: The Environment Act sets new standards for environmental management, such as requiring national strategies for air quality and waste. It also deals with the establishment of an Environment Agency (including Natural Resources Wales and the Scottish Environmental Protection Agency).

8.2.12 **Water Act 2003:** The Water Act 2003 amends the Water Resources Act 1991 and the Water Industry Act 1991 to make provision with respect to compensation under Section 61 of the Water Resources Act 1991.

8.2.13 **Flood and Water Management Act 2010:** The Act makes provision for water, including provision about the management of risks in connection with flooding and coastal erosion.

8.2.14 **Well-being of Future Generations (Wales) Act 2015**: The Act strengthens existing governance arrangements for improving the social, economic, environmental and cultural well-being of Wales to ensure that present needs are met without compromising the ability of future generations to meet their own needs. The Act ensures that when making decisions public bodies take into account the impact they could have on people living in Wales in the future.

8.2.15 **Environment (Wales) Act 2016:** The Act puts in place the legislation needed to plan and manage Wales' natural resources in a more proactive, sustainable and joined-up way. The Act clarifies the law relating to shellfisheries, marine licencing, flood risk management and land drainage in Wales.

8.2.16 **Water Environment (Water Framework Directive) (England and Wales) Regulations 2017**: The WFD has been transposed into the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. WFD is delivered in England and Wales through a framework of River Basin Management Plans (RBMPs). England and Wales are divided into 11 River Basin Districts (RBDs), each consisting smaller management units known as water bodies, including all river, lake, groundwater, coastal, and transitional waters located within that RBD.

8.2.17 **Water Resources (Abstraction and Impounding) Regulations SI 2006/641**: These Regulations contain provisions relating to the licensing of abstraction and impounding of water in England and Wales in the light of amendments made by the Water Act 2003 to the Water Resources Act 1991.

8.2.18 **Flood Risk Regulations 2009:** The Flood Risk Regulations 2009 transposes the EC Floods Directive (Directive 2008/60/EC) on the assessment and management of flood risk into domestic law in England and Wales and implements its provisions. The regulations designate a Local Lead Flood Authority (LLFA) and imposes duties on NRW and Lead Local Flood Authorities to prepare a number of documents including:

a) Preliminary Flood Risk Assessments;
b) Flood hazard and flood risk maps; and
c) Flood Risk Management Plans.

8.2.19 **Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009:** these regulations are based on the 'polluter pays principle and impose obligations on operators of economic activities requiring them to prevent, limit or remediate environmental damage. They apply to damage to protected species, natural habitats, sites of special scientific interest (SSSIs), water and land and implement Directive 2004/35/EC, on environmental liability.

8.2.20 **The Groundwater (England and Wales) Regulations 2009:** These regulations implement parts of the WFD that apply to groundwater (such as the Groundwater Directive). They supplement the Environmental Permitting Regulations 2010 and existing water pollution legislation.

8.2.21 **The Water Supply (Water Quality) Regulations 2010**: These regulations provide the framework for drinking water quality in England in respect of public supplies provided by water companies and licensed water suppliers. The Drinking Water Inspectorate, acting on behalf of the Secretary of State, enforces the legislation.

8.2.22 **The Water Framework Directive (Standards and Classification) Directions England and Wales 2015**: The Water Framework Directive (WFD) Directions presents the updated environmental standards to be used in the second cycle of the Water Framework Directive (2000/60/EC) river basin management planning process in England and Wales. Environmental standards help assess risks to ecological quality of the water environment.

8.2.23 **The Groundwater (Water Framework Directive) (Wales) Direction 2016:** This sets out instructions to Natural Resources Wales on obligations to protect groundwater, including requirements to monitor and set thresholds for pollutants, add new pollutants to the monitoring list and change the information reported to the European Commission.

8.2.24 **The Environmental Permitting Regulations 2016**: the Environmental Permitting (England and Wales) (Amendment) (No. 2) Regulations SI 2016/475 came into force on 6 April. They amend the Environmental Permitting (England and Wales) Regulations SI 2010/675 in order to extend the requirement for an environmental permit to flood risk activities in addition to polluting activities included under the previous regulations. The new permitting requirements for flood risk activities replaces the current "flood defence consent scheme", allowing the Environment Agency and Natural Resources Wales (NRW) to concentrate on higher risk activities. NRW is identified out as the regulator for Wales.

National Planning Policy

8.2.25 **The Wales Spatial Plan (WSP)** sets out the planning agenda for Wales. Its main principle is that development should be sustainable and protect water resources and manage flood risk.

8.2.26 **Planning Policy Wales Edition 9 (November 2016):** (PPW) sets out the land use planning policies of the Welsh Government. It specifically outlines design approaches and techniques that improve water efficiency and minimise adverse impacts on water resources, surface water quality, the ecology of rivers and groundwater. It also ensures that new development is not exposed unnecessarily to flooding. Chapter 13 'Minimising and Managing Environmental Risk and Pollution' provides much of the information relevant to the water environment.

8.2.27 **Technical Advice Note (TAN) 5: Nature Conservation and Planning (2009):** TAN 5 gives advice as to the consideration of impacts on designated sites in relation to the water environment.

8.2.28 **Technical Advice Note (TAN) 15: Development and Flood Risk (2004):** TAN 15 provides technical guidance which supplements the policy set out in PPW in relation to development and flooding. It advises on development and flood risk and provides a framework for the assessment of flooding.

8.2.29 **Welsh Government: Taking Wales Forward 2016-2021**: sets out the priorities of Welsh Government. It includes priorities relating to reductions in carbon emissions, delivering improvements to trunk roads and investment in flood defence / water management.

Regional Management Plans

8.2.30 **Western Wales River Basin Management Plan (RBMP) 2015:** River Basin Management Plans (RBMPs) are drawn up for the 11 river basin districts in England and Wales as a requirement of the WFD. The plan for the Western Wales River Basin District is managed by NRW and sets out the programme of measures needed to achieve the objective of the WFD over the next six year period (2015-2021).

8.2.31 **Western Wales Flood Risk Management Plan (FRMP) 2015**: The Western Wales FRMP was first published in 2015 by NRW. The plan gives an overview of the flood risk in the Western Wales River Basin District and set out intended priorities to manage and reduce flood risk over the next six years and beyond.

Local Planning Policy

8.2.32 **Pembrokeshire Local Development Plan (LDP) 2013-2021**: the following policies are considered relevant as part of this assessment:

GN1	General Development Policy, Point 8;
GN2	Sustainable Design, Point 3;
GN3	Infrastructure and New Development;
GN23	Minerals Working, Point 4; and
GN24	Recycled Waste Materials and Secondary Aggregates, Point 5.

8.2.33 **Pembrokeshire Local Flood Risk Management Strategy 2012**: as the lead local flood authority (LLFA), Pembrokeshire County Council have responsibility for 'local flood risks', which includes the risk of flooding from ordinary watercourses, surface runoff and groundwater. The Council have published a draft Flood Risk Management Strategy that details responsibilities, measures, objectives and assessments of flood risk.

Relevant Guidance

8.2.34 The Environment Agency's Pollution Prevention Guidelines (PPGs) have now been revoked and in Wales are being replaced by the Guidance for Pollution Prevention (GPPs). These will provide guidance on similar areas of practice and where GPPs have yet to be issued, PPGs are still promoted as best practice in order to minimise pollution impacts during construction. The relevant PPGs include:

PPG 1	Understanding your environmental responsibilities – good environmental practices;
GPP 2	Above ground oil storage tanks;
PPG 3	Use and design of oil separators in surface water drainage systems;
PPG 4	Treatment and disposal of sewage where no foul sewer is available;
GPP 5	Works and maintenance in or near water;
PPG 6	Working at construction and demolition sites;
PPG 7	Safe storage – The safe operation of refuelling facilities;
GPP 8	Safe storage and disposal of used oils;
GPP 13	Vehicle washing and cleaning;
PPG 18	Managing fire water and major spillages;
GPP 21	Pollution incident response planning;
PPG 22	Incident response – dealing with spills; and
PPG 26	Safe storage – drums and intermediate bulk containers (PPG 26).

8.2.35 CIRIA Guidance used for the assessment includes:

Control of Water Pollution from Construction Sites – Guide to Good Practice (SP156);

Control of Water Pollution from Construction Sites – Guidance for Consultants and Contractors (C532);

Control of Water Pollution from Linear Construction Projects – Technical Guidance (C648); and

Environmental good practice on site (C692).

Groundwater control: design and practice (second edition) (C750)

8.3 Consultations (undertaken and proposed)

8.3.1 The following stakeholders will be consulted throughout the assessment, both to gather baseline data and to inform the assessment:

a) Pembrokeshire County Council;

b) Natural Resources Wales; and

c) Pembrokeshire Rivers Trust.

8.3.2 Consultation has so far been undertaken with NRW during a meeting and walkover of the Scheme, with a geomorphology technical specialist, on 30th June 2017.

8.4 Surveys to date and further surveys required

8.4.1 To date the following surveys were undertaken:

Ground investigation undertaken by WYG in 2016 on behalf of the Welsh Government. Results are presented in their factual report[52]. These investigations included drilling of boreholes and installation of groundwater monitoring instrumentation. As part of these investigations three rounds of groundwater monitoring were undertaken in 2016;

A Preliminary Sources Study Report, prepared by Mott MacDonald in March 2016 to document the findings of the geotechnical and hydrogeological desk based studies carried out;

A desktop survey of available mapping and Envirocheck data[53];

A site walkover on 29th & 30th June 2017 by a suitably qualified geomorphologist; and

Questionnaire survey of landowners to identify features including private water supplies, abstractions, springs.

8.4.2 Further groundwater level monitoring will be undertaken along the originally proposed route and within the extension section.

8.5 Assessment Methodology

8.5.1 The assessment will be undertaken in accordance with DMRB guidance HD 45/09 Road Drainage and the Water Environment (2009), which provides the methodology and criteria for identifying likely impacts of a proposed road scheme on the water environment, and predicting their magnitude and the significance of the resulting effects. There are four topic areas assessed as part of the HD 45/09 approach:

a) Determining the effect from routine highway runoff on the quality of surface watercourses;

b) Determining the effect from routine highway runoff on the quality of groundwater resources;

c) Predicting the likelihood of an accidental spillage causing pollution to receiving water bodies; and

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[52] Welsh Government, A40 Llandewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016.

[53] Envirocheck report provided during the tender stage, dated 23rd November 2015.

d) Assessing flood risks.

8.5.2 In addition to the topic areas set out in HD 45/09 further assessment will be carried out where other impacts were identified, including:

a) Assessment of the potential effects on the water environment due to construction related impacts, using a source – pathway – receptor based assessment; and

b) A WFD compliance assessment to consider any potential impacts on WFD quality elements (e.g. hydromorphology) that may cause a deterioration in the status of a waterbody or prevent it from reaching good status in the future; and

c) Assessment of effects on the groundwater resource due to the proposed excavation of highway cuttings, the creation of embankments and any potential impacts on groundwater levels.

8.5.3 HD 45/09 provides a standard methodology for the assessment of each topic area, which has four key steps:

Step 1	Identification of water features within the study area and an assessment of the importance/value/sensitivity of each of these receptors;
Step 2	Identification of potential impacts to the water features identified in Step 1, from construction and/or operation. Under the WFD, an impact is defined as causing a deterioration in the status of a water body or preventing a water body from reaching Good status in the future;
Step 3	Assessment of the potential magnitude of any construction or operation impacts on the receptor; and
Step 4	Assessment of the overall significance of any effects to receptors due to impacts, using the matrix.

8.5.4 Specific methods required by HD 45/09, which only have relevance to particular construction or operation impacts, are detailed in following sections for construction and operation.

8.6 Identification of Baseline

8.6.1 The drainage and water environment baseline data for the study area will be obtained from a combination of desktop study, walkover survey, a groundwater levels survey and consultation with relevant bodies.

8.6.2 For the initial baseline description, information has been obtained from the following sources:

a) **NRW 'Water Watch Wales'** (last accessed 28/07/2017)[54];

b) **NRW (2015) Western Wales River Basin Management Plan;**

c) **Preliminary Sources Study Report,** by Mott MacDonald (2016);

d) **Envirocheck Report[53]; and**

e) **A site walkover,** undertaken on 29th & 30th June 2017.

8.6.3 As part of the development of the full ES chapter, additional information will be obtained from:

a) Groundwater monitoring reports; and

b) Consultation with relevant bodies.

8.6.4 The baseline will describe the existing condition of surface and groundwater bodies, flood risk and road drainage layout within the study area. The importance or sensitivity to change will be considered for each water feature. Table 5 sets out the attribute for each water feature considered in defining the baseline. This has been adapted from HD 45/09 to also take account of WFD attributes.

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[54] http://waterwatchwales.naturalresourceswales.gov.uk/en/

Table 5 Surface water features, their attributes and indicators of quality (adapted from HD 45/09)

Feature	Attribute/Service	Indicator of quality	Possible measure
Watercourse	Water Supply/quality	Amount used for water supply (potable); Amount used for water supply (industrial/agricultural); Chemical water quality.	Location and number of abstraction points; Volume abstracted daily; Physio-chemical quality elements of WFD ecological status; Supporting hydrological regime element of WFD ecological status.
	Dilution and removal of waste products	Presence of surface water discharges and effluent discharges.	Daily volume of discharge (treated/untreated)
	Recreation	Access to watercourse; Use of watercourse for recreation.	Length of watercourse used for recreation (fishing, water sports) and number of clubs
	Biodiversity	Biological water quality	WFD ecological status class
		Fisheries quality	Fish Status; Supporting hydromorphological element of WFD ecological status, includes geomorphology
	Value to economy	Value of use of watercourse	Length of watercourse used for recreation commercially; Number of people employed; Length of river bank developed; Length of watercourse fished commercially.
	Conveyance of flow	Presence of watercourses	Number and size of watercourses
Floodplain	Conveyance of flood flows	Presence of floodplain; Flood flows.	Developed area within extent of floodplain affected; Existing flood risk/flood return period; Location/importance of flood flow routes.
Groundwater	Water Supply/quality	Amount used for water supply (potable); Amount used for water supply (industrial/agricultural).	Location and number of abstraction points; Volume abstracted daily; Location and grade of source protection zone; WFD groundwater quantitative chemical status.
	Soakaway	Presence of soakaways or other discharges to the ground.	Location and number of discharge points; and daily volume discharged.
	Vulnerability	Groundwater vulnerability.	Classification of aquifer vulnerability.
	Economic value	Extent of use for abstractions.	Number of people employed.

Feature	Attribute/Service	Indicator of quality	Possible measure
	Conveyance of flow	Presence of groundwater supported watercourses; Potential for groundwater flooding; Groundwater interception by road structures or drainage.	Changes to groundwater recharge, levels or flows; Number and size of watercourses.
	Biodiversity	Presence of groundwater supported wetlands.	Changes to groundwater recharge, levels or flows; Status or classification of wetland.

8.7 Methodology

Construction Impacts

8.7.1 The assessment of construction impacts will follow the guidance set out in HD 45/09, which recommends that construction impacts are considered using the source – pathway – receptor approach and defers specific guidance of bridge/highway construction impacts to CIRIA 648 Control of Water Pollution from Linear Construction Projects.

8.7.2 The potential impacts of construction on surface water will be assessed based on the planned construction methods and sequencing and after discussion with the contractor. Potential impacts that will be considered include:

Potential surface water impacts: impacts to surface water quality from sediment runoff, spillages or discharges, impacts to flood risk, and impacts on fish or eel passage/spawning due to noise, light, vibration or physical modification.

Potential groundwater impacts: changes to groundwater levels (such impacts will be assessed together with impacts due to operation of the Scheme) and impacts on groundwater quality due to spillages and discharges during construction.

8.7.3 Where construction methods are not available, standard construction practices will be assumed. Cumulative impacts as a result of construction phasing will also be assessed.

Operational Impacts

8.7.4 An assessment of the potential impacts during operation will be undertaken for the five assessment components as set out below.

8.7.5 **Surface Water Quality:** An assessment of the potential impacts of routine runoff on surface waters will be undertaken to determine whether there is an environmental risk and if pollution mitigation measures are needed. The Highways Agency Water Risk Assessment Tool (HAWRAT) will be used to assess short term risks from intermittent discharge (i.e. first flush) and the tool outputs will also be compared against Environmental Quality Standards (EQS's) to assess the potential for annual cumulative impacts.

8.7.6 The methodology assesses the impact of road drainage water with any pollutants it contains, based on the predicted traffic volumes, the carriageway surface area and the local climate conditions. The impact assessment methodology dealing with water quality considers potential dilution within the receiving watercourse, the morphology and sensitivity of the watercourse and any protected sites downstream of the discharge point. Baseline surface water quality monitoring is not required for the HAWRAT method and is therefore not proposed as part of the EIA methodology.

8.7.7 **Geomorphology:** a qualitative assessment of possible impacts on the river geomorphology will be undertaken based on a suitably qualified river geomorphologist or engineer's understanding of the potential for impacts to the watercourse flow dynamics and sediment transport processes and the subsequent effects this this might have on the ecological potential of the water body.

8.7.8 Where possible, the 1 and 2D results of the flood modelling will be used to gain insight into the impacts of the proposals on flow dynamics during flood events. These types of impacts will be assessed based on experience of previous schemes and a theoretical understanding of flow.

8.7.9 Potential geomorphological responses to any anticipated changes in flow dynamics will then be evaluated. Where possible, the assessment will be supported by consultation and a site visit with NRW officers with appropriate experience of fluvial geomorphology.

8.7.10 **Groundwater Quality:** Annex I of HD 45/09 provides a methodology (Method C) to assess the potential impact on the quality of groundwater resources from routine runoff discharges to the ground. This risk assessment procedure is based on the source-pathway-receptor (S-P-R) protocol. The principles of this approach will be applied to the discharge of road drainage where:

a) The source comprises the road drainage water with any pollutants it contained as it enters any unlined ditch or watercourse, attenuation pond or soakaway discharge system that in accordance with HD 45/09 has potential to transmit water through the ground to groundwater;

b) The pathway represents the processes that may modify the pollutants during transmission through the discharge system and the ground until the actual ‘point of entry’ to groundwater; and

c) The receptor is the groundwater.

8.7.11 For there to be a risk of impact to groundwater, all elements of the S-P-R model have to be present to create a pollutant linkage. In accordance with HD 45/09, a pathway to the groundwater receptor is only considered to be feasible if the receiving watercourse at the proposed outfall has little flow during dry periods. In accordance with HD 45/09 this is assessed as a Q95 flow of less than $0.001m^3/s$.

8.7.12 **Hydrogeology and Groundwater Resources: a** specific methodology for the assessment of potential effects of the Scheme on hydrogeology and groundwater resources is not covered by HD 45/09. The proposed method of assessment will include the following:

a) Use of desk study information, the findings from site walkover studies and ground investigations to develop a ground model, including the likely groundwater levels across the Scheme.

b) Identification of any sensitive receptors that are reliant on the current groundwater levels, such as NRW designated groundwater Source Protection Zones (SPZ), existing abstraction wells, or spring lines that feed surface water courses.

c) Identification of potential features or activities that are proposed for the Scheme that may result in an impact on groundwater levels, such as the long-term dewatering of highway cuttings.

d) Assessment of the potential impacts on the receptors. For the proposed highway cuttings, this would include hydrogeological calculations of the likely drawdown of the water table.

8.7.13 **Accidental Spillage: t**he operational pollution effects from accidental spillage will be calculated using Method D from the HD 45/09 guidance. When considering the risk of spillages, the calculated spillage risk return period must not be greater than 1 in 100 years, or 1 in 200 years where spillage could affect protected areas for conservation such as Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs) and Special Area of Conservation (SACs).

8.7.14 For assessment of the risk posed by accidental spillage, in line with HD 45/09 guidance, if the annual probability that a spillage would cause a serious pollution incident to a water body is less than 1%, then the risk posed is considered acceptable and no further assessment has been carried out.

8.7.15 The risk is assessed initially without any mitigation measures. If mitigation measures are needed to reduce the probability, a reduction factor is applied, depending on the type of mitigation applied.

8.7.16 **Flood Risk:** the assessment of potential flood impacts will be undertaken in accordance with the principles of DMRB and TAN15. The 1 in 100 year and 1 in 1000 year probability flood events will be assessed and an additional allowance to account for future climate change will be applied to the 1 in 100 year flood event, following agreement on the allowance with NRW. The principles of any modelling methodology will be agreed with NRW prior to the commencement of any modelling.

Significance Criteria

8.7.17 The significance of effects on the water environment will be based on the methodology contained within the HD 45/09 guidance, Annex IV. The importance or sensitivity of the affected receptor is combined with the magnitude of any effects to define the significance of the effects. Potential effects not covered by this guidance, chiefly related to geomorphology and WFD compliance, will be assessed using the supplementary methods explained in the sections above.

8.8 Limitations and Assumptions

8.8.1 Assessment of the drainage and the water environment aspects of the Scheme will be carried out in accordance with HD 45/09, and supplementary methods as explained in the above sections for potential impacts not covered by this guidance.

8.8.2 Limitations and assumptions associated with the recommended methods are discussed below.

8.8.3 **Surface Water:** the accuracy of the baseline condition described in the assessment is dependent upon the accuracy of information obtained from NRW and its ‘Water Watch Wales’ website.

8.8.4 For the HAWRAT model flow data is required. Due to the lack of flow data available for the watercourses in the study area, the Q95 flow will be estimated using LowFlows software. The catchment area for each watercourse may require manual delineation if it is too small to be delineated by the software. Where the Q95 estimated by the LowFlows software is < 0.001 m^3/s, in accordance with HD 45/09 guidance, a Q95 of 0.001 m^3/s is used.

8.8.5 The water hardness parameter for HAWRAT will be obtained from the Drinking Water Inspectorate (DWI) map which shows the rate of water hardness. This data is considered to be appropriate to use in the absence of chemical data for each watercourse. It is assumed that local potable water would have a similar hardness characteristic as the local surface water and the three water hardness levels used by the HAWRAT model are based on broad ranges.

8.8.6 The threshold limits for soluble zinc and copper and for sediments are based on the limits set by the HAWRAT model.

8.8.7 **Groundwater:** the Method C assessment results in a significance of effect that is relevant to the specific locality of the point of discharge, which is not relevant to the wider groundwater body due to dilution effects. Supplementary risk assessment is proposed to overcome this situation if it arises.

8.9 Study Area

8.9.1 The study area for the assessment will include the geographical extent of the full scope of the works, all surface and groundwater bodies within 500m and high-value water bodies over 500m, up to the point of potential effect from the Scheme. The furthest extent of the study area will be limited to the point on a receiving watercourse or groundwater body whereby the significance of the effect of any potential impact is deemed to be neutral.

8.9.2 The 500m buffer has been selected based on professional judgement of the potential impacts posed by the Scheme. It is in line with study areas for assessments of the impact on the water environment undertaken for other highway construction projects. Water bodies outside the 500m buffer will be identified during the assessment, based on professional judgement of their value and connectivity to the Scheme area.

8.10 Baseline Conditions

8.10.1 The initial baseline information included in the following sections has been collected by a combination of desk-based study and a walkover survey of the study area as defined above. As part of the development of the ES, this initial baseline will be supplemented with additional information during the general design of the Scheme and consultation with relevant bodies.

Surface Water

8.10.2 Baseline information includes the current WFD status and status objectives, environmental designations, available flow data, existing drainage of the A40 and any discharge and abstraction points. The following surface water features were identified in the study area:

Longford Brook and a number of its unnamed tributaries. Longford Brook and an unnamed tributary are crossed approximately midway along the proposed route at Ffynnon Farm and Pen-troydin-fach. Other tributaries, generally to the north and west of the Scheme, are within the 500m study area;

The Afon Daulan and a number of its unnamed tributaries. The Afon Daulan and an unnamed tributary are crossed by the proposed route to the north of Llanddewi Velfrey, near Pen-troydin-fawr. Another tributary to the northeast of the Scheme, is within the 500m study area;

The Afon Marlais and a number of its unnamed tributaries. The Afon Marlais itself is at its closest 80m from the Scheme's western edge. The catchment is parallel to the southern boundary of the existing route of the A40;

A tributary of Narbeth Brook, which, based on OS mapping, rises 20m south of the existing A40 at Redstone Farm. The potential offline route of the proposed Scheme at this location would cross this watercourse;

Two unnamed tributaries of the Afon Taf, which are not crossed by, but are within, 200m and 500m from the eastern boundary of the proposed route;

Four ponds at grid references SN 14315 16763, SN 13051 16396, SN 12163 17049 (Caermaenau Fawr) and SN 13415 17249 (Pen-ca'rmaenau); and

Springs at multiple locations. As the proposed route spans the watershed between multiple catchments, the watercourses described above arise across the study area, with the majority indicated on OS mapping as being spring-fed.

8.10.3 Flow data for the watercourses in the vicinity of the Scheme are not available from the National River Flow Archive[55] or the NRW river levels website[56].

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[55] National River Flow Archive. Accessed at: www.nrfa.ceh.ac.uk on 28th July 2017.

[56] Natural Resources Wales: River Level Map. Accessed at: https://naturalresources.wales/riverlevels?lang=en on 28th July 2017.

8.10.4 Consented discharges within the study area, as identified by the Envirocheck report, include:

Discharge from Llanddewi Velfrey Sewage Treatment Works into a tributary of Pont-Shan Brook, approximately 200m south of the Scheme; and

Discharge of freshwater to the Afon Marlais from Pantygorphwys-Uchaf, 350m from the western end of the Scheme.

Groundwater

8.10.5 The following ground water features were identified in the study area:

A licenced abstraction (No. 356) at Blaen Pentrhoydin from an enclosed well, approximately 250m south of the proposed route;

A well at Scapin Farm, marked on OS mapping, on the southern edge of Llanddewi Velfrey, approximately 700m south of the proposed route;

A licenced abstraction from a spring at Panteg, to the southeast of Llanddewi Velfrey, approximately 900m south of the proposed route;

A number of wells around Ffynnon Farm, marked on OS mapping, alongside and to the north of the proposed route;

A well to the south of Redstone Farm, marked on OS mapping, to the south of the existing A40;

A well at Caermaenau Fawr, marked on the Envirocheck mapping, approximately 350m to the north of the western end of the Scheme; and

A licenced abstraction (No. 503) at Henllan from a well, approximately 500m south of the proposed route.

8.10.6 The bedrock underlying the Scheme is classified as a Secondary B aquifer and with superficial deposits, present in the valley bottom on Longford.

8.10.7 There are no Source Protection Zones within the study area.

8.10.8 The Scheme would require two significant areas of cutting to the north and east of Llanddewi Velfrey. Springs are marked in these areas, indicating the groundwater is likely to be present at a shallow depth. Groundwater monitoring data has been obtained as part of the 2016 investigation and is presented in the WYG factual report[57] and will be assessed to confirm the hydrogeological model for the Scheme area.

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[57] Welsh Government, A40 Llandewi Velfrey to Penblewin, Ground Investigation Factual Report, WYG, June 2016.

Water Framework Directive

8.10.9 The study area includes four WFD river water bodies and two WFD groundwater bodies. These are:

Taf – Felin Cwrt to Gronw river water body;

Longford Brook – HW to confluence with E. Cleddau river water body;

Marlais – headwaters to confluence with Taf river water body;

Narbeth Brook - headwaters to conf with E. Cleddau river water body;

Tywi, Taf and Gwendraeths groundwater body; and

Cleddau and Pembrokeshire groundwater body.

8.10.10 The current status, failing elements and reasons for failure of each of these WFD water bodies is summarised in Table 6.

8.10.11 A WFD Protected Area, the Cleddau Rivers Special Area of Conservation (SAC), is approximately 5km downstream of the proposed crossing of Longford Brook and 1.25km downstream of the proposed watercourse crossing at Redstone Cross. The SAC is designated due to the presence of Bullhead, River Lamprey, Brook Lamprey, Otter and Sea Lamprey, along with rare habitats including rivers with floating vegetation often dominated by water-crowfoot, active raised bogs and alder woodlands on floodplains. Potential impacts to the site and associated ecology will be addressed in the nature conservation chapter of the ES and the AIES.

Flood Risk

8.10.12 The route of the Scheme is not at risk of flooding from rivers and sea, based on NRW's flood map viewer[58].

8.10.13 Limited areas in the vicinity of watercourse crossings and along the proposed western section with the same alignment as the existing A40 are classified as have a low to medium surface water flood risk[59]. A low risk of surface water flooding equates to a chance of flooding of between 1 in 1000 and 1 in 100 years, whilst a medium risk equates to a chance of between 1 in 100 and 1 in 30 years.

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[58] NRW Risk of Flooding from Rivers & Sea Map. Accessed at https://naturalresources.wales/our-evidence-and-reports/maps/flood-risk-map/?lang=en on 16th March 2017.

[59] NRW Surface Water Flood Risk Map. Accessed at https://naturalresources.wales/our-evidence-and-reports/maps/flood-risk-map/?lang=en on 16th March 2017.

8.10.14 The Western Wales Flood Risk Management Plan and Pembrokeshire County Council's Flood Risk Management Strategy do not indicate any measures to reduce flood risk in the study area.

8.10.15 All areas of the Scheme route are designated as Zone on Welsh Government's TAN15 mapping. Areas designated as Zone A are considered to be at little or no risk of fluvial or coastal/tidal flooding.

8.11 Potential Effects

8.11.1 Linear construction projects, such as roads, have the potential to intersect a number of surface and groundwater features and create pollution sources or pathways that are not present under existing conditions.

8.11.2 Potential effects of roads on the water environment can be split into direct or indirect effects and occur as a result or construction, operation or a combination of construction and operation. Typically, these effects are grouped into temporary, short-term construction effects and permanent, long-term operational effects, although short and long term effects can occur as a result of both construction and operation activities.

8.11.3 The assessment will consider the following potential effects on the water environment during construction:

a) Pollution of receiving waters as a result of accidental spillage or the runoff of sediments or contaminants from construction areas;

b) Changes in the flow or levels of surface and groundwater features, including private water supplies, and associated effects on dependant features (i.e. springs, wetlands and groundwater-fed watercourses); and

c) Changes in flood risk and conveyance of drainage.

8.11.4 The assessment will consider the following potential effects on the water environment during operation:

a) Pollution of waters receiving road runoff, including routine runoff and in the event of accidental spillage on the carriageway;

b) Changes in the flow or levels of surface and groundwater features, including private water supplies, and associated effects on dependant features (i.e. springs, wetlands and groundwater-fed watercourses);

c) In channel sediment transfer or movement, often as a result of modification to the existing surface water network; and

d) Fluvial flooding as a result of increased surface water runoff and changes to surface water and floodplain capacities.

8.11.5 The mobilisation of existing contaminants is another potential effect during both construction and operation and will be considered in the assessment of Geology and Soils Section 7.

8.11.6 The impact on designated sites with hydrological linkages will be assessed in the Nature Conservation Section 9.

Table 6 Summary of WFD water bodies in the study area. Information relevant for Cycle 2 of the WFD (2015-2021) and obtained from http://waterwatchwales.naturalresourceswales.gov.uk/en/ (Accessed on 16th March 2017).

WFD Waterbody	**Taf -Felin Cwrt to Gronw**	**Longford Brook - HW to conf with E. Cleddau**	**Marlais - headwaters to confluence with Taf**	**Narbeth Brook - headwaters to conf with E. Cleddau**	**Tywi, Taf and Gwendraeths**	**Cleddau and Pembrokeshire**
ID	GB110060036283	GB110061030680	GB110060029240	GB110061030660	GB41002G200500	GB41002G200400
Type of Waterbody	River	River	River	River	Groundwater	Groundwater
Management Catchment	Carmarthen Bay and the Gower	Cleddau and Pembrokeshire Coastal Rivers	Carmarthen Bay and the Gower	Cleddau and Pembrokeshire Coastal Rivers	WA South West	WA South West
Area (km^2)	41.42	14.54	26.63	17.89	1,947.43	1,115.63
HMWB/AWB?	No	No	No	No	No	No
Overall Status	Moderate	Moderate	Good	Good	Poor	Poor
Objective	Good by 2021	Good by 2021	NA	NA	Poor by 2015	Good by 2021
Chemical Status	Fail	Good	Good	Good	Poor	Poor
Ecological Status (river), Quantitative Status (groundwater)	Moderate	Moderate	Good	Good	Good	Good
Driver of failure to achieve Good status	Zinc, Cadmium	Fish	NA	NA	Chemical Dependent Surface Water Body Status	Chemical GWDTEs test
Reason for not achieving Good status	Suspect data - pending investigation	Other (not on list)	NA	NA	Point source pollution from abandoned mines.	Unknown
Other (including Mitigation Measures)	Dwr Cymru to investigate sources, transport and pathways of microbial pollution to Shellfish Waters as part of AMP 6 NEP programme. NRW to regulate.	Reduce diffuse source pollution at source by controlling or managing diffuse source inputs. Cleddau Rivers SAC at downstream end of catchment.				

9 Nature Conservation

9.1 Introduction

9.1.1 This section sets out the proposed approach to the assessment of effects on ecology and nature conservation in terms of sites designated for their nature conservation importance (international, national and local), the habitats present, and the protected or otherwise notable species which they support.

9.1.2 It identifies the nature conservation constraints to enable an informed decision on the level and approach to the assessment to be established. During the EIA process, the potential effects of both the construction and operational phases of the Scheme will be considered, and these effects avoided and mitigated so far as practicable. The significance of the likely ecological and nature conservation effects will also be assessed.

9.1.3 The effects of the Scheme on European Sites will also be considered in parallel to the EIA through the AIES process as set out in DMRB Volume 11, Section 4, Part 1.

9.2 Relevant Guidance

9.2.1 The following guidance, initiatives and plans are relevant and will be considered during the assessment:

a) Guidelines for Ecological Impact Assessment in the UK 2016 (Chartered Institute of Ecology and Environmental Management);

b) Guidelines for Baseline Ecological Assessment (Institute of Environmental Assessment);

c) DMRB Volume 11, Section 3, Part 4: Ecology and Nature Conservation;

d) Interim Advice Note 116/08 (W) Nature Conservation in Relation to Bats;

e) Interim Advice Note 130/10 Ecology and Nature Conservation: Criteria for Impact Assessment;

f) DMRB Volume 11, Section 4, Part 1: Assessment of Implications (of Highways and/or Roads Projects) on European Sites (Including Appropriate Assessment);

g) Technical Advice Note (TAN) 5: Nature Conservation and Planning;

h) The UK Post-2010 Biodiversity Framework;

i) Welsh Transport Planning and Appraisal Guidance: WelTAG;

j) Trunk Road Estate Biodiversity Action Plan 2004-2014;

k) The State of Birds in Wales (RSPB Cymru, BTO Cymru, the Wildfowl and Wetlands Trust, the Welsh Ornithological Society and Countryside Council for Wales);

l) Otter Road Casualties in South Wales: Recommendations for Mitigation: A report by the Cardiff University Otter Project;

m) Birds of Conservation Concern 3: The Population Status of Birds in the United Kingdom, Channel Islands and the Isle of Man;

n) Pembrokeshire Biodiversity Action Plan (Pembrokeshire County Council); and

o) Action Plan for Pollinators (Welsh Government).

9.3 Consultations (undertaken and proposed)

9.3.1 NRW were engaged in discussions over the methods and extent of surveys which were undertaken during 2016. NRW will be an important consultee during the EIA and AIES process and will be invited to the ELG Meetings along with the Local Authority.

9.4 Surveys undertaken to date and additional surveys required

9.4.1 The following surveys were undertaken during 2016 to provide baseline information for the assessment:

a) Extended Phase 1 Habitat Survey;

b) Targeted woodland and grassland National Vegetation Classification Survey;

c) Hedgerow surveys.

d) Badger surveys;

e) Bat roost surveys;

f) Bat activity surveys;

g) Bat transect surveys

h) Dormouse surveys;

i) Otter surveys;

j) Breeding bird surveys;

k) eDNA testing for great crested newts, and targeted presence/absence surveys of one pond; and

l) Reptile surveys.

9.4.2 Additional surveys are required to allow additional information to be obtained to inform the development of mitigation proposals and any subsequent protected species licence applications that would be required for the construction of the proposed Scheme. These are surveys include presence/absence surveys for great crested newts and bat emergence and activity surveys.

9.5 Assessment Methodology

Scope of Proposed Assessment

9.5.1 The assessment of effects will follow a methodology primarily taking account of the following guidance:

a) DMRB Volume 11, Section 2, Part 5: HA205/08 Assessment and Management of Environmental Effects; and

b) Guidelines for Ecological Impact Assessment in the UK Chartered Institute of Ecology and Environmental Management (CIEEM).

9.5.2 The Guidelines for Ecological Impact Assessment in the UK (2016) are the current industry standard for ecological assessment and are therefore considered to be current good practice. The assessment of impacts on ecological receptors will therefore be undertaken in line with the CIEEM guidance in terms of the assessment of the significance of effects.

9.5.3 The scope of the assessment will consider the potential effects outlined below.

Assessment of Potential Effects

9.5.4 The assessment of the effects of the Scheme will include those arising from:

a) the permanent land take required for the Scheme;

b) construction; and

c) operation.

9.5.5 The potential effects of the permanent land take for the Scheme would primarily arise from habitat loss which, as well as resulting in the loss of habitat of intrinsic value in its own right, would reduce the area available for foraging and nesting animals. Reducing the area can reduce viability of the habitat and lead to a reduction in the diversity of plant and animal communities present. The integrity of the habitat could therefore be altered, and the conservation status of species affected.

9.5.6 In addition to land take, the new road, highway fencing, drainage and bridge/culvert alterations have the potential to create a barrier to movement of species between areas of habitat ('habitat fragmentation'). Mitigation to any barrier identified will be incorporated into the design.

Assessment of Significance

9.5.7 In accordance with the CIEEM guidelines, a significant impact, in ecological terms, is defined as 'an impact (whether negative or positive) on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a given geographical area, including cumulative and in-combination impacts'. It is important to note however that in accordance with the CIEEM guidelines, the actual determination of whether an impact is ecologically significant is made irrespective of the value of the receptor in question. In this respect the CIEEM methodology differs from some other approaches to EIA.

9.5.8 The value of a feature that will be significantly affected is used to determine the geographical scale at which the impact is significant, e.g. an ecologically significant impact on a feature of county importance will be considered to represent a significant impact at a county level. This in turn is used to determine the implications in terms of legislation, policy and /or development management.

9.5.9 Any significant impacts remaining after mitigation (the residual impacts), together with an assessment of the likelihood of success of the mitigation, are the factors to be considered against legislation, policy and development management in determining the Scheme.

9.6 Study Area

9.6.1 In accordance with the relevant guidance, the ecology desk study area for the Scheme extends to 30 km for SACs designated for bats, 10 km for other internationally designated sites, 2 km for nationally designated SSSIs and 1 km for locally designated Sites of Importance for Nature Conservation (SINCs).

9.6.2 For protected species the desk study area extends for 5km (other than for bats for which it is 10km) and for other species of conservation concern, 1 km.

9.6.3 The proposed study area for ecological field surveys will include all land within 500m of the centre line of the proposed Scheme and any compound or laydown areas that will be used.

9.7 Baseline Context

9.7.1 There are a number of designated sites within the desk study area as defined above. These are shown in the Table 7.

Table 7 Designation sites within the desk study area

Designation	**Approximate Distance from Scheme**
Afon Cleddau Dwyreiniol / Eastern Cleddau River SSSI	2km
Afonydd Cleddau / Cleddau Rivers SAC	2km
Pembrokeshire Marine / Sir Benfro Forol SAC	6.2km
Yerbeston Tops SAC	8.7km
Carmarthen Bay and Estuaries / Bae Caerfyrddin ac Aberoedd SAC	9.7km
Pembrokeshire Bat Sites and Bosherton Lakes / Safleoedd Ystlum Sir Benfro a Llynnoedd Bosherton SAC	9.1km
Carmarthen Bay SPA;	10km
Bristol Channel Approaches / Dynesfeydd Mor Hafren pSAC	10km
Limestone Coast of South West Wales / Arfordir Calchfaen De Orllewin Cymru SAC	17.8km
North Pembrokeshire Woodlands / Coedydd Gogledd Sir Benfro SAC	18.3km

9.7.2 The surveys that were undertaken in 2016 have identified the presence of a number of legally protected species and notable habitats. These include:

a) Broad-leaved woodlands;

b) Badger setts;

c) Reptile populations;

d) Dormice;

e) Otters;

f) Bat roosts on and within the vicinity of the proposed Scheme;

g) Great crested newts and other amphibians;

h) A number of bat species including lesser horseshoe, greater horseshoe and barbastelle bat, foraging within the vicinity of the proposed Scheme; and

i) A common breeding bird assemblage.

9.8 Potential Effects

9.8.1 The potential effects of the Scheme during construction would include:

a) Habitat loss as a result of the construction of the Scheme resulting from use of land for soil storage areas or construction compounds etc;

b) Potential hydrological effects of the earthworks resulting in changes in water levels in watercourses and wetland areas;

c) Temporary and permanent severance/fragmentation of habitats or corridors used by species (in addition to that caused by the completed Scheme);

d) Disturbance to sensitive species in adjacent areas from noise, light, unaccustomed human activity;

e) Effects of air pollution from construction vehicle exhaust gases and dust from haul roads;

f) Potential effects of pollution from inappropriate storage of chemicals or spillages on nearby or more distant receptors;

g) Potential effects of run-off from the construction area resulting in particulate pollution of watercourses; and

h) Spreading of invasive plant species.

9.8.2 The effects to be assessed relating to operation of the Scheme would include:

a) severance/fragmentation of habitats or corridors used by species;

b) animal road casualties as normal commuting routes are disrupted;

c) disturbance to sensitive species from noise and light;

d) effects of highway drainage on existing watercourses and the hydrological regime;

e) salt accumulation from de-icing operations may affect plant communities on the roadside verges and the ecology of the receiving watercourses;

f) potential for pollution events resulting from collisions/other traffic incidents on the new road;

g) effects of air pollution resulting from vehicle exhaust gases and particulates on sensitive habitats and species; and

h) potential positive effects of new landscape management.

9.8.3 The potential for effects on the European designated sites will also be addressed in the AIES to fulfil the requirements of the Conservation of Habitats and Species Regulations 2010.

9.9 Mitigation Measures

9.9.1 The wider landscape through which the Scheme would be constructed includes sites which were designated at the highest level for their nature conservation value. It is essential that the Scheme avoids effects on these sites so far as practicable, and, where the effects cannot be avoided, that appropriate and effective mitigation is provided. The avoidance and mitigation measures will be developed as part of the Scheme design and in the light of the results of the ecological surveys.

9.9.2 Due to the presence of a number of legally protected species including dormice and bats, the design of the Scheme and landscape proposals will need to take in to account the requirements to aid the passage of these species across the road. At least one bat roosts is located under the footprint of the Scheme and would need compensation. Mitigation in terms of vegetation clearance methods would also be required for breeding birds, amphibians and reptiles.

9.9.3 As referred to above, the Welsh Government has particular responsibilities with respect to the conservation and enhancement of SSSIs under Section 28 of the Wildlife and Countryside Act 1981 and of biodiversity under the Environment (Wales) Act 2016. The ES will include both mitigation and enhancement measures for the Scheme to address these obligations.

9.9.4 The Scheme would include a number of mitigation and enhancement measures which will be developed during the EIA process. These are likely to include but not be limited to:

a) The design of the Scheme, its drainage and construction will take into account amphibians and also ensure the potential for these species becoming trapped in the drainage system is minimised.

b) Where invasive plant species are present mitigation measures will be adopted to manage the presence of such species including the control of the species in accordance with existing guidelines such as the relevant Environmental Agency guidance.

c) Measures to allow species to cross the road using underpasses will be considered.

d) Measures to reduce the potential to cause harm to species during construction

e) Measures to mitigate for habitat loss and for loss of connectivity;

f) Barriers, in the form of otter and badger fencing, to reduce the risk of the relevant mammal species entering the road corridor;

g) A 5-year aftercare scheme for the soft estate to ensure establishment and undertake maintenance of ecological measures.

9.9.5 Mitigation and enhancement measures will be discussed with the attendees of the ELG.

9.9.6 Other plainly establish uncontroversial mitigation measures will also be included within the design and construction of the Scheme including pollution prevention measures and mammal underpasses as set out in the requirements of the relevant sections of the DMRB.

10 Landscape and Visual

10.1 Introduction

10.1.1 This section of the Scoping Report describes the scope of the landscape and visual assessment (LVIA). References to national and local planning policies to be considered are included as well as the approach to the assessment of likely significant effects of the preferred route and approaches to mitigation.

10.2 Policy and Guidance

National Planning Policy

10.2.1 The current land use planning policies for the Welsh Government are set out in Planning Policy Wales Edition 9 (November 2016). Of relevance to landscape and visual impact assessment (LVIA), are:

Chapter 4 ‘Planning for Sustainability’;

Chapter 5 ‘Conserving and Improving Natural Heritage and the Coast’;

Chapter 6 ‘The Historic Environment’ and;

Chapter 13 ‘Minimising and Managing Environmental Risks and Pollution’.

10.2.2 Planning Policy Wales (PPW) also supports the use of Natural Resources Wales’ LANDMAP data system as an important information resource.

10.2.3 PPW is supplemented by a series of topic based Technical Advice Notes (TANs). The relevant TANs include:

TAN10 ‘Tree Preservation Orders’;

TAN 12 ‘Design’ and;

TAN 18 Transport.

Local Planning Policy

Pembrokeshire County Council

10.2.4 The Pembrokeshire Local Development Plan (LDP), adopted in February 2013 guides planning and development in the county up to 2021. Of relevance are the following policies:

GN.37 ‘Protection and Enhancement of Biodiversity’;

GN.38 ‘Protection and Enhancement of the Historic Environment’ and;

GN.39 ‘Transport Routes and Improvements’.

Neighbouring Authorities

10.2.5 The Scheme may be visible from outside of the region covered by the Pembrokeshire LDP, with potential long distant views of the preferred route from adjacent areas.

10.2.6 The relevant policies of adopted Local Development Plans of Carmarthenshire County Council (December 2014 to 2021), and Pembrokeshire Coast National Park (September 2010 to 2021), will be considered as part of the assessment.

10.3 Relevant Guidance

10.3.1 The assessment will be carried out in accordance with methodology set out within ‘Interim Advice Note 135/10 (W) Landscape and Visual Effects Wales Only’ (Welsh Government 2014) (hereafter referred to as IAN 135/10 (W)), which replaces guidance within DMRB, Volume 11, Section 3, Part 5 (Highways Agency).

10.3.2 Other relevant documents referred to include:

a) ‘LANDMAP’, maintained by Natural Resources Wales, including guidance notes;
    i. GN3 ‘Using LANDMAP for LVIA of Onshore Wind Turbines’ (2013);
    ii. GN4 ‘LANDMAP and the Cultural Landscape’ (2016);
    iii. GN5 ‘LANDMAP and the Geological Landscape’ (2016).

b) ‘Guidelines for Landscape and Visual Impact Assessment, Third Edition’ (GLVIA3)
(The Landscape Institute and Institute of Environmental Managers and Assessment, 2013);

c) Photography and Photomontage in LVIA (Landscape Institute 2011); and

d) Roads in Lowland Areas: A Design Guide (Highways Directorate, Welsh Office 1993).

Work Carried Out to Date

10.3.3 Welsh Government have been reviewing improvement options for the A40 between St Clears and Haverfordwest for several years. Previous work includes WelTAG Stage 1 assessment carried out by WSP ¦Parsons Brinckerhoff and TACP in 2015 which updated an earlier study carried out by Parsons Brinckerhoff in 2004. For the purpose of the EIA, previous work will be reviewed.

10.4 Baseline Conditions

Landscape Designations

10.4.1 The proposed improvement would not have a direct impact on any designated landscape.

10.4.2 At its nearest point at Canaston, Pembrokeshire Coast National Park is over 5 km west of the Penblewin roundabout that marks the western limit of the proposed improvement. Preliminary visual analysis suggests that the proposed improvement would theoretically be visible from the Daugleddau area of the National Park at Slebech, more than 7 km due west. Long distant views would also theoretically be visible from the Mynydd Preseli area of the National Park, more than 12 km due north.

10.4.3 The Milford Haven Waterway Landscape of Historic Interest overlaps the Daugleddau area of the Pembrokeshire Coast National Park. Long distant views would theoretically available from Slebech, more than 7 km due west of Penblewin. The Preseli Landscape of Historic Interest overlaps the Mynydd Preseli area of the Pembrokeshire Coast National Park. Long distant views would theoretically be available to from the villages of Maenclochog, Llandilo, and Efailwen more than 8 km north of the proposed improvement.

10.4.4 At just over 2 km south of the mainline, Blackaldern is the nearest Park and Garden of Special Historic Interest to the proposed improvement. It is predicted that intervening hills to the east of Narberth would interrupt visibility. At approximately 10 km due west, long distant views are theoretically available to the Belvedere at Picton Castle Park and Garden of Special Historic Interest, although views within this designed landscape are directed south-eastward by woodland and overlook the Eastern Cleddau valley.

Landscape Context

10.4.5 Countryside Council for Wales produced a regional character map for Wales in 2006. The proposed improvement and the majority of the study area is located within Landscape Character Area 44: Taf and Cleddau Vales. This is predominantly an area of undulating farmland made up of lowland escarpments, hills and river valleys. The Preseli Hills are about 12 km due north of the A40 and the shore of Carmarthen Bay is about 10 km due south.

10.4.6 The A40 crosses the Cleddau Ddu at Canaston Bridge then gradually climbs the Landdewi Velfrey escarpment as it travels eastward. From Robeston Wathen through the village of Llanddewi Velfrey the road follows the ridge line. From the outskirts of the village the A40 begins its descent towards the valley floor crossing Afon Marlais at Pont Fadog and then crossing Afon Taf at Pont Loerig on the western outskirts of Whitland. Extensive views northward of the Preseli Hills and the broad ridge that separates the Eastern Cleddau and the Afon Taf rivers are available from the Llanddewi Velfrey escarpment where gaps in vegetation allow. Distant views southward from the road are restricted by higher ground.

10.4.7 Settlements tend to be clustered where main roads and railways meet. Narberth and Whitland are the largest settlements located within the study area. Clunderwen, Llanddewi Velfrey, Llandissilio, Llanfallteg and Templeton are amongst the main villages. Settlement of the land in between the main transport routes consists of a dispersed hamlets, farms and rural dwellings served by a network of minor roads.

10.4.8 Landcover is a mosaic of predominantly pasture with patches of arable land, woodland and the settlements. Field boundaries tend to be a mixture of traditional Pembrokeshire hedge banks, managed hedges and hedgerows with trees. Managed field boundaries give the area an open aspect that enable views of the uplands to the north and the rolling farmland to the south. Where hedgerows have been allowed to grow, views are restricted to a smaller area.

Landscape Receptors

10.4.9 Sensitive landscape receptors will be identified following guidance within IAN 135/10 (W) and GLVIA3. To begin with a review of the landscape resource within the study will be carried out, using the relevant guidance. The LVIA will utilise the LANDMAP spatial datasets.

10.4.10 The susceptibility of the landscape to accept change is assessed on its vulnerability to degradation through the introduction of new and/or loss of existing elements as a result of the proposed improvement. The ability of a landscape to accommodate change depends on the physical nature of the areas affected and their vulnerability, not necessarily the quality of the landscape. For example, a high-quality landscape with an interesting varied landform and dense woodland cover would have a higher capacity to accommodate changes than a flat open landscape. The adverse effects

10.4.11 LANDMAP Aspect Areas are assessed using the evaluation data to determine their sensitivity to potential effects. Those Aspect Areas that are directly affected by the development, usually containing wholly or partly the development area or lying next to the development area are those most likely to suffer significant change.

10.4.12 Site based assessment will be carried out to consider the local character and quality of the elements or components that make up the landscape. A judgement of landscape value will be made that also takes into consideration designations of ecological and archaeological significance.

10.4.13 Judgements of the relationship between the susceptibility to change attached to landscape receptors and their value are used to determine the landscape sensitivity. IAN 135/10 (W) suggests three categories of ‘high’, ‘medium’ and ‘low’ to describe the sensitivity of the landscape. The landscape character units defined as ‘high’ are considered particularly vulnerable to change and those categorised as ‘low’ are considered able to accept change of the type proposed.

Visual Receptors

10.4.14 People that may experience a change in view, the places where views are experienced, and the activity of the visual receptors inform the visual assessment. Representative viewpoints will be identified within the study area for receptor groups and noteworthy viewpoints.

10.4.15 Sensitive visual receptors will be identified following guidance within IAN 135/10 (W) and GLVIA3. Sensitive visual receptors are likely to be individual and groups of dwellings, users of public rights of way or visiting popular visitor attractions. IAN 135/10 (W) suggests three categories of ‘high’, ‘medium’ and ‘low’ to describe the sensitivity of visual receptors.

Viewpoints

10.4.16 The Scheme would cause changes to the landscape and so a number of viewpoints will be considered in the assessment. Due to the topography and the distribution of hedges and woodland, views of the Scheme would not be extensive. The following viewpoints are being considered for inclusion:

Viewpoint	Location and description
1	View from south of Bounty Farm looking south.
2	View from south of Pen-Caermenau looking southeast
3	View from public road 300m north of Caerau Gaer Scheduled Ancient Monument looking north
4	View from public road 500m east of View 3, looking north
5	View from Llanfallteg Road approximately 500m north of Pentroydin-fawr.
6	View north on Llanfallteg Road from northern extent of Llanddewi Velfrey.
7	View north and east from near to Blaen-pen-troydin.
8	View south west from public footpath north of Blaen-pen-troydin.
9	View north from A40 at Cross Cottage.
10	View southwest from public footpath near Tir Bach.
11	View north west from south of the A40 near Upper Fron.

10.5 Proposed Scope of Baseline Studies

10.5.1 The proposed improvement could have significant adverse landscape and visual impacts and would require detailed assessment.

Landscape Effects

10.5.2 In accordance with Annex 1 of IAN 135/10 (W), the study area for the assessment of landscape effects would cover the proposed improvement site and the wider landscape context within which the proposed improvement might influence landscape character.

10.5.3 The baseline study will include a combination of desk work based on LANDMAP and field survey. Landscape character classification will involve the sorting of the landscape into areas of consistent and recognisable character. A brief summary of the LANDMAP aspect areas affected by the development are included below:

Visual and Sensory	One aspect area directly affected has been evaluated as being of moderate character and scenic quality, attractive yet typical of rural Pembrokeshire. The north-facing slopes extend the visual influence of transport corridor to the Eastern Cleddau and Afon Taf river valleys, which were evaluated as having high character and scenic qualities.
Cultural Landscape	Aspect areas directly affected were assessed as high quality despite low and moderate evaluation of rarity and sensitivity. The proposed improvement could have a visual influence on distant areas that were evaluated as outstanding quality.
Historic Landscape	One aspect area directly affected has been assessed as being of high quality due to the diversity of archaeological remains and built heritage. The proposed improvement could have a visual influence on distant areas that have been evaluated as outstanding and high quality.
Geological Landscape	One aspect area directly affected has been assessed as being of high quality. The area includes rock formations considered to be of national importance.
Landscape Habitats	Aspect areas directly affected have been evaluated as being of moderate quality.

10.5.4 Existing vegetation that would be directly affected the proposed improvement works would be surveyed using a review of aerial photography and field surveys.

10.5.5 A photographic record of elements that represent character areas will be included.

Visual Effects

10.5.6 In accordance with Annex 2 of IAN 135/10 (W), the study area of the assessment of visual effects will extend to the whole area from which the proposed improvement could be visible.

10.5.7 A Zone of Theoretical Visibility (ZTV) will be produced to show the indicative extent of the surrounding area from which views of the proposed improvement would be available. The ZTV will be based on a digital terrain model that does not take into account the screening effects of surface features such as buildings and substantial vegetation. Site surveys will test the ZTV and the assess screening effect of surface features.

Study Area

10.5.8 The study area for the baseline landscape character assessment will include the extents of the proposed improvement and the wider area. A limit to views is proposed as 5 km from the centre-line of the proposed improvement. It is accepted that long distant views may be available to designated landscapes beyond 5 km and it is proposed that an assessment is made from any promoted or important viewpoints in outlying areas.

10.6 Assessment of Effects

Scope of Proposed Assessment

10.6.1 IAN 135/10 (W) contains a range of criteria for the assessment of magnitude of change, sensitivity of receptor and significance of effect for landscape and visual effects. These will be used in the assessment.

10.6.2 Direct landscape effects associated with the proposed improvement are likely to include physical change to the landform and surface features, fragmentation of land parcels and communities and the introduction of moving traffic into rural areas. Indirect landscape effects are likely to include the influence of road traffic on the tranquillity of surrounding areas.

10.6.3 Direct visual effects associated with the proposed improvement are likely to include changes in view and their composition for viewers. Indirect visual effects are likely to include changes to the way people use places.

10.6.4 Landscape and visual effects will be assessed for the construction phase of the proposed improvement, and will include the following:

a) Site clearance and disruption of field boundaries and vegetation;

b) Earthworks construction of embankments and/or excavation of cuttings;

c) Construction of ancillary elements such as flood water attenuation areas;

d) Movement of construction and haulage vehicles;

e) Location of site compounds and welfare units and;

f) Prominent lighting of night-time working.

10.6.5 Assessments will be made of the Year 1 effects in winter before any mitigation planting has become established, and will include the following:

a) View of embankments, cuttings and roadside verges;

b) Traffic, road surface and structures;

c) Signage, including safety barriers and;

d) Night time effect of vehicle headlights, new road lighting and sign lighting.

10.6.6 Year 15 effects in summer after mitigation planting has matured enough to satisfy its design function will include the following:

a) Enduring views of signage and structures and;

b) Residual lighting impacts.

10.7 Assessment of Potential Effects

Landscape

10.7.1 The assessment will consider construction and operational effect on each landscape character area identified during the baseline study. In accordance with Annex 1 of IAN 135/10 (W), the magnitude and nature of impact will be estimated as one of five levels of severity; major, moderate, minor, negligible (which could be adverse or beneficial), and no change.

10.7.2 The output of the landscape character assessment will determine the landscape sensitivity. It will depend on the value of the receiving landscape and its ability to accept the proposed road improvement. The landscape sensitivity will be assessed as one of three levels; high, medium or low.

10.7.3 The significance of effect will be determined by considering together the magnitude of impact and the landscape sensitivity. The result would range from neutral to very large (which could be detrimental or beneficial).

10.7.4 Potential significant effects on landscape receptors could be the rolling farmland to the north of Llanddewi Velfrey.

Visual Impact

10.7.5 The assessment will include consideration of construction and operational effects on views from different receptor groups that include residential properties, community facilities, commercial properties, public rights of way and selected viewpoints.

10.7.6 In accordance with Annex 2 of IAN 135/10 (W), the assessment will consider the short/medium term effect during the winter of Year 1, and the medium/long term effect during summer of Year 15. The magnitude and nature of impact will be estimated as one of five levels of severity; major, moderate, minor, negligible (which could be adverse or beneficial), and no change.

10.7.7 The magnitude of impact would then be considered together with the sensitivity and activity of the visual receptors and a subsequent category of significance of effect would then be established, ranging from neutral to very large (again could be adverse or beneficial).

10.8 Potential impacts

10.8.1 The Scheme is expected to have an impact on the landform of the Llanddewi Velfrey ridge with an effect on the landscape and views to the north. Landform with generally separate receptors in the main settlement from the road so that views would pass over the top of the earthworks and traffic. Views to the road and its traffic from the north would generally be distant, although a few receptors such as isolated farmhouses and public rights of way would provide closer views of the road. However, the wide long views to the north from the road could potentially provide added interest for the traveller. The western section of the Scheme would be at grade, or close to existing ground level and views in and out for most receptors would be limited by intervening landform and vegetation.

10.9 Proposed mitigation

10.9.1 A scheme of mitigation would include modification of the earthworks to integrate the engineering with the adjacent landform. Hedge and mass tree planting would be used to link the road with adjacent landscape features and where possible the visible extent of permanent land take would be minimised. Trees and landform would also be used to provide visual screening. All features of environmental mitigation and enhancement, such as noise, drainage or ecological measures, will be designed to form a cohesive and integrated whole to be shown in the Environmental Masterplan.

11 Archaeology and Cultural Heritage

11.1 Introduction

11.1.1 This section of the Scoping Report describes the scope of the archaeology and heritage assessment. References to national and local planning policies to be considered are included as well as the approach to the assessment of likely significant effects of the preferred route and approaches to mitigation. Archaeology and cultural heritage is the evidence relating to earlier and existing cultures that may be found within the perimeter of a project. DMRB defined three subject areas as follows:

Archaeological Remains are materials created or modified by past human activities that contribute to the study and understanding of past human societies and behaviour.

Historic Buildings are architectural or designed or other structures with a significant historical value.

Historic Landscapes are defined by perceptions that emphasise the evidence of the past and its significance in shaping the present landscape.

11.1.2 Cultural heritage encompasses all these and other linguistic and cultural practises valued by contemporary society.

11.2 Legislative and planning policy context

11.2.1 The requirements for an Design and Build project are set out in DMRB Vol 11 Sec 3 Part2. This implies that the Design Organisation, will report to and confirm with Transport Wales and Cadw on the scope of assessment proposed.

11.2.2 The Design Organisation, will be responsible for agreeing the Scheme Design, assessment reports, archaeological designs and mitigation measures with Transport Wales and Cadw. The Design Organisation will also consult with the regional archaeological trust and obtain up to date information from its site and monuments record. The organisation in this case is the Dyfed Archaeological Trust which maintains the Heritage Environment Record (HER).

11.2.3 National legislation and guidance that is relevant to the cultural heritage for this area comprises:

Ancient Monuments and Archaeological Areas Act 1979 (Ref 10.2);

Planning (Listed Buildings and Conservation Areas) Act 1990 (Ref 10.3);

Planning Policy Wales edition 3 (July 2010) (Ref 10.4);

Historic Environment (Wales) Act 2016;

Settings of Historic Assets in Wales, Cadw May 2017;

Conservation Principles for the Sustainable Management of the Historic Environment in Wales, Cadw 2011;

Welsh Office Circular 1/98: Planning and the historic environment directions by the Secretary of State for Wales (Ref 10.5);

Welsh Office Circular 60/96: Planning and historic environment – archaeology (Ref 10.6);

Welsh Office Circular 61/96: Planning and historic environment: historic buildings and conservation areas (Ref 10.7);

Chartered Institute for Archaeologists 'Standards and guidance for historic environment desk-based assessment' (2017) (Ref 10.8).

11.2.4 The Pembrokeshire Local Planning Development Plan, adopted February 2013, contains the following proposed policy relevant to the historic environment:

GN.38 Protection and Enhancement of the Historic Environment: development that affects sites and landscapes of architectural and/or historical merit or archaeological importance, or their setting, will only be permitted where it can be demonstrated that it would protect or enhance their character and integrity.

11.3 Consultations

11.3.1 There will be consultations with interested parties including Cadw and the Dyfed Archaeological Trust Planning Service. Cadw are sending a representative to the ELG meetings, but there has been no previous contact with Cadw regarding this project. Following an evaluation of the setting of heritage sites consultations will be undertaken with all relevant statutory consultees, including the Welsh Historic Gardens Trust, where sites and the settings are affected.

11.4 Surveys undertaken to date and additional surveys required

11.4.1 No surveys were undertaken for the project to date. Some data has been collected from publicly available sources to assist with initial route design in previous studies by others on behalf of Welsh Government. All information on sites on the route is the result of previous general data collection.

11.4.2 A desk based assessment and detailed surveys are required as part of the provisions of the contract and to meet standard requirements.

11.5 Assessment Methodology

11.5.1 Tasks to be undertaken will include the following:

a) Acquire Historic Environment Records information for 500m study area and designated sites within 5km radius;
b) Undertake reviews of recorded assets and examine published local history and other sources, including published documentary, cartographic (Tithe Map and historic Ordnance Survey maps) and air photographic (Google Earth and National Monument Records air photographs) data;
c) Examine available Lidar surveys of the area and undertake geophysical survey of the project area;
d) Prepare summary archaeology and landscape development description, incorporating data from a combination of the various surveys using GIS;
e) Undertake predictive analysis on archaeological data;
f) Identify direct and indirect impacts and develop a mitigation strategy in line with DRMB Vol 11 Sec 6 Part 1.

11.5.2 The assessment will be presented as a chapter for inclusion in the ES. All work will be prepared in accordance with Chartered Institute of Field Archaeologists Standard and Guidance for Historic Environment Desk-Based Assessment, January 2017 and DMRB Vol 11 Section 3 Part 2.

11.5.3 The subject matter will be broken down in four main areas. These will be identified and considered separately insofar as they are directly overlapping, but may require different mitigation techniques:

a) Archaeological remains;
b) Historic buildings;
c) Historic landscapes; and
d) Cultural heritage.

11.6 Study Area

11.6.1 Information on all designated sites within 5Km of the project limits will be collected and used for background information and any potential impact. Undesignated sites within 500m of the project will be collected and assessed for impact.

11.7 Baseline Context

11.7.1 Information obtained to date, indicates that there are a range of heritage sites along the project corridor. Further sites can be expected to be identified in the greenfield sections of the project, while other sites are known near to the online sections.

11.7.2 The archaeological and cultural heritage assets contained within the area covered by the route option is varied. Most sites are from the last two hundred years, with a range of sites in the area stretching back through the medieval to the Prehistoric period. A Gazetteer of cultural heritage features, drawn from the databases noted in 10.6, is presented in Table 8.

Neolithic (4000 BC to 2200 BC)

11.7.3 Although Mesolithic and probably earlier, people had used this area, it is not until the Neolithic that evidence of man is known. This is limited to a couple of isolated findspots and the Llan burial chamber in Lampeter Velfrey. In the study area, there must be further Neolithic sites, but they have yet to be identified.

Bronze Age (2500 BC to 700 BC)

11.7.4 Evidence of Bronze Age use of the area is shown by large numbers of round barrows the area. These are often found in concentrations such as at Redstone in the west of the area. These represent a belief in the afterlife shown by the burials within them. Bronze Age society was relatively mobile; burial sites being a fixed point the landscape, located on relatively high points. Five groups of such sites been Designated as Scheduled Ancient Monuments.

11.7.5 Evidence of domestic use of the area is shown by the frequent discovery of burnt mounds. These are collections of burnt fire shattered stone in a matrix of charcoal rich soil. They are typically found in close association with springs or small watercourses. Radiocarbon dating normally shows them to be of Bronze Age date, although some are earlier and they can be as late as the Post-Roman era. On excavation, these features are usually associated with a small water-filled trough. Experimental archaeology shows that water in these troughs can be brought to boiling point by throwing stones into the trough. This can then be used for cooking or possibly, some form of sauna. These sites are very common Wales, Ireland and Scotland. All the features in the study area were found by a single Ordnance Survey surveyor T.C. Cantrill who identified many in the region during his fieldwork in the early 20th century. It is likely that many more of these insignificant sites await discovery in the area, as shown by over 50 such sites found in the recent pipeline across South Wales.

Iron Age (800 BC to AD 43)

11.7.6 This period is characterised by a more settled economy featuring defended enclosures. These often contained houses enclosed by defensive bank and ditch. Some were formed by cutting off ridges with an earth bank to create a promontory fort. There are several of these in the western study area using the ridges along the meanders of the East Cleddau River Valley. The economy of these people is thought to be based on herds of cattle and sheep which required protection. There are many other similar enclosures known only from cropmarks in the area. Although these sites originate in the Iron Age, many continue to be used through the Roman period and it is likely that some continued even into the post Roman period.

Roman (AD 43 to AD 410)

11.7.7 The most obvious evidence of Roman activity in the study area is the line of the road running west from Whitland along the north of the study area. This was well constructed with evidence of two periods of construction. It can be traced towards the Roman fort at Wiston, just outside study area. Though the road is likely to have had its origins in the military period, it indicates strong interest in West Wales. No other sites of Roman date were identified, although activity has been recorded in some of the Iron Age sites adjacent to the study area. This is typical and is probably repeated in similar sites in the study area.

Early Medieval (AD 410 to AD 1066)

11.7.8 The adoption of Christianity during the Roman period can be seen in the discovery of inscribed crosses in several locations dating to the early medieval. Domestic settlement probably continued or re-established itself in the defended enclosures, although new centres of settlement probably began, possibly in the locations used by later farms and, consequently, are difficult to identify.

Medieval (1066 to 1540)

11.7.9 Llanddewi Velfrey, Lampeter Velfrey and Crinow were part of the commote of Efelffre, a pre-Norman territorial unit, which was the origin of the suffix Velfrey.

11.7.10 The medieval period is characterised by castles and churches with associated settlement that signified a settled landscape with a developed farming system. To the east was the Whitland Abbey, which is most associated with being the place where Hywel Dda drew up his laws around 940. It functioned as a Cistercian monastery between the 12th and 16th centuries.

11.7.11 The period saw the early development of market towns such as Narberth, and some of the larger villages began to develop such as Lampeter Velfrey, Clunderwen and Llandissilio. The villages were set in a landscape of long rectangular fields, parts of which can be seen in the present-day landscape.

Post-medieval (1540-1901)

11.7.12 The strong social and cultural division of West Wales, the Landsker line, probably was at its strongest in this period. Though it originates from the settlement of Flemings in South Pembrokeshire in the 12th century, the clearest evidence for the linguistic provision comes from names, records and civil transactions of the later period. The study area lies north of the Landsker division and firmly in the Welsh speaking area, as shown by inscriptions on gravestones in the two main chapels, Bethel and Ffynnon, close to the proposed road alignment.

11.7.13 Communications were prominent in this period. The line of the A40 was adopted as a turnpike between Whitland and Penblewin operated by the Whitland Trust. A later development was railway line from Carmarthen to Haverfordwest erected in 1854 along the north of the study area. Whitland was the junction for lines to Pembroke Dock, Tenby, Fishguard and Cardigan. The station became a marshalling yard and was a focal point in the transport of agricultural products to industrial areas. The construction of a milk processing factory gave a huge impetus to the development of the town. This was in contrast the town of Narberth, isolated from both the A40 and the railway leading to a slower growth.

11.7.14 The village of Llanddewi Velfrey appears to have its origins close to the Church of St Davids. During the Victorian period, it moved more toward the line of the present day A40 as shown by historic maps. This resulted in the development of a strip settlement along the A40.

Summary of Heritage Assets

11.7.15 Table 8 lists the individual known cultural heritage features that could potentially be affected.

Table 8 Gazetteer of Heritage Sites

Easting	Northing	Name	Status	Ref
207038	218281	Camp 200m NE of Stoneyford Promontory Fort	SAM	PE105
207122	218453	Camp 370m NE of Stoneyford Enclosure	SAM	PE104
207258	217422	Llawhaden Village Pound	LBII	18796
207292	217452	Llawhaden Castle	SAM	PE024
207303	217465	Llawhaden Castle	LBII*	6065
207348	218189	Camp 400m NW of Holgan Promontory Fort	SAM	PE102
207463	217254	Llawhaden Bridge	SAM	PE023
207473	217251	Llawhaden Bridge and River Bank Wall	LBII*	6064
207520	217468	Church of St. Aidan	LBII	6062
207633	215536	Bush Inn Camp Promontory Fort	SAM	PE182
207933	219716	Gelly Earthwork Rath	SAM	PE184
208085	213257	Mounton Chapel	LBII	6082
208363	219511	Gelli Bridge	LBII	18799
208369	219516	Gelli Bridge (partly in Llawhaden community)	LBII	83174
208438	215925	Rock Well	LBII	18801
208450	215746	Robeston Wathen Church	LBII	6092
208510	215776	Robeston House	LBII	18800
208547	219674	Longridge Bridge (Partly in New Moat Community)	LBII	82469
208572	219733	Cleddau Railway Bridge (partly in New Moat Community)	LBII	82464
208739	212966	Molleston Camp Enclosure	SAM	PE274
208859	217683	Pen Llwyn House	LBII	6071
208863	214093	Iron Age Hillslope Enclosure in Canaston Wood	SAM	PE413
209081	217912	Bethesda Congregational Chapel	LBII	18797
209310	220316	Dovecote at Llandre-Egremont	LBII	82465
209325	220323	Llandre-Egremont Farmhouse	LBII	9398
209353	212945	The Grove	LBII	18978

Easting	Northing	Name	Status	Ref
209383	216824	Pont Shan	LBII	6537
209383	216827	Pont Shan	LBII	18798
209425	217114	Vaynor Gaer Ringwork	SAM	PE115
209458	220291	Llandre Entrenchment Enclosure	SAM	CM089
209702	212387	Great Molleston Farmhouse	LBII	18977
209805	217513	Vaynor	LBII*	6072
209994	215130	Milestone	LBII	6533
210209	216556	Sodstone Manor	LBII	6540
210293	216347	Coach House & Stables Sodstone House	LBII	6539
210297	216314	Sodstone House	LBII	6538
210836	214467	Plas Farmhouse	LBII	6476
210839	214428	Parish Church of St Andrew	LBII	6475
210861	214668	Bethesda Baptist Chapel	LBII	6485
210883	214816	Hill House (Chestnut Tree Lodge)	LBII	6500
210891	215047	No.21 Northfield Road	LBII	6505
210894	214813	The Emporium	LBII	6501
210895	214678	Gates to Bethesda Chapel	LBII	6486
210900	214643	National Westminster Bank	LBII	6484
210900	214784	No.3 High Street	LBII	6479
210901	214790	No.2 High Street	LBII	6478
210901	215062	Bloomfield Terrace	LBII	6503
210903	214635	Howell Williams Solicitor, County of Pembroke Sherriff's Office	LBII	6483
210904	214797	The Coach & Horses Inn	LBII	6477
210906	214627	Pencraig	LBII	6482
210907	215069	Bloomfield Terrace	LBII	6504
210912	214797	Animal Kitchen	LBII	6516
210926	214622	Town Hall	LBII	6481
210932	214643	The Golden Sheaf	LBII	6480
210945	214427	Milestone by entrance to New Cemetery	LBII	6474
210949	214590	Anthony Maxwell – Photographer	LBII	6494
210953	214585	Anthony Maxwell – Photographer	LBII	6493
210959	214573	No.14 Market Square	LBII	6492
210966	214616	Hugh H Morgan	LBII	6487
210972	214596	War Memorial	LBII	6495
210972	216010	Blaen Marlais	LBII	6508
210974	214546	The Former Courthouse	LBII	6558

Easting	Northing	Name	Status	Ref
210975	214582	Telephone Call-box by War Memorial	LBII	6496
210975	214586	Lamp Standard by War Memorial	LBII	6497
210978	214392	Narbeth Castle	LBII	6473
210981	214522	No.12 Market Square	LBII	6498
210982	214617	Megna Indian Takeaway	LBII	6488
210985	214394	Narberth Castle	SAM	PE040
210988	214620	The Old Pharmacy	LBII	87564
210997	214585	Whispers	LBII	6490
210997	214606	Pillar Box	LBII	6489
211000	215998	Barn in Grounds of Blaen Marlais	LBII	6509
211001	215080	Bloomfield	LBII	6502
211002	214645	Barclay's Bank	LBII	6510
211005	214511	The Rutzen Arms P.H.	LBII	6499
211006	214584	Olieme House	LBII	6491
211015	216416	Redstone Cross Round Barrows	SAM	PE154
211032	214651	Old Bank House	LBII	6511
211036	214634	G.Badham & Sons	LBII	6515
211040	214658	Staunton House	LBII	6512
211052	214632	Llwynon	LBII	6513
211057	216939	Cowhouse at Cilrath Fach	LBII	6529
211059	214634	Annexe adjoining No.61 (Llwynon)	LBII	6514
211076	216950	Lofted Cowhouse at Cilrath Fach	LBII	6530
211080	214630	Tabernacle United Reformed Church	LBII	6522
211083	214611	Schoolroom to Tabernacle United Reformed Church	LBII	6523
211090	216922	Cilrath Fach	LBII	6528
211091	216959	Stable at Cilrath Fach	LBII	6531
211095	216945	Barn at Cilrath Fach	LBII	6532
211145	215914	Stable attached to Blaen Ffynnonau	LBII	6507
211145	215923	Blaen Ffynnonau	LBII	6506
211202	213321	Allensbank	LBII	18974
211211	217923	Grondre House	LBII	82467
211334	213034	Narberth Mountain Enclosure	SAM	PE394
211454	213274	Milestone on Lane leading off A478 to Cold Blow	LBII	6527
211639	214670	Byre at Greenway Farm	LBII	6520
211640	214662	Outhouse at Greenway Farm	LBII	6521
211653	214649	Stable adjoining Greenway Farm	LBII	6519

Easting	Northing	Name	Status	Ref
211653	214653	Cartshed adjoining Greenway Farm	LBII	6518
211656	214662	Greenway Farm	LBII	6517
211933	214206	Coach House at Blackaldern	LBII	6525
211953	214528	Milestone	LBII	6536
211961	214204	Blackaldern	LBII	6524
212107	214395	Parish Boundary Stone	LBII	6526
212130	217010	Cae'r Maenau Fawr House		NMR 21700
212135	221577	Llandissilio War Memorial	LBII	82947
212184	220784	Cottage by Nant-y-Ffin Hotel	LBII	82946
212277	220593	Crugiau Round Barrows	SAM	CM309
212322	218940	Earthworks SE of Clyn-Derwen Enclosure	SAM	CM065
212755	214375	Parish Church of St Teilo	LBII	6535
212830	216320	Settlement, Henllan		NMR 309064
212833	214178	Clyn Pattel Motte & Bailey Motte	SAM	PE412
212854	214359	Parc Glas	LBII	6534
212908	214039	Crinow and Lampeter Velfrey Parish Boundary Stone	LBII	18998
213270	216820	Henllan Lodge		NMR 302516
213280	216290	Henllan House		NMR 22048
213306	216339	Henllan, Garden		NMR 265865
213405	215294	Llangwathan Castle Mound Motte	SAM	PE434
213648	216898	Ffynnon Baptist Chapel	LBII	6056
213650	216320	Henllan Enclosure		NMR 402252
213985	216102	Caerau Gaer Rath	SAM	PE176
214019	220519	Eithin-man	LBII	82466
214155	212548	Milepost at Gelli-deg	LBII	18991
214392	215870	St David's Parish Church	LBII	18982
214392	215870	St. David's Parish Church	LBII	18982
214449	216075	Llanddewi Gaer Promontory Fort	SAM	PE086
214661	218513	Barn at Glanrhyd	LBII	9731
214686	218439	Offices & Outbuildings to W of Glanrhyd House (also known as The Court House)	LBII	9730
214688	218533	Glanrhyd Farm	LBII	15630
214714	214048	Llan Burial Chamber Chambered tomb	SAM	PE026
214717	218447	Water house at rear of Glanrhyd House	LBII	82473
214721	218439	Glanrhyd House	LBII	9729
214766	216897	War Memorial	LBII	18983
215164	212357	Blaengwaith-Noah Camp Promontory Fort	SAM	PE085

Easting	Northing	Name	Status	Ref
215178	219469	Llanfallteg Bridge	LBII	82348
215471	214402	Telephone Call-box to SE of St Peter's Church	LBII	87566
215496	214612	Castell Ringwork	SAM	PE177
215501	214412	War Memorial	LBII	18989
215523	214439	Church of St Peter	LBII	6055
215539	218280	Roman Road 300m East of Bryn Farm Road	SAM	PE472
215577	212127	Milepost at Glan Rhyd	LBII	18990
215709	216121	Panteg farmhouse	LBII*	6547
215930	216980	Bethel Welsh Independent Chapel		NMR 11066
216252	217009	Old Stable Block at Gwindy	LBII	6542
216287	217020	Gwindy Farmhouse with walls and railings to garden	LBII	6541
216290	217020	Gwyndy House		NMR 22025
216635	214687	Derry Cottage	LBII	18999
216843	220428	Lan	LBII	82347
217018	216417	Waundwrgi Farmhouse	LBII	18985
217104	212372	Milepost near Lower Llantydwell	LBII	18988
217179	216929	Fron	LBII	18984
217199	217201	Pengawse Ring Cairn	SAM	PE390
217394	217762	Trewern Mansion	LBII	6546
217461	214105	Carvan Congregational Chapel	LBII	18997
217658	216889	Pengawse Medieval House Site Manor	SAM	PE389
217708	218747	St Canna's Chair Inscribed stone	SAM	PE148
217709	212314	Crug Swllt Round Barrow	SAM	PE364
217733	218714	Llangan Church Cropmark Enclosure	SAM	CM264
217769	219863	Inscribed Stone N of Parciau Farmhouse	SAM	CM069
217848	216352	Llan-Marlais Round Barrow	SAM	PE327
218185	212645	Cyffic and Lampeter Velfrey Parish Boundary Stone	LBII	18986
218186	212648	Milepost in Tavernspite village	LBII	18987
218720	218200	Blaen-lliwe, Cropmark Enclosure South Of		NMR 309346
219849	215033	Llwynybrain Cottage	LBII	24953
220040	216170	Trevaughan Bridge	LBII	9416
220134	217283	Roman Road 250m NE of Pwll-y-Hwyaid Road	SAM	CM279

11.7.16 The potential effects on cultural and built heritage include physical impacts upon archaeological feature and historic landscape, visual impacts on the setting of archaeological features and on the setting of built heritage features, and historic landscape.

11.7.17 Sites that are located within 500m of the route are shown in Table 9. There are no direct impact impacts on any of these sites, although it is possible that noise and visual perception may be impacted in certain circumstance. It is known from the tender documents that other sites, in particular, two burnt mounds, are close to the route north of Llanddewi Velfrey. They are not included here as the Dyfed Archaeological Trust HER has not been consulted.

Table 9 Sites known within 500m of the route options

Name	Status	Source
Ffynnon Baptist Chapel	LBII	NMR 6056
Gwindy Farmhouse with walls and railings to garden	LBII	NMR 6541
Old Stable Block at Gwindy	LBII	NMR 6542
War Memorial	LBII	NMR 18983
Cae'r Maenau Fawr House	LBII	NMR 21700
Gwyndy House		NMR 22025
Henllan House		NMR 22048
Henllan, Garden		NMR 265865
Henllan Lodge		NMR 302516
Settlement, Henllan		NMR 309064
Henllan Enclosure		NMR 402252
Bethel Welsh Independent Chapel		NMR 11066

11.7.18 There is a high likelihood that intrusive works could uncover previously-unrecognised archaeological deposits. The potential for previously-unrecorded sites has not been quantified but is likely to be adverse.

11.7.19 Initial evaluation on the site is by geophysical assessment. Further evaluation works might be required, including evaluation trenching and full area assessment.

11.8 Potential Effects

11.8.1 Impacts identified include physical impact on heritage features, damage and indirect impacts on buried archaeological features, change in visual perception and noise in specific heritage locations.

11.8.2 The identified impacts on cultural heritage have not been definitively established and thus it is not possible to state with any certainty at this stage what impact would remain following detailed design and mitigation. Once a detailed design is produced for the proposed Scheme, the residual effects can be assessed in more detail.

Cumulative Impacts

11.8.3 The overall cumulative impact alongside other contemporary and future developments is likely to be adverse. At this stage, any magnitude of impact has not been quantified.

11.8.4 The study found that sites of cultural heritage value, primarily of built heritage assets dating from the 19th and 20th centuries, were distributed throughout the study area. Additional sites of earlier date were recorded. Further study is required to assess the full range of heritage sites within the study area.

12 Community and Private Assets (including Agricultural and land use)

12.1 Introduction

12.1.1 This topic will be addressed in two chapters so that there will be separation of assessments of agricultural land use from other land use and community assets.

12.1.2 Agricultural Land and Farm Businesses will be carried out in accordance with the methodology within the DMRB Volume 11, section 3, Part 6. As per the DMRB and national planning policy set out in Planning Policy WALES Edition 9, November 2016) the agricultural assessment will cover the loss of land and soil resources, the type of land management and farming practices currently operated and the potential impacts on these, and matters such as severance, disturbance and disruption. The agricultural assessment will be reported in a separate chapter.

12.1.3 The loss of land used by the community would be assessed in accordance with the methodology within the DMRB Volume 11, Section 3, Part 6, Chapter 4. However, it should be noted that previous studies have shown that no community land would be taken by the Scheme.

12.1.4 The effects on development land will be considered because there are allocations under the Pembrokeshire Local Plan for housing on the north side of the A40 in Llanddewi Velfrey.

12.2 Policy Context

National Planning Policy

12.2.1 Well Being of Future Generations Act which has the vision of community facilities that contribute to ‘A modern, fit for purpose, inclusive and sustainable infrastructure across Wales’. Under the Act it is proposed that there should be three levels of provision, with the overarching principles being the tackling of poverty and inequalities along with consideration of effective co-location of services appropriately applied to each level.

12.2.2 Public bodies, including Welsh Government, must work towards delivering all 7 well-being goals. The Resilient Wales goal of maintaining and enhancing a biodiverse natural environment with healthy functioning ecosystems must be given equal prominence within all well-being objectives laid out by Welsh Government and public bodies. Future land management policies must therefore deliver for this goal as much as any other goal. Sustainable land management is crucial to successful progress on Welsh Government indicators on the status of biodiversity and ecosystems and has a key role in helping gather the data to inform the measurements of progress.

12.2.3 Environment (Wales) Act 2016 also has relevance in achieving sustainable land management and biodiversity goals and to reducing carbon emissions by 2050.

12.2.4 National Planning Policy governing the non-agricultural development of agricultural land is set out in Planning Policy Wales (Edition 9, 2016). Paragraph 4.10.1 notes that:

> *"Land of Grades 1, 2 and 3a of the Department for Environment, Food and Rural Affairs (DEFRA) Agricultural Land Classification system (ALC) is the best and most versatile and should be conserved as a finite resource for the future. In development plan policies and development management decisions considerable weight should be given to protecting such land from development, because of its special importance. Land in Grades 1, 2 and 3a should only be developed if there is an over-riding need for the development, and either previously developed land or land in lower agricultural grades is unavailable, or available lower grade land has an environmental value recognised by a landscape, wildlife, historic or archaeological designation which outweighs the agricultural considerations. If land in grades 1, 2 and 3a does need to be developed, and there is a choice between sites of different grades, development should be directed to land of the lowest grade".*

12.2.5 Technical Advice Note (TAN) 6 "Planning for Sustainable Rural Communities" also advises at paragraph 6.2.1 that "when preparing development plans and considering planning applications, planning authorities should consider the quality of agricultural land and other agricultural factors." Section 6.2 advises on the "other" factors to consider when assessing the effects of development on agricultural land these include:

a) The effects on farm size and structure;

b) The effects on the efficient use of buildings, fixed equipment and capital investment; and

c) The effects on drainage, both surface water and land drainage systems.

Local Planning Policy

12.2.6 The Pembrokeshire Local Development Plan provides for the allocation of land for new housing and employment land. Under the Settlement Strategy Llanddewi Velfrey, is categorised as a Service Village, which includes allocations for housing (12 No.) and employment and to provide some services and facilities so as to sustain fragile rural settlement.

12.3 Consultations

12.3.1 Consultations will also be undertaken with all affected agricultural landowners / occupiers, with the local planning authority.

12.4 Surveys undertaken to date and additional surveys required

12.4.1 A detailed Agricultural Land Classification of some of the route options to the north of Llanddewi Velfry was undertaken in 2004 as part of the Stage 2 DMRB's Assessment Work. Interviews (face-to-face or by telephone) with affected farming occupiers will be undertaken as part of the Stage 3 work.

12.4.2 A survey of community facilities and land will be required.

12.5 Assessment Methodology

12.5.1 This section will identify and predict the likely effects of the proposed development on agricultural land quality and farm businesses.

12.5.2 The following baseline survey work will be undertaken in order to inform the assessment:

Community land and facilities: through contacts with the community all land and facilities will be identified.

Agricultural Land Quality: a review of the 2004 detailed ALC survey will be undertaken so that a calculation of land take per Grade can be calculated.

Agricultural Businesses: in order to identify the number of affected agricultural holdings we will undertake a review of Land Registry information provided by the client, with a review of relevant questionnaires provided by the client; and a review of Aerial Photography.

12.5.3 From this work, a detailed knowledge of land ownership interests affected by the proposed Scheme will be collated.

12.5.4 The main affected agricultural owners / occupiers will be visited and interviewed in order to collect information about their agricultural use of the land. Face-to-face interviews will be held with the occupiers of the most affected units. Where land-take is minimal or limited to field edges we will view the Site and undertake telephone interviews with the occupiers.

12.6 Study Area

12.6.1 The Study Area will include all land directly affected by the Scheme i.e. within the main route corridor along with any land within the same ownership / occupation as that directly affected.

12.7 Baseline Context

Community land and facilities

12.7.1 The route will pass land and facilities that are used by the community, and land allocated under the local plan for housing, although the potential effects are considered to be indirect.

Agricultural Land Quality

12.7.2 Based on information set out in the Stage 2 Assessment Work the route will cross land that is predominately of sub-Grade 3b quality i.e. land that is not “best and most versatile agricultural land”.

Farm Businesses

12.7.3 The proposed route alignment affects an area of predominately permanent pastureland which is grazed by livestock (beef, sheep and dairy) and utilised for fodder production.

12.8 Potential Effects

12.8.1 The process of EIA requires various thresholds to be set to determine the levels of significance of impact. There are no universally recognised definitions of what constitutes “significant”; this will differ according to the perspective of the stakeholder(s). However, for the purposes of this technical assessment, and to assist in its interpretation, common assessment criteria and terminology were developed for the analysis of predicted impacts.

12.8.2 The assessment criteria for impacts on agricultural soil resources and businesses as set out below were agreed previously with the Regional Planning Advisor from the Technical Services Department of the Welsh Government. The criteria are based on the formulaic approach proposed in the Revised DMRB guidance.

Receptors

12.8.3 Community facilities include the village hall and cricket ground in Llanddewi Velfrey, the filling station, shop and public house.

12.8.4 Agricultural land, in particular land of the best and most versatile quality (Grades 1, 2 and 3a) is recognised as being a finite resource of national importance. There are no defined thresholds for assessing the magnitude of the impact, so thresholds were agreed in consultation with the Welsh Government.

12.8.5 Therefore, in respect of effects on agricultural land, this is a resource of national importance and the thresholds reflect both the quantum and quality of the agricultural land affected.

12.8.6 Farm and land-based rural businesses, whether run by owner-occupiers, tenants, licensees or contractors, and whether affected directly or indirectly, are a key receptor. The assessment will consider the physical effects, including land loss, severance, the potential effects on the movement of livestock and machinery, field accesses, drainage and the use of farm buildings. It will also consider, taking a long-term view, the potential effects on the medium to long-term ability for the remaining holding to continue in a beneficial agricultural use.

12.8.7 The effect on occupying and neighbouring land-based businesses is a more transient impact to assess. Such businesses vary from year to year, and even from day to day, affected by many external influences such as management wishes and decisions, market prices, illnesses and diseases, the weather and monetary exchange rates.

12.8.8 Whilst the quality and quantity of agricultural land influences the farming and other land management practices operated over it, the effect on those businesses is assessed as being of local importance, due to their transient nature. That distinction is not intended to denigrate the important role of land managers in providing food for the nation and other opportunities and services.

Assessment Criteria for agricultural impacts

12.8.9 The assessment on land resources will be carried out in three stages. First the magnitude, secondly the importance / sensitivity of the receptor, and thirdly the significance of impact will be considered. These were determined against the criteria set out in Table 10 below.

Table 10 Magnitude of Impact Assessment Criteria for Agriculture

Impact Magnitude	**Definition**	
	Impact on Soils	**Impact on Local Agriculture**
Major	The proposed Scheme would directly lead to the loss of over 20 hectares of “best and most versatile agricultural land” (Grades 1/2/3a).	The impact of the proposed Scheme would render a full-time agricultural business non-viable.
Moderate	The proposed Scheme would directly lead to the loss of between 5 and 20 hectares of “best and most versatile agricultural land” (Grades 1/2/3a).	The impact of the proposed Scheme would require significant changes in the day to day management of a full-time agricultural business.
Minor	The proposed Scheme would directly lead to the loss of less than 5 hectares of “best and most versatile agricultural land” (Grades 1/2/3a) or the loss of any quantity of non “best and most versatile agricultural land” (Grades 3b/4/5).	Land take would require only minor changes in the day to day management / structure of a full-time agricultural business or land take would result in the loss or a significant impact on a part-time business.
Negligible	No direct impact upon agricultural land	Land take would require only negligible changes to an agricultural business

Table 11 Sensitivity of Receptors

Sensitivity	**Receptor**
High	Land resources are matters of potentially national importance, as identified in PP(W). The BMV agricultural land (Grades 1, 2 and 3a) is of national importance. The effect on land resources is a combination of the quantum and quality of agricultural land affected, relative to both the national resource and the relative availability of land of that quality locally. Land resources of BMV quality should therefore be classified as being of high environmental value (sensitivity).
Medium	Land that is of poorer quality, Grades 3b, 4 and 5, are of lower sensitivity and are afforded no special protection in PP(W). They are nevertheless a finite resource of local importance and so are regarded as of moderate sensitivity. Full-time farm businesses are of medium sensitivity, as the way that farms are operated will vary over time according to ownership, security of tenure and local and international economic factors. Farm businesses are tolerant of some change without detriment to their character.
Low	Part-time farm businesses are of low sensitivity. The way that farms are operated will vary over time according to ownership, security of tenure and local and international economic factors. Farm businesses are tolerant of some change without detriment to their character.

12.8.10 A combination of the magnitude and sensitivity will allow an assessment of the significance of the impact to be made as per Table 12 below.

Table 12 Significance of Impact Criteria

Magnitude	**Sensitivity**		
	High	**Medium**	**Low**
Major	Major Adverse / Beneficial	Moderate Adverse / Beneficial	Minor Adverse / Beneficial
Moderate	Moderate Adverse / Beneficial	Minor Adverse / Beneficial	Minor Adverse / Beneficial
Minor	Minor Adverse / Beneficial	Minor Adverse / Beneficial	Minor Adverse / Beneficial
Negligible	Negligible	Negligible	Negligible

13 Air Quality

13.1 Introduction

13.1.1 This section of the Scoping Report details the proposed scope of the assessment for local air quality and regional pollutant emissions, during both the construction and operational phases of the Scheme.

13.1.2 There is the potential for local air quality to be affected during the construction of the Scheme from exhaust emissions from construction vehicles and fugitive dust emissions from site activities.

13.1.3 Emissions from vehicle exhausts contain a number of pollutants, including oxides of nitrogen (NO_x), carbon monoxide (CO), hydrocarbons, carbon dioxide (CO_2) and particulate matter (PM). The quantities of each pollutant emitted depend on the type of vehicle, quantity and type of fuel used, engine size, speed of the vehicle and abatement equipment fitted. Once emitted, the pollutants are diluted and dispersed into the ambient air. Pollutant concentrations of nitrogen dioxide (NO_2) and PM in the air can be measured or modelled, and then compared with air quality standards. Local air quality would be affected as a result of the operation of the Scheme by redistributing vehicles across the network.

13.2 Policy Context

EU Limit Values

13.2.1 In May 2008, the Council Directive (2008/50/EC) on Ambient Air Quality and Cleaner Air for Europe came into force. The Directive sets ‘limit values’ and ‘target values’ for ambient concentrations of pollutants. The limit values defined in the Directive are legal requirements and compliance with these is reported on an annual basis by Welsh Ministers. The Directive also covers the division of the UK into zones for the purpose of compliance reporting. The Directive was transposed into national legislation in Wales by the Air Quality Standards (Wales) Regulations 2010 (WSI 2010 No. 1433).

13.2.2 The Scheme is located in the South Wales Zone (UK0041), which is covered by an Air Quality Plan published in 2015 by Defra. Draft revised Air Quality Plans for the UK were published in May 2017. Regional plans for each of the zones, including the South Wales Zone, have not been released at the time of writing however are due to be published in July 2017. The assessment undertaken as part of the EIA will consider policies and measures set out in these emerging plans. Consideration will be given to the EU limit values to determine the air quality effects of the Scheme in the South Wales Zone.

13.2.3 In addition to limit values to protect human health, the EU has set NOx limit values for the protection of vegetation. The annual mean limit value for NOx for the protection of vegetation is 30 µg/m3. The limit values for the protection of vegetation apply to locations more than 20 km from towns with more than 250,000 inhabitants or more than 5 km from other built-up areas, industrial installations or motorways. As stated in the EU Directive, monitoring sites need to be representative of an area of 1,000 square kilometres, the limit does not have a statutory basis in micro-scale environments such as those close to a road or other pollution source.

13.2.4 The United Nations Economic Commission for Europe (UNECE) and the World Health Organisation (WHO) have set a critical level for NOx (30µg/m3), for the protection of vegetation. Therefore, the statutory nature conservation agency's (Natural Resources Wales) policy is to apply the 30 µg/m3 criterion as a benchmark, on a precautionary basis, in internationally designated conservation sites and in Sites of Special Scientific Interest (SSSIs).

13.2.5 In addition, critical loads for nitrogen deposition have been set that represent (according to current knowledge) the exposure below which there should be no significant harmful effects on sensitive elements of the ecosystem.

UK Objectives

13.2.6 The National Air Quality Strategy (NAQS) was first published in 1997 and subsequently reviewed and revised in 2000, as the Air Quality Strategy for England, Scotland, Wales and Northern Ireland. The current strategy was published by Defra in 2007. This provides national objectives, which are not legally binding, for human health and the protection of vegetation for specified pollutants, including those of concern to the assessment of the Scheme.

13.2.7 Part IV of The Environment Act (1995) requires local authorities to undergo a process of Local Air Quality Management (LAQM), requiring review and assessment of air quality in each administrative area. The LAQM system assesses where the UK objectives are exceeded and requires local authorities to declare Air Quality Management Areas (AQMAs) and derive Air Quality Action Plans (AQAPs) to outline measures to improve air quality.

Air Quality Standards

13.2.8 The air quality EU and UK limit values applicable to the Scheme are shown in Table 13. Some pollutants have standards expressed as annual mean concentrations (long-term) due to the chronic way in which they affect health or the natural environment (i.e. effects occur after a prolonged period of exposure to elevated concentrations). Others have standards expressed as 24-hour, 1-hour or 15-minute mean concentrations (short-term) due to the acute way in which they affect health or the natural environment (i.e. after a relatively short period of exposure). Some pollutants have standards expressed in terms of both long-term and short-term concentrations.

Table 13 Air Quality Standards

Pollutant	**Averaging Period**	**Limit Value**	**Date for Compliance**
Human Health			
Nitrogen Dioxide (NO_2)	Annual mean	40µg/m^3	Wales(a) 11 June 2010
			EU(b) 01 Jan 2010
	1-hour mean	200µg/m^3	Wales(a) 11 June 2010
		not to be exceeded more than 18 times a year (99. 8th percentile)	EU(b) 01 Jan 2010
Fine Particulate Matter (PM_{10})	Annual mean	40µg/m^3	Wales(a) 11 June 2010
			EU(b) 01 Jan 2005
	24-hour mean	50µg/m^3	Wales(a) 11 June 2010
		not to be exceeded more than 35 times a year (90. 4th percentile)	EU(b) 01 Jan 2005
Designated Sites			
Nitrogen Oxide (NOx)(c)	Annual mean	30 µg/m^3	31 Dec 2000 Wales(a)
			19 July 2001 EU(b)

(a) The Air Quality Standards (Wales) Regulations 2010, WSI 2010 No. 1433

(b) Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

(c) For the protection of vegetation only

13.2.1 UK air quality regulations make clear that exceedances of the air quality limit values/objectives set for the protection of human health should be assessed at locations which are situated outside buildings and where members of the public are likely to be regularly present. LAQM TG (16) published by Defra states that the assessment should focus on locations at which members of the public are likely to be exposed for a period of time appropriate to the averaging period of the limit value/objective. For example, air quality limit values/objectives with an annual mean averaging period apply at the facades of residential properties, schools, hospitals, care homes etc. Hourly limit values/objectives may also apply where members of the public might reasonably be expected to spend one hour or more e.g. busy shopping streets and daily limit values/objectives would apply in the gardens of residential properties and hotels.

Well-being of Future Generations (Wales) Act 2015

13.2.2 The Act has a number of well-being goals to achieve through implementation of sustainable development. Changes in air quality can have an impact on the health of habitat and humans, as such the goals to create 'a resilient Wales' and 'a healthier Wales' are applicable.

Planning Policy Wales, Edition 9

13.2.3 Planning Policy Wales (Welsh Government, 2016) sets out land-use planning policies for Wales. One of the underlying aims is the protection of the environment, which includes air quality policies. Specific policies relating to air quality are provided by Planning Policy Wales as:

a) Policy 13.10 - Improving the Quality of Water and Air;

b) Policy 13.11 - Development Plans and Improving the Quality of Water and Air; and

c) Policy 13.12 - Development Management and Improving the Quality of Water and Air.

13.2.4 Air quality specific policies of Planning Policy Wales 13.10 and 13.12 include the following excerpts:

13.2.5 'The planning system should determine whether a development is an acceptable use of land and should control other development in proximity to potential sources of pollution rather than seeking to control the processes or substances used in any particular development.'

13.2.6 'The potential for pollution affecting the use of land will be a material consideration in deciding whether to grant planning permission. Material considerations in determining applications for potentially polluting development are likely to include:

a) Location, taking into account such considerations as the reasons for selecting the chosen site itself;

b) Impact on health and amenity;

c) The risk and impact of potential pollution from the development … particularly if the development would impact on an Air Quality Management Area (AQMA), an area which has been declared as exceeding the UK air quality objectives, or a Special Area of Conservation (SAC); and

d) Prevention of nuisance.'

13.2.7 Chapter 8 of Planning Policy Wales includes policies specifically related to transport, including the highway network, and it is noted that emissions from transport contribute significantly to climate change and air pollution, which can in turn affect human health. Planning Policy Wales promotes the need to integrate the strategies and policies for both transport and air quality.

Pembrokeshire County Council (PCC) Local Development Plan 2013-2021

13.2.8 Policies relevant to air quality include:

GN1: General Development Policy, Point 2 – developments will be permitted where they will not result in a significant detrimental impact on local air quality;

GN3: Infrastructure and New Development- provision must be made for mitigation of potential adverse impacts upon air quality.

Carmarthenshire County Council (CCC) Local Development Plan

13.2.9 Policies relevant to air quality include:

EP2: Pollution – New developments will be required to demonstrate that they do not conflict with National Air Quality Strategy objectives or adversely affect to a significant extent, designated AQMAs.

13.3 Relevant Guidance

13.3.1 The method for assessing the likely operational air quality effects of the Scheme will follow the guidance described in DMRB Volume 11, Section 3, Part 1: HA 207/07. In addition, the associated Interim Advice Notes will be considered:

IAN 170/12v3 Updated Air Quality Advice on the Assessment of Future NOx and NO2 Projections for Users of DMRB Volume 11, Section 3, Part 1 'Air Quality';

IAN 174/13 Updated Advice for Evaluating Significant Local Air Quality Effects for DMRB Volume 11, Section 3, Part 1 'Air Quality' (HA 207/07).

13.3.2 The IANs listed above have not yet been adopted in Wales, however, it is considered that these IANs reflect current best practice guidance and as there is no suitable Welsh equivalent guidance, these were used to inform the proposed method of assessment. It has been acknowledged that references to the National Planning Policy Framework (NPPF) set out in the above IANs are not relevant in the Welsh context.

13.3.3 It has been noted that Highways England have produced IAN 175/13 to assess compliance with the EU Directive. IAN175/13 has been withdrawn and is currently pending update. Therefore, no assessment has been undertaken following the IAN175/13 assessment methodology.

13.3.4 It should be noted that DMRB HA207/07 provides limited guidance regarding assessing air quality during construction. Therefore, industry standard guidance published by the Institute of Air Quality Management (IAQM) will be used to provide a more robust technical assessment.

Dust Guidance

13.3.5 Dust is the generic term used in the British Standard document BS 6069 (Part Two) to describe particulate matter in the size range 1–75 µm in diameter. Dust nuisance is the result of the perception of the soiling of surfaces by excessive rates of dust deposition. Under provisions of the Environmental Protection Act 1990, dust nuisance is defined as a statutory nuisance.

13.3.6 There are currently no formal standards or guidelines for what constitutes dust nuisance in the UK, nor are formal dust deposition standards specified. This reflects the uncertainties in dust monitoring technology and the highly subjective relationship between deposition events, surface soiling and the perception of such events as a nuisance. In law, complaints about excessive dust deposition would have to be investigated by the local planning authority and any complaint upheld for a statutory nuisance to occur. However, dust deposition is generally managed by suitable on-site practices and mitigation rather than by the determination of statutory nuisance and/or prosecution or enforcement notice(s).

13.3.7 The IAQM has published guidance on the assessment of dust from demolition and construction. This provides a risk-based qualitative approach for determining the potential for dust impacts during the construction phase of the Scheme.

13.4 Consultations (undertaken and proposed)

13.4.1 The following organisations will be contacted for consultation and agreement of the air quality assessment methodology. Pembrokeshire County Council and Carmarthenshire County Council provide public protection and environmental health services and will be consulted on the air quality assessment as part of the ELG. Natural Resources Wales will be consulted if Designated Sites are affected by the Scheme.

13.5 Surveys undertaken to date and additional surveys required

13.5.1 Air quality diffusion tube monitoring survey has been undertaken over six months in 2017 to determine ambient air quality at seven locations on the current and proposed routes for this Scheme. Due to seasonal variations in pollutant concentrations, the monitoring commenced in July and was complete by December 2017. There is limited monitoring information available from the local authority.

13.5.2 The results of the six month monitoring survey will be annualised, following the methodology set out in LAQM TG(16), to estimate annual mean concentrations at all monitored locations. Following annualisation, the monitored results will also be bias-adjusted, following the methodology set out in LAQM TG(16), to account for uncertainty associated with the passive diffusion tube monitoring method. To aid in deriving a bias-adjustment factor for the monitoring survey, one of the monitoring locations will be co-located with the automatic monitoring station in Narberth, which is operated by Pembrokeshire County Council.

13.6 Assessment Methodology

13.6.1 The proposed scope of assessment will include three main components. Firstly, an assessment of potential effects during construction, which can be broadly classified into two elements of exhaust emissions from construction vehicles and fugitive dust emissions from site activities. Secondly, a local air quality assessment (operational phase) for the affected road network. Thirdly, an assessment of regional pollutant emissions where required.

‘Scoping-Out’ of issues

13.6.2 The operation of site equipment, and machinery during the construction of the Scheme would result in emissions to atmosphere of exhaust gases. However, such emissions are unlikely to be significant, particularly in comparison to levels of similar emissions from vehicle movements on the local road network. Any impacts can be mitigated by use of equipment meeting recent emission control standards, operating well-maintained vehicles, and construction works planning to reduce trip generation and duration. The impacts of site equipment are therefore proposed to be scoped out of this assessment. Construction traffic generated by Scheme is not anticipated to meet any of the criteria outlined in DMRB as having the potential to impact air quality, therefore, an assessment of air quality effects from construction traffic is proposed to be scoped out.

13.6.3 Interim Advice Notes produced by Highways England in relation to air quality and the assessment of effects from highways schemes were reviewed. IAN 185/15 ‘updated traffic, air quality and noise advice on the assessment of link speeds and generation of traffic data into speed-bands’ provides an assessment methodology for assessing the impact of congestion on local air quality. The study area does not suffer from congestion therefore an assessment using IAN 185/15 has been scoped out.

13.7 Assessment of Potential Effects

Construction

13.7.1 Fugitive dust emissions arising from construction activities are likely to be variable in nature and would depend upon the type and extent of activity, soil type and moisture content, road surface conditions, and weather conditions. Periods of dry weather combined with higher wind speeds have the potential to generate more dust.

13.7.2 Fugitive dust arising from construction and demolition activities generally has a particle size greater than the PM_{10} fraction (which can potentially affect human health). It is noted that construction activities can contribute to an increase in local PM_{10} concentrations. Unmitigated dust impacts can harm human and ecological health and cause nuisance. Appropriate dust control measures can be highly effective for controlling emissions from potentially dust generating activities identified above, and adverse effects can be greatly reduced or eliminated.

13.7.3 An assessment of the likely effects during construction would be undertaken using the risk-based approach published by the IAQM in which sensitive receptors are identified within 350m of construction activities. Mitigation measures will be recommended where sites are assessed to be at risk of generating dust effects and incorporated in the CEMP for the Scheme. The IAQM guidance notes that the significance of dust effects should be determined using professional judgement. However, it also notes that with the implementation of effective site-specific mitigation measures, the impact of dust effects can generally be determined as not significant. It is not anticipated that increases in vehicles as a result of the construction phase would be significant and therefore an assessment of the emissions associated with construction traffic will be scoped out.

Operation

13.7.4 Concentrations of NO_2 and PM_{10}, the key pollutants of concern in the UK in relation to road traffic, will be assessed at receptors within the study area using ADMS-Roads dispersion modelling for a Baseline Scenario (2016), Opening Year (2021) both with and without Scheme scenarios, and the Future Year (2036) both with and without Scheme scenarios. This will follow the detailed level assessment methodology outlined in DMRB HA207/07.

13.7.5 In addition, the assessment will be undertaken in accordance with IAN170/12. IAN 170/12 provides a methodology to account for the uncertainty surrounding future projections of NOx and NO_2 concentrations, and this would allow the assessment to assess robustly the changes in pollutant concentrations in the opening and future year of the Scheme. Although not adopted in Wales, it is considered that IAN 170/12 reflects current best practice guidance, and as there is no suitable Welsh equivalent guidance, this will be used to inform the proposed method of assessment.

13.7.6 Evaluation of the significance of the local air quality findings will be undertaken in accordance with IAN 174/13. This requires evaluation of significance for NO_2 and PM_{10}

13.7.7 The estimated levels of pollution in the existing, opening and design year of assessment, and the change due to the Scheme, will be compared with the air quality standards described in Table 13. For the local air quality assessment, the evaluation of significance of effects will take into account the guidance in

IAN 174/13, which determines whether the Scheme is significant or not significant with regard to air quality. Although the guidance in IAN 174/13 has not yet been adopted in Wales, in the absence of available equivalent Welsh guidance it is proposed that this guidance will be used for this assessment.

13.7.8 The approach for evaluation of significant local air quality effects is described in Section 3 of IAN 174/13. The guidance in Section 3 and Table 3.1 of IAN 174/13 will be taken into account within the assessment (see Table 14).

Table 14 Overall Evaluation of Local Air Quality Significance

Key Criteria Questions	**Yes/No**
Is there a risk that environmental standards will be breached?	
Will there be a large change in environmental conditions?	
Will the effect continue for a long time?	
Will many people be affected	
Is there a risk that designated sites, areas, or features will be affected?	
Will it be difficult to avoid, or reduce or repair or compensate for the effect?	
On balance is the overall effect significant?	
Evidence in support of the professional judgement:	

13.8 Study Area

13.8.1 The study area is defined by the guidance used to assess potential air quality effects. Air quality effects during the construction phase will be assessed within 350m of construction works where receptors are present. This assessment will include receptors in Llanddewi Velfrey and isolated properties on the outskirts of the village. It is not anticipated that any ecological receptors (designated sites) sensitive to dust would be affected during the construction phase. The study area for the assessment of operational effects consists of the area within 200m of road sections which are likely to be affected by the Scheme, as required by the DMRB.

13.8.2 The criteria for determining the local affected road network are presented in Table 15.

Table 15 Criteria for determining the local road network

Criteria	Threshold
Road alignment will change	by 5m or more; or
Daily traffic flows will change	by 1,000 AADT; or
Heavy Duty Vehicles (HDV) flows will change	by 200 AADT or more; or
Daily average speed will change	by 10kph or more; or
Peak hour speed will change	by 20kph or more.

13.8.3 The study area includes the existing A40 and proposed offline highway sections. The assessment is therefore likely to include those residential properties in Llanddewi Velfrey and isolated properties within 200m of the existing and proposed road network. There are no Designated Sites within 200m of the existing or proposed road network, likely to be assessed.

13.8.4 The criteria used to define the study area for the assessment of regional air quality effects are also set out in the DMRB. However, these differ from those set out for the local air quality assessment. The criteria for determining the regional road network considered are presented in Table 16. This assessment will determine NOx, PM_{10} and CO_2 emissions associated with users of the Scheme.

Table 16 Criteria for determining regional air quality network

Criteria	Threshold
Changes of more than	10% in AADT; or
	10% to the number of heavy duty vehicle; or
	daily average speed of more than 20kph.

13.9 Baseline Context

13.9.1 Existing or baseline ambient air quality refers to the concentration of relevant substances that are already present in the environment. These are present from various sources, such as industrial processes, commercial and domestic activities, traffic and natural sources.

13.9.2 A desk-based review of the following data sources will be undertaken to determine baseline air quality conditions in this assessment for both human and ecological receptors. Pembrokeshire County Council and Carmarthenshire County Council can provide review and assessment reports and local air quality monitoring data. Further data can be obtained from the Welsh Air Quality Forum website.

Future Baseline

13.9.3 Air quality is predicted to improve in the future with the introduction of cleaner fuel technologies into the UK vehicle fleet. However, given that construction is proposed to begin in 2018, baseline air quality at the start of construction is predicted to be similar to the existing situation.

13.9.4 An assessment of air quality concentrations will be undertaken for the Opening Year and Design Year without the Scheme in place. This will enable future baseline air quality conditions to be considered. In accordance with guidance, this will take into account likely future changes in background concentrations and emissions. This will also consider potential impacts on future air quality concentrations as a result of climate change.

13.10 Potential Effects

13.10.1 During construction there is potential for the mobilisation of dust due to the nature of the works to construct the Scheme. The potential effect of this dust mobilisation is soiling upon receptors within the vicinity of the works. The assessment of construction dust will determine the scale of these potential effects and will provide appropriate mitigation measures. The mitigation measures are designed so that any residual effect is not significant.

13.10.2 During operation it is anticipated that much of the traffic that currently passes through Llanddewi Velfrey would bypass the village. By moving this traffic further away from receptors improvements in air quality can be expected. Where the Scheme brings traffic closer to receptors a deterioration in air quality can be expected. In both circumstances, it is anticipated that air quality would remain below the air quality standards.

14 Noise and Vibration

14.1 Subject Introduction

14.1.1 This section of the Scoping Report details the proposed scope of the noise and vibration assessment for both the construction and operational phases of the Scheme.

14.1.2 The construction of the Scheme has the potential to give rise to temporary increases in noise and vibration at sensitive receptors, a methodology is proposed for establishing the likely significance of these temporary impacts.

14.1.3 The operation of the Scheme may give rise to changes in noise levels (both adverse and beneficial) due to the proposed changes to the alignment which would introduce traffic noise into new areas whilst reducing traffic noise impacts for a larger number of sensitive receptors around Llanddewi Velfrey. Proposed methods for assessing the likely significance of permanent noise changes are presented in this section.

14.2 Policy Context

Well-being of Future Generations (Wales) Act 2015

14.2.1 The Act has a number of well-being goals to achieve through implementing sustainable development. Changes in noise levels can have an impact on the health of habitat and humans, as such the goals to create 'a resilient Wales' and 'a healthier Wales' are applicable.

Planning Policy Wales Edition 9

14.2.2 Planning Policy Wales Edition 9 - November 2016 (Welsh Assembly Government, 2016), describes the planning development policies of the Welsh Assembly Government. Chapter 13 of the policy 'Minimising and Managing Environmental Risks and Pollution' sets out the policy objectives with regard to noise from new development. Paragraph 13.13.1 states the policy objectives:

> *'Noise can affect people's health and well-being and have a direct impact on wildlife and local amenity. Noise levels provide an indicator of local environmental quality. The objective of a policy for noise is to minimise emissions and reduce ambient noise levels to an acceptable standard. Noise Action Plans, drawn up by the Welsh Ministers in*

> *relation to Wales under the Environmental Noise Directive, and the Wales Regulations, aim to prevent and reduce environmental noise where necessary and preserve environmental noise quality where it is good. They are a planning consideration in the use and development of land.'*

14.2.3 With regard to the assessment of noise associated with development, paragraph 13.15.1 states the following:

> *'Noise can be a material planning consideration, for example in proposals to use or develop land near an existing source of noise or where a proposed new development is likely to generate noise. Local planning authorities should make a careful assessment of likely noise levels and have regard to any relevant Noise Action Plan before determining such planning applications and in some circumstances, it will be necessary for a technical noise assessment to be provided by the developer.'*

14.2.4 Paragraph 13.15.2 provides guidance on noise generation near protected areas:

> *'Special consideration is required where noise-generating development is likely to affect a protected species, or is proposed in or near statutorily designated areas, including urban 'quiet areas' designated in Noise Action Plans. The effect of noise on the enjoyment of other areas of landscape, wildlife and historic value should also be taken into account.'*

TAN 11 Noise

14.2.5 TAN 11 (Welsh Assembly Government, 1997) provides technical guidance on noise generating development including transportation projects.

Pembrokeshire County Council (PCC)

14.2.6 Local Development Plan 2013-2021Policies relevant to noise include:

GN1: General Development Policy, Point 2 – developments will be permitted where they will not result in an increase in noise and vibration levels; and

GN3: Infrastructure and New Development- provision must be made for mitigation of potential adverse impacts including noise intrusion.

GN.37: Protection and Enhancement of Biodiversity – policy to ensure that species and their habitats are protected from the potentially adverse effects of development, and where possible enhanced. Potentially adverse effects may include disruption to species and habitats prior to, during and/or after construction for example unacceptable noise.

14.3 Consultations (undertaken and proposed)

14.3.1 Consultation would be undertaken with the Environmental Health Officer (EHO) at Pembrokeshire County Council in order to establish any existing noise concerns, particularly sensitive receptors in the study area and to confirm local policy, in particular in relation to construction noise.

14.4 Surveys undertaken to date and additional surveys required

14.4.1 No noise surveys were undertaken prior to the preparation of this Scoping Report. The preferred method of assessing the noise levels from a road Scheme is through the use of prediction rather than by measurement, however, a noise survey can assist with the understanding of existing noise levels. It is therefore proposed to undertake baseline noise surveys following the comparative and/or shortened measurement procedures as described in the Department of Transport/Welsh Office document "Calculation of Road Traffic Noise" (CRTN).

14.4.2 The shortened measurement procedure requires that 3 x one hour measurements are undertaken in consecutive hours between the hours of 10:00hrs and 17:00hrs on a typical weekday. A full hour measurement may be represented by a 15 minute sample measurement where the traffic flows meet certain conditions as set out in CRTN. The three hour measurement can then be used to derive the 18 hour noise level, $L_{A10,18hr}$ as predicted by the CRTN methodology.

14.4.3 As an alternative, where it is possible to find secure locations, up to three noise loggers may be deployed to record noise levels over a full 24 hour period and the CRTN comparative noise measurement procedure will be used at up to nine additional positions. At each 'satellite' position, a minimum of two 15 minute samples would be measured concurrently with a noise logger which is subject to noise from the same road under the same conditions.

14.5 Assessment Methodology

14.5.1 The assessment methodology would follow the 'detailed' methodology procedure as set out in DMRB HD213/11.

Construction Noise and Vibration

14.5.2 DMRB HD213/11 points to BS 5228 Parts 1 & 2 for the prediction and assessment of the effects of construction noise.

14.5.3 For this assessment the ‘ABC’ assessment method described in BS 5228 will be used to establish the threshold of potential significant effect for construction noise at residential receptors. Under this approach, the adverse impact threshold is determined at a dwelling using the existing ambient noise level, rounded to the nearest 5dB. This is then used to determine the assessment category: A, B or C, which then defines the adverse noise impact threshold, as described in Table 17. The predicted construction noise level is then compared to the appropriate noise impact.

14.5.4 If the L_{Aeq} construction noise level exceeds the appropriate noise impact threshold level, then an adverse impact with the potential to cause a significant effect is identified.

14.5.5 Having established if there is a potentially significant effect using the ABC method, the final assessment of significance is made using professional judgement. This is evaluated by considering various other factors, as discussed under “Determining Significance of Effects” at the end of this section.

14.5.6 The threshold of vibration perception in residential environments is identified at an exposure level of 0.3mm/s peak particle velocity (PPV) in accordance with guidance in BS 5228: Part 2. Complaint is likely where levels occur above 1.0mm/s PPV at residential properties but this exposure can be tolerated if prior warning and explanation has been given to residents. Above a level of 10mm/s PPV the vibration is likely to be intolerable for any more than a very brief exposure to this level.

14.5.7 The overall significance of the effect is assessed using professional judgement by considering not only the criteria above but also other factors, as discussed at the end of this section.

Table 17 Threshold of potential significant effect at dwellings according to ABC method in BS 5228 Part 1

Assessment category and threshold value period	**Threshold value, (dB)**		
	Category A	**Category B**	**Category C**
Night-time (23:00 – 07:00)	45	50	55
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
Other: Weekday evenings (19:00 – 23:00) Saturdays (13:00 – 23:00) Sundays (07:00 – 23:00)	55	60	65

Category A:	threshold value to use when ambient noise levels (rounded to the nearest 5dB) are less than these values
Category B:	threshold value to use when ambient noise levels (rounded to the nearest 5dB) are the same as Category A values
Category C:	threshold value to use when ambient noise levels (rounded to the nearest 5dB) are higher than Category A values.

Operational Noise and Vibration

14.5.8 DMRB HD 213/11 Revision 1 sets out threshold noise level changes of 1dB $L_{A10,18hr}$ in the short-term or 3dB $L_{A10,18hr}$ in the long term, which if likely to be exceeded, should result in a 'Detailed' assessment being undertaken. As the proposed Scheme includes a section of the route that would be constructed offline, there is clear potential for these thresholds to be exceeded, where the route passes close to noise sensitive receptors which are currently at some distance from the existing route. The assessment of operational noise for the appropriate study area will therefore be undertaken at the 'Detailed' level.

14.5.9 The DMRB approach to assessing noise impact is to compare the noise levels for the Do Something scenario against noise levels for the Do Minimum scenario. The method requires that comparisons are made between the baseline noise situation (before the change produced by the Scheme) and the noise level in both the Scheme Opening Year and the Worst-Case Year in the first fifteen years after opening (generally the 15th year after opening).

14.5.10 DMRB HD 213/11 requires that a night-time noise assessment is carried out. The L_{night} descriptor is used to represent the noise level at dwellings between the hours of 23:00 and 07:00. For the night-time noise assessment, only dwellings with a noise level over 55dB$L_{night,\ outside}$ in the long term are considered.

14.5.11 Noise predictions will be carried out according to the Calculation of Road Traffic Noise (CRTN) methodology using proprietary software and Annex 4 of HD 213/11. Traffic noise levels will be calculated across a grid of receiver positions, and contours of noise level exposure established. The calculation area will be determined as per the methodology described below in 14.7.

14.5.12 Noise levels are calculated in terms of the $L_{A10,\ 18h}$ index as specified in CRTN. This represents the A-weighted noise level exceeded for 10% of the time between the hours of 06:00 and 00:00 on an average weekday. The traffic flow predictions on which the noise calculations are made will be taken from the traffic impact assessment data for the different scenarios.

14.5.13 In addition to traffic flow information, the traffic noise calculations will take into account digital mapping data derived from both topographical surveys and landscaping details. Man-made features such as building infrastructure and man-made ground areas will also be modelled, as well as existing noise mitigation barriers and bunding. Positions of noise sensitive receivers will be identified. Details of earthworks, road surfaces, and other relevant information, will also be modelled.

14.5.14 There is no established UK guidance that clearly defines criteria for the assessment of significance effects arising from road traffic noise. The response of people to noise is subjective, and sensitivity to changes in traffic noise varies across the population. Given the variability of response and the potential for non-acoustic factors to influence perceptions of noise, any assessment of significance can only represent the general community response to traffic noise.

14.5.15 Chapter 3 of DMRB HD 213/11 Revision 1 notes that 'A change of 1dB(A) in the short-term (e.g. when a project is opened) is the smallest that is considered perceptible. In the long-term, a 3dB(A) change is considered perceptible, and such an increase should be mitigated if possible.'

14.5.16 DMRB provides categories for assessing road noise impact magnitude. These magnitude of impact descriptors are shown below in Table 18 (short term) and Table 19 (long term). The different scales reflect the different threshold criteria referred to in HD 213/11 (paragraph 3.5) for short term changes in traffic noise as opposed to the response to long term, steady state differences in traffic noise.

Table 18 DMRB classification of magnitude of noise impact in the short term

Noise Change [dB(A)]	Magnitude of Impact in the Short-term
0	No change
0.1 – 0.9	Negligible
1.0 – 2.9	Minor
3.0 – 4.9	Moderate
5.0 +	Major

Table 19 DMRB classification of magnitude of noise impact in the long term

Noise Change [dB(A)]	Magnitude of Impact in the Long-term
0	No change
0.1 – 2.9	Negligible
3.0 – 4.9	Minor
5.0 – 9.9	Moderate
10.0 +	Major

14.5.17 For residential receptors, the overall significance of the effect is assessed using professional judgement by considering not only the DMRB noise impact criteria but also other factors, as discussed under 'Determining Significance of Effects' at the end of this section.

14.5.18 DMRB recommends that the effects of vibration should also be considered where appropriate. In the case of ground-borne vibration, the likelihood of perceptible vibration being caused is particularly dependent upon the smoothness of the road surface. Research has shown that vibration levels caused by heavy vehicles travelling at 110kph over a 25mm hump (i.e. a large discontinuity consistent with poorly backfilled trench) could cause perceptible vibration at up to 40m from the road. This would infer that it is unlikely that significant levels of vibration would be generated at distances greater than this. Also, with a newly laid road surface it is a requirement of new highway construction specification that the surface would be smooth and free from any discontinuities of this magnitude. Paragraph A5.26 of DMRB states: 'Such vibrations are unlikely to be important when considering disturbance from new roads and an assessment would only be necessary in exceptional circumstances'. No such exceptional circumstances are envisaged for the Scheme and hence no impacts or effects from ground-borne vibration are anticipated.

14.6 Determining Significance of Effects

14.6.1 All of the identified sources of noise and vibration will be evaluated to determine if there would be adverse impacts and the potential to cause significant effects according to the criteria described above for Construction and Operational impacts respectively.

14.6.2 If potentially significant effects are identified, the overall assessment of significance is evaluated using professional judgement based on the factors set out in the following list.

Residential receptors

a) the magnitude of the impact and effect identified (based on overall noise level and noise change);

b) the number and grouping of adversely affected dwellings and shared open areas;

c) the level and character of the existing noise environment;

d) any unique features of the source or receiving environment in the local area;

e) combined exposure to noise and vibration;

f) duration of impact and effect (for construction); and

g) the effectiveness of mitigation measures that could avoid or reduce the adverse effects.

Non-residential

a) the generic use (e.g. educational, healthcare, religious buildings or community uses) and hence relevant guidance on noise;

b) the times of use;

c) the design of the receptor (especially windows, doors and ventilation systems) and hence ability of receptor to experience changes in external noise environment without significant change in internal noise conditions);

d) the layout - whether the most sensitive parts of the building are closest to and face the proposed Scheme or are located further from the Scheme and are on the opposite side of a building;

e) duration of impact and effect (for construction); and

f) the effectiveness of mitigation measures that could avoid or reduce the adverse effects.

14.7 Study Area

14.7.1 The study area would be determined in accordance with DMRB HD213/11. This requires the following steps:

a) Identify the start and end points of the physical works associated with the road project.

b) Identify the existing routes that are being bypassed or improved, and any proposed new routes, between the start and end points.

c) Define a boundary one kilometre from the carriageway edge of the routes identified in (ii).

d) Define a boundary 600m from the carriageway edge around each of the routes identified in (ii) above and also 600m from any other affected routes within the boundary defined in (iii) above. The total area within these 600m boundaries is termed the 'calculation area'. An affected route is where there is the possibility of a change of 1 dB $L_{A10,18h}$ or more in the short-term or 3 dB $L_{A10,18h}$ or more in the long-term.

e) Identify any affected routes beyond the boundary defined in (iii).

f) Define a boundary 50m from the carriageway edge of the routes identified in (v) above.

14.7.2 It is acknowledged in DMRB HD 213/11 that a reduced study area may be necessary dependent on the extents of the traffic model.

14.8 Baseline Context

14.8.1 No site visits or surveys were undertaken prior to the production of this Scoping Report, however, a desktop study indicates that the study area is rural in character with the A40 likely being the major noise source. Noise levels at boundaries of the study area are likely to be substantially lower than adjacent to the existing A40.

14.8.2 The baseline noise levels affecting sensitive receptors in the study area will be determined primarily through prediction of the Do-Minimum situation in the planned opening year of the Scheme. This will be supplemented by noise surveys as described in paragraphs 14.4.2 and 14.4.3 to determine the current baseline noise levels.

14.9 Potential Effects

14.9.1 Construction of both the online and offline sections of the Scheme are likely to give rise to increases in noise for sensitive receptors within around 300m of the works (this is dependent on exact location in relation to existing noise sources which would provide masking to construction noise). Increases would be temporary and best practicable means would be used to minimize impacts. Where necessary temporary noise barriers may be recommended to reduce noise impacts further.

14.9.2 It is unlikely that piling activities would be required as part of the construction of the Scheme making it unlikely that any significant vibration impacts would occur, however other activities could give rise to perceptible vibration impacts.

14.9.3 The operation of the Scheme has the potential to give rise to increases in noise at isolated properties close to the offline sections of the Scheme, however this is expected to affect a very small number of receptors whilst there would be noise reductions at a larger number of receptors in Llanddewi Velfrey where traffic diverts from the existing A40 route onto the new by-pass. Where Scheme improvements would be online, there may be noise increases or decreases at nearby receptors, dependent on predicted changes in traffic speed, movement of the traffic source lines relative to nearby receptors and future road surfacing materials (i.e. low noise surfacing).

14.9.4 To provide an indication of how noise may affect receptors at a community level as a result of the proposed Scheme, Tables 20 and 21 set out the numbers of residential and non-residential addresses (considered to be potentially noise sensitive) within 600m of the existing and the proposed new routes split into distance bands.

Table 20 Number of Residential Addresses Within 600m

Scenario	**Distance Band (m)**					**Total**
	50	**100**	**200**	**300**	**600**	
Existing	59	28	28	18	70	203
Proposed	10	11	25	38	94	178

Table 21 Number of Potentially Noise Sensitive Non-Residential Addresses Within 600m

Scenario	**Distance Band (m)**					**Total**
	50	**100**	**200**	**300**	**600**	
Existing	7		1		1	9
Proposed	1			2	7	10

14.9.5 In total there are 25 fewer residential addresses within 600m of the proposed new route for the A40. This has the potential to lead to overall reduced noise impacts however, the extent of these reductions would depend on the predicted noise levels from both the new road and the retained local road through Llanddewi Velfrey.

14.9.6 All of the ten residential addresses within 50m of the proposed new road, are currently within 50m of the existing A40 and therefore impacts would be limited to any changes due to traffic flow, composition and speed.

14.9.7 There are two receptors, Maesyffynnon and Maes yr Rhos which are almost equidistant (at around 50m to 100m) between the existing A40 and the proposed new by-pass around Llanddewi Velfrey. These receptors have the potential to be adversely impacted by an increase in noise on existing ‘quiet’ façades facing the new road.

14.9.8 Properties on Glan Preseli to the north of the existing A40, fall within 200m to 300m from the proposed by-pass and may also be impacted by changes in noise levels on existing ‘quiet’ facades.

14.9.9 There are three properties within 600m, to the north, of the proposed new by-pass around Llanddewi Velfrey; Pentroyden Fawr which is at just over 100m from the route, Valley View at just over 200m and Castell at around 300m from the route. These properties are currently further away from the existing A40 and therefore have the potential to experience increased noise levels with the Scheme, although this will depend on the three-dimensional landform between the new road and the properties, amongst other factors. This will be determined by detailed noise modelling.

14.9.10 Although Table 21 indicates that there may potentially be one additional non-residential sensitive receptor within 600m of the proposed new road, there are fewer potentially sensitive receptors within 50m to 200m of the road.

15 Materials

15.1 Subject Introduction

15.1.1 The materials chapter of the ES will consider potential impacts of the Scheme due to the use of material resources, and the generation and management of waste. The chapter will consider the materials balance, and potential for surplus materials. It will include assessment of potential impacts during construction and operation from the import of primary raw materials, secondary or recycled/reused materials and manufactured construction products, along with assessment of the generation and management of wastes.

15.1.2 The material resources assessment will follow guidance set out in DMRB Interim Advice Note 153/11[60]. The above IAN has not yet been adopted in Wales. However, it is considered that the IAN reflects current best practice guidance and, as there is no suitable Welsh equivalent guidance, it has been used to inform the proposed method of assessment. It is acknowledged that references to the National Planning Policy Framework (NPPF) set out in the above IAN are not relevant in the Welsh context.

15.1.3 As defined in IAN 153/11, for the purposes of assessment, Materials are defined as comprising:

a) The use of material resources; and

b) The generation and management of waste.

15.2 Policy Context

15.2.1 This section has been prepared in accordance with DMRB HA 200/08 Volume 11, Section 1, Part 1 [61], in relation to the assessment of materials.

15.2.2 The materials assessment follows the guidance set out in DMRB Interim Advice Note 153/11. In line with IAN 153/11 a Scoping Level Assessment is required, and as the project value is >£300,000, as a minimum, a Simple Assessment will be undertaken in accordance with the guidance. Dependent on the outcome of this assessment, a Detailed Assessment may also be required in accordance with IAN 153/11.

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[60] Interim Advice Note 153/11 – Guidance on the Environmental Assessment of Material Resource (2011).

[61] Design Manual for Roads and Bridges, Volume 11, Section 1, Part 1 - HA 200/08 (2008).

National Policy

15.2.3 The relevant national policies are as follows:

The National Waste Strategy, Towards Zero Waste – One Wales: One Planet (2010)[62] provides an overarching framework for the management of all types of waste, with the overall aim of reducing residual waste to zero by 2050. It is supported by a series of sector plans which detail how the outcomes, targets and policies in Towards Zero Waste are to be implemented. The Overarching Waste Strategy Document for Wales – Article 28 of the Waste Framework Directive requires EU Member States to prepare a national waste management plan.

WRAP Cymru Delivery Plan: 2011-15[63], titled Working Together for a World Without Waste, focuses on the most important issues: minimising resource use and diverting priority materials from landfill. The plan is divided into two themes: waste prevention and resource minimisation (including reuse) and; recycling and recovery (including preparation for reuse).

Climate Change Strategy for Wales 2010[64] – Chapter 12 "Resource efficiency and waste sector emission reduction" sets out actions to reduce emissions in the waste sector including: reducing indirect emissions associated with resource consumption by increasing reuse, recycling and composting.

The Well-being of Future Generations (Wales) Act 2015[65] – The act strengthens existing governance arrangements for improving the well-being of Wales to ensure that present needs are met without compromising the ability of future generations to meet their own needs. The act requires all public bodies to embed climate change into their decision-making. The Materials chapter particularly relates to objective 12: Manage, use and enhance Wales' natural resources to support long-term well-being.

Environment (Wales) Act[66], **Part 1: "Sustainable management of natural resources (2015)**[67]" – This act includes three key features that aim to ensure that sustainable management of natural resources will be a core consideration in decision-making. Part 1: "Sustainable management of natural resources" provides a modern legislation for managing Wales's natural resources to help

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[62] Towards Zero Waste – One Wales: One Planet, Welsh Government (June 2010).
[63] WRAP Cymru Delivery Plan 2011-15 http://www.wrapcymru.org.uk/sites/files/wrap/WRAPCymruDeliveryPlan.pdf
[64] Climate Change Strategy for Wales, Welsh Government (October 2010)
[65] http://www.legislation.gov.uk/anaw/2015/2/pdfs/anaw_20150002_en.pdf
[66] http://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-bill/?lang=en
[67] http://gov.wales/docs/desh/publications/150512-sustainable-management-of-natural-resources-delivery-framework-en.pdf

tackle the challenges faced, and is focused on the opportunities resources provide.

Planning Policy Wales (Edition 9, November 2016)[68] sets out Welsh Government's objectives in terms of waste management. The main focus of the policy is planning of future waste management facilities. However, it states that 'waste prevention efforts at the design, construction and demolition stage should be made by developers'. It goes on to state that 'all opportunities should be explored to incorporate re-used or recyclable materials or products into a new building or structure.'

Chapter 14 of Planning Policy Wales (Edition 9, November 2016)[69]This policy covers the short and long-term future use and safeguarding of mineral deposits.

Technical Advice Note 21: Waste[70] provides advice on how the land use planning system should contribute towards sustainable waste management and resource efficiency.

Local Policy

15.2.4 Pembrokeshire County Council Local Development Plan[71], Adopted Plan (February 2013) provides policies on Sustainable development (Strategic Policy 1), safeguarding mineral resources (Strategic Policy 6) and waste (Strategic Policy 11). GN.22 Prior Extraction of the Mineral Resource[72] provides supplementary good practice guidance.

15.3 Relevant Guidance

15.3.1 The overarching policy in relation to the handling of material resources relevant to the Scheme is the EU Waste Framework Directive 2008/98/EC[73.] This provides the legislative framework relating to the collection, transport, recovery and disposal of waste. It includes a common definition of 'waste', which is 'any substance or object which the holder discards or intends to discard', with the term 'discard' including the disposal, recovery or recycling of a substance. The overall purpose of the Waste Framework Directive is to set out measures to protect the environment and human health by preventing or reducing the adverse effects of waste generation and its management, and

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[68] http://gov.wales/topics/planning/policy/ppw/?lang=en

[69] http://gov.wales/topics/planning/policy/ppw/?lang=en

[70] Technical Advice Note 21: Waste, Welsh Government (February 2014).

[71] https://www.pembrokeshire.gov.uk/content.asp?nav=1626,109,2045

[72] Good Practice Guidance Note – LDP policy GN.22 – prior extraction of the mineral resource.

[73] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

by improving the efficiency of resource use. Member States are required by the Directive to take all the necessary measures to ensure that waste is recovered or disposed of without endangering human health or causing harm to the environment. The Directive sets a number of high-level objectives, which have influenced national waste management policy and legislation. In particular, Article 11 of the Waste Framework Directive (amended in 2008) requires that Member States take the necessary measures to achieve 70% recycling of non-hazardous construction and demolition waste by 2020.

15.3.2 In addition to the above Directive, reference is made to the following guidance and legislation relating to material resources and wastes:

a) Interim Advice Note (IAN) 125/09(W) Supplementary Guidance for Users of DMRB Volume 11 'Environmental Assessment'[74].

b) Interim Advice Note (IAN) 153/11 Guidance on the Environmental Assessment of Material Resources.

c) Design Manual for Road and Bridges (DMRB) Volume 11, Section 3 Part 3, Disruption Due to Construction[75]. This covers the effect on people and on the natural environment which can occur, mainly during construction works.

d) DEFRA Environmental Permitting (England and Wales) Regulations 2010.

e) DEFRA Environmental Permitting Guidance 'The Waste Framework Directive' for the Environmental Permitting (England and Wales) Regulations 2010.

f) The Waste (England and Wales) Regulations 2011. This implements revisions to the Waste Framework Directive in England and Wales.

g) The Hazardous Waste (England and Wales) Regulations 2005.

h) Definition of Waste: Development Industry Code of Practice, Version 2 (Contaminated Land: Applications in Real Environments (CL:AIRE) 2011) [76].

15.4 Consultations (undertaken and proposed)

15.4.1 Consultation with NRW and Pembrokeshire County Council will be undertaken to identify any concerns regarding material resources and waste

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[74] Interim Advice Note (IAN) 125/09(W) Supplementary Guidance for Users of DMRB Volume 11 'Environmental Assessment' (2009).

[75] Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3 Part 3, Disruption Due to Construction, Highways Agency (1993).

[76] Contaminated Land: Applications in Real Environments (CL:AIRE) (2011) Definition of Waste Development Industry Code of Practice

management. NRW will be specifically consulted with respect to the Site Waste Management Plan which will be produced as part of the CEMP.

15.5 Surveys undertaken to date and additional surveys required

15.5.1 Much of the information needed for this chapter of the ES will be derived from existing and proposed geotechnical and contaminated land studies, the available ground investigation information and the preliminary Scheme design. Preliminary design of the Scheme is still being developed, and therefore, the earthworks strategy has not been finalised.

15.5.2 Preliminary estimates of likely quantities of earthworks excavations are in the range of 300,000m^3 to 400,000m^3. A key aim of the contractor is for the design to achieve a nett earthworks balance, and to minimise all material imports and exports.

15.6 Assessment Methodology

15.6.1 The existing baseline conditions will be identified from desk-based studies and information from ground investigations. This information will be used to determine the nature of existing materials on site that would be used in the earthworks. The potential locations of material sources and disposal sites will also be considered.

15.6.2 The desk based studies will utilise the following sources:

a) British Geological Survey 1:50,000 Sheet 228 Haverfordwest (Drift) 1976;

b) British Geological Survey 1:50,000 Sheet 228 Haverfordwest (Solid) 1976;

c) British Geological Survey 1:100,000 South West Wales Mineral Resource Map;

d) British Geological Survey 1:100,000 South West Wales Aggregate Safeguarding Map;

e) A40 Llanddewi Velfrey to Penblewin Improvement Preliminary Sources Study Report, March 2016, Mott MacDonald;

f) A40 Llanddewi Velfrey to Penblewin Improvement Ground Investigation Report, June 2017, Arup;

g) Pembrokeshire County Council (2013) Local Development Plan up to 2021; and

h) Natural Resources Wales Public Register – list of operational waste management facilities.

15.6.3 As a minimum, a Simple Assessment shall be carried out in accordance with IAN 153/11, and dependent on the outcome of this assessment, a Detailed Assessment may also be required.

15.6.4 The Simple Assessment will assemble data and information that is readily available to address potential effects identified at the Scoping level, to reach an understanding of the likely environmental effects to inform the final design, or to reach an understanding of the likely environmental effects that will identify the need for Detailed Assessment.

15.6.5 For the purposes of assessing the effects associated with materials use and waste, the Simple Assessment is a qualitative exercise which should aim to identify the following:

a) The materials required for the project and where information is available, the quantities;

b) The anticipated waste arisings from the project, and where information is available, the quantities and type (e.g., hazardous);

c) The impacts that would arise from the issues identified in an initial scoping exercise in relation to materials and waste;

d) The results of any consultation; and

e) A conclusion about whether this level of assessment is sufficient to understand the effects of the project or whether a Detailed Assessment is necessary.

15.6.6 The assessment will identify the environmental impacts and the measures to mitigate the impacts. The assessment of potential effects due to construction will be based on estimated material requirements and will include a review in terms of material volumes, sources and movements. Vehicle movements required for delivery and export of materials will be considered. The assessment of effects due to operation will be considered based on likely maintenance requirements.

15.6.7 Should a Detailed Assessment be required in accordance with IAN 153/11, it will utilise the data gathered at the Simple Assessment level and where necessary collate additional information to quantify the materials required for the project and to forecast the quantities and types of waste that would be produced. For the purposes of assessing the effects associated with materials use and waste, the Detailed Assessment is a quantitative exercise.

15.7 Study Area

15.7.1 The study area for the materials assessment will include the footprint of the construction works. Consideration of the potential effects outside the construction works will also be included in relation to material sources, vehicle movement (import/export), and waste management. It is likely that material sources and waste facilities will be as local to the Scheme as practical.

15.8 Baseline Context

15.8.1 Based on the Preliminary Sources Study Report[77] completed by Mott MacDonald for the Llanddewi Velfrey to Penblewin section of the Scheme, the ground conditions are likely to consist of areas of superficial deposits comprising topsoil and glacial till. The underlying bedrock is likely to be composed of weak to moderately strong mudstones and siltstones with interbedded sandstones and areas of conglomerates.

15.8.2 Groundwater levels are anticipated to be high in low lying areas. The superficial deposits and the weathered bedrock are likely to have low permeability but there may be perched groundwater where the strata are more permeable.

15.8.3 The mineral resources map identifies areas of sub alluvial superficial deposits within the Scheme area. The aggregate safeguarding map identifies sand and gravel, and sandstone deposits within the Scheme area.

15.9 Potential Effects

15.9.1 The Scheme has the potential to generate local effects during the construction phase. Potential effects during construction are:

a) The generation of excess materials requiring removal from site to landfill or an alternative site.

b) The requirement for the import of construction materials (including primary aggregates).

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[77] A40 Llanddewi Velfrey to Pontblewin Improvement – Preliminary Sources Study Report, Mott MacDonald (March 2016)

15.9.2 The Scheme has limited potential to generate an effect during the operational phase as there are no day-to-day requirements to import or export materials and the operation of the Scheme is intended to generate minimum quantities of waste. Potential material use and waste arisings are summarised in Table 22.

Table 22 Potential wastes and material use

Project Activity	**Material use and potential to generate significant impact**	**Potential waste arisings and potential to generate significant effects**
Site clearance	N/A	Vegetation surface strip, kerbs, trees, traffic signs, lighting etc. Low volume. Limited potential for significant effects.
Earthworks	Topsoil, general fill, capping – reuse of site won material. Import of primary and secondary aggregates. Earthworks balance targeted, limited potential for significant effects.	Surplus excavated material – reuse, recycle or dispose. Low surplus volume anticipated. Limited potential for significant effects.
Installation of pavement	Import of primary or secondary / recycled materials. Potential for relatively large volumes to be required. Potential for significant effects.	Surface planings – potential to recycle / reuse.
Installation of manufactured products	Drainage, kerbs, traffic signs, lighting etc. Low volume. Limited potential for significant effects.	No significant waste generated.
Operation of the road	No significant material resources required.	No significant waste arisings.

16 All travellers

16.1 Subject Introduction

16.1.1 This section of the scoping report will address the effects of the Scheme on the journeys made by:

a) Non-Motorised Users of roads, footpaths, cycleways and bridleways (hereafter collectively referred to as NMU routes) and

b) on vehicle travellers using the public road network. However, the assessment will not cover aspects which are included within the cost-benefit economic analysis.

16.1.2 The assessment will be carried out following guidance in DMRB Volume 11, Section 3, Part 8.

16.2 Policy Context

16.2.1 The Active Travel (Wales) Act, 2013. This legislation requires '…Welsh Ministers and local authorities to take reasonable steps to enhance the provision made for, and to have regard to the needs of, walkers and cyclists; for requiring functions under the Act to be exercised so as to promote active travel journeys and secure new and improved active travel routes and related facilities; and for connected purposes'. This is supported by the proposed Active Travel Action Plan (Welsh Government, 2014a). In addition, the Transport Act 2000 (as amended by the Transport (Wales) Act 2006) is relevant.

16.2.2 Planning Policy Wales (2016) sets outs the objectives for 'Transport' Technical Advice Note (TAN) 18 (2007): Transport; One Wales: Connecting the Nation (Welsh Assembly Government, 2008) 'The Wales Transport Strategy' and the 'National Transport Plan 2010'.

16.2.3 NMU routes are protected by primary legislation that includes:

a) National Parks and Access to the Countryside Act 1949

b) Countryside Act 1968

c) Highways Act 1980

d) Wildlife and Countryside Act 1981

e) Road Traffic Act 1988

f) Rights of Way Act 1990

g) Town and Country Planning Act 1990

h) Countryside and Rights of Way Act 2000

i) Natural Environment and Rural Communities Act 2006

16.2.4 Planning Policy Wales (2016) sets outs the objectives for 'Transport' (including walking and cycling) in Chapter 8 and 'Tourism, Sport and Recreation' in Chapter 11. Also relevant are Technical Advice Note (TAN) 16 (2009): Sport, Recreation and Open Space; Technical Advice Note (TAN) 18 (2007): Transport; One Wales: Connecting the Nation (Welsh Assembly Government, 2008) 'The Wales Transport Strategy' and the 'National Transport Plan 2010'.

16.2.5 The Local Development Plan sets out policy for NMU routes under 'Leisure Routes' and 'Public Realm'. Policy GN.34 sets out the need to protect these routes.

16.2.6 The A40 is one of the key routes to and from the ferry port at Fishguard. Pembrokeshire Local Plan sets out the need to maintain landscape quality as a setting for tourism.

16.3 Relevant Guidance

16.3.1 Under legislation, Welsh Government has set out how NMU routes are to be managed, protected and improved in Wales in a document entitled 'Guidance for Local Authorities on Public Rights of Way', published in October 2016 to replace a number of Welsh Office Circulars and Regulations.

16.4 Consultations (undertaken and proposed)

16.4.1 Consultations with the Planning Authority and Highway Authority will be undertaken. Reference to the Definitive Map will be made to ensure that all relevant Public Rights of Way are known. Non-statutory consultees will be consulted, including groups representing Equestrians, walkers and cyclists.

16.5 Surveys undertaken to date and additional surveys required

16.5.1 Desk studies of routes were undertaken in KS1 and 2. Surveys and counts of the users of NMU routes is required to properly understand the relative importance of each route and the significance of impact of any changes that could result from the Scheme. Ten locations were identified for undertaking counts. These will be surveyed on both a week day and weekend day.

16.5.2 The study area will be the extent of NMU routes within the 500m route corridor (250m each side), although only those routes that are affected are assessed.

16.6 Assessment Methodology

16.6.1 The All Travellers topic includes an assessment of the effects on the public rights of way (footpaths, bridleways and restricted byways); cycle routes; permissive non-motorised user (NMU) routes; public highways; public transport; overbridge and underpass crossings.

16.6.2 The assessment of effects on all travellers considers the construction and operation of the proposed new road and changes in amenity and effects on community severance and driver stress. ‘Views from the Road’ are also considered.

16.6.3 The following guidance documents are relevant:

DMRB Volume 11:

a) Section 2, Part 5, HA 205/08 (Highways Agency et al., 2008);

b) Section 3, Part 8 ‘Pedestrians, Cyclists, Equestrians and Community Effects’ (Highways Agency, 1993a) in respect of the potential effects on pedestrians, cyclists and equestrians;

c) Section 3, Part 9 ‘Vehicle Travellers’ (Highways Agency, 1993b) in respect of the potential effects on driver stress;

d) Interim Advice Note 125/09(W) Supplementary guidance for users of DMRB Volume 11 ‘Environmental Assessment’ (Wales Only) (Welsh Assembly Government, 2009).

16.6.4 With respect to NMUs (pedestrians, cyclists and equestrians), the requirements of the DMRB Volume 11, Section 3, Part 8 (Highways Agency, 1993a) are as follows.

a) Journey length, local travel patterns: using the method for reasonably straightforward travel patterns;

b) proposed changes in journey length and duration;

c) changes in amenity on the NMU routes, assessing changes that would arise from the proposed Scheme compared to the Do Minimum scheme. Amenity is here defined as the relative pleasantness of the environment or journey.

d) increases or reductions in Community Severance. This will apply the method for new severance with the new road and relief of existing severance through the reduction of traffic on the detrunked old road.

16.7 Study Area

16.7.1 The study area will be the extent of NMU routes within the 500m route corridor (250m each side), although only those routes that are affected are assessed.

16.8 Baseline Context

16.8.1 There is a well-established Public-Rights of Way network throughout the study area, but no designated cycle routes. Information for this has been obtained from the Definitive Map of Public Rights-of-Way (PRoW).

16.8.2 The pedestrian, cyclist and equestrian baseline conditions will also be established by undertaking site visits and public rights of way condition and user surveys.

16.9 Potential Effects

16.9.1 The Scheme would cut across or cause potentially adverse effects on 10 NMU routes, or which 8 could be severed. Mitigation could include underpasses to provide a route under the Scheme, or crossings.

17 Heat and Radiation

17.1 Subject Introduction

17.1.1 The EIA regulations of 2017 require an assessment of the likely significant effects of a project on the environment resulting from heat and radiation. This Section examines whether there are likely to be any significant effects.

17.1.2 During construction some heat is generated by machinery and released from materials used. During operation of the road over the next few decades, some of vehicles be powered by internal combustion engine which generates waste heat from burning hydrocarbons. The amount of heat and radiation generated is small and is likely to be quickly dissipated into the atmosphere. In traffic assessments conducted as part of this project, traffic growth on the A40 would not change as a result of the improvements.

17.1.3 With no change brought about by the Scheme there can be no significant changes in heat and radiation and no new sources of either heat or radiation would be introduced. It is anticipated that the generation of heat or radiation is unlikely to be relevant to the scope of this project and so has been scoped out.

17.2 Conclusion

17.2.1 An assessment of the effects of heat and radiation on the environment has been scoped out.

18 Climate Change

18.1 Subject introduction

18.1.1 EIA Regulations 2017 introduced the requirement to include consideration of the impact of the proposed development on climate and the vulnerability of the project to climate change. An assessment related to climate change is composed of three elements:

a) **Greenhouse gas (GHG) emissions assessment** – quantifies the potential GHG emissions associated with the construction and operation of the proposed development and identifies mitigation measures to reduce these emissions.

b) **Climate change resilience (CCR) assessment** – evaluates the effectiveness and feasibility of adaptation measures integrated into the proposed development to avoid or reduce hazards and/or increase resilience of the proposed development to climate change impacts.

c) **In-combination climate change impact (ICCI) assessment** – evaluates the combined effect of the proposed development and potential climate change impacts on the receiving environment during construction and operation.

18.2 Known Baseline

GHG assessment

18.2.1 A GHG assessment was undertaken in 2017 which quantified the whole life carbon footprint of the project based on the preliminary design. This included capital, operational and user carbon emissions. The baseline considers the user emissions from the existing A40 as defined by the 'Do minimum' scenario.

18.2.2 For user carbon, the assessment compares the emissions resulting from two scenarios:

a) Do minimum scenario (baseline) – emissions without the proposed Scheme, projected as a future baseline in the operational phase

b) Do something scenario – emissions with the proposed Scheme.

CCR and ICCI assessments

18.2.3 The baseline environment for the CCR and ICCI assessments includes consideration of:

a) **Current climate conditions** – established for a range of climate variables based on the long-term average of historical weather data for 1961 – 1990. This data is a comparator for the projected future climate conditions.

b) **Future climate conditions** – based on projections of different emissions scenarios and probability levels.

18.2.4 The description of the future climate baseline will be based upon climate change projection data from the United Kingdom Climate Projections 2009 (UKCP09)[78]. The UKCP09 climate change projection data is the most widely used data for the UK and are available for different emission scenarios and time periods up to the 2080s.

18.2.5 The assessments will include consideration of future climate conditions over two timescales. The timescales will include a medium-term (2050s) and long-term projection (2080s) projection. Note that 'the 2050s' is defined by the Met Office as the period 2040-2069, decades are defined similarly for the 2080s (2070-2099).

18.2.6 Overall, the trends in climate variables for Pembrokeshire are expected to include:

a) High temperatures – Increase in mean daily temperatures in the summer and winter, increase in the number of hot days (days when daily mean temperature is >25°C) and increased insolation

b) Low temperatures – Decrease in the number of frost days (days when daily minimum temperature <0°C).

c) High precipitation – Increase in mean daily rainfall in the winter, increase in the number of days with heavy rain.

d) Low precipitation – Decrease in mean daily rainfall in the summer, increase in the annual number of dry spells.

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[78] UK Climate Projections 2018 (UKCP18) are expected to be available from November 2018, and therefore will not be available within the timeframe required for this assessment. Refer to http://ukclimateprojections.metoffice.gov.uk/24125 [Accessed June 2018]

e) Extreme weather – Increase in extreme wind events[79]. Increase in the number of lighting days, particularly in Autumn[80].

18.3 Completed and planned surveys

18.3.1 No additional surveys are required to calculate the effects of traffic. Traffic data for the existing road and modelled for the proposed Improvement Scheme will be available from surveys already conducted for the Scheme.

18.4 Consultations

18.4.1 No consultation with statutory or non-statutory consultees is considered necessary.

18.4.2 Liaison with the design team for the proposed development will be necessary in order to identify and propose how this scheme mitigates against increasing GHG emissions. For the GHG assessment, liaison with Transport and Air Quality specialists will be necessary to ensure consistency of approach. For the CCR assessment, liaison will be undertaken with the Water Resources specialist to understand risks and mitigation measures associated with flooding. Consultation will be carried out with other EIA topic leads to ensure that the ICCI assessment includes consideration of key issues in all topics.

18.5 Key Issues

Greenhouse gas emissions

18.5.1 GHG emissions from human activities, such as burning fossil fuels and changing land uses, are causing anthropogenic climate change. The UK and Wales have legally binding GHG reduction targets through the Climate Change Act 2008 and the Environment (Wales) Act 2016.

18.5.2 A GHG assessment of the scheme was undertaken in 2017 which quantified the whole life carbon footprint of the project based on the preliminary design. This included capital, operational and user carbon emissions.

18.5.3 The GHG assessment showed that emissions from vehicles using the road account for the vast majority of emissions over the project life. These

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[79] IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, https://ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap23_FINAL.pdf [Accessed June 2018] page 1279

[80] UK Climate Projections (2010) Future changes in lightning from the UKCP09 ensemble of regional climate model projections, http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87950&filetype=pdf [Accessed June 2018]

emissions are slightly higher with the scheme (compared to without the scheme) due to an increase in average speeds, based on the traffic forecast models, and also a very slight increase in vehicle kilometres travelled due to the alignment of the proposed road.

Climate change resilience

18.5.4 Key issues related to adaptation to climate change include flooding risks due to changes in the amount, frequency and timing of precipitation, as well as sea level rise and storm surges. Increases in average temperatures and frequency of extreme temperature and other weather events also have the potential to impact the proposed development and other environmental receptors. These will need to be taken into consideration during the design stages; both for general layout and detailed design.

18.5.5 Issues related to climate predominantly concern the operational phase and how buildings and infrastructure were designed and developed to integrate climate change resilience. Flood risk (including from sea level rise) will be assessed within the water resources assessment of the EIA and will therefore be cross-referenced rather than duplicated in this chapter.

18.5.6 The impacts of climate change are already being experienced, particularly in terms of increased frequency and severity of extreme weather events such as storms and heatwaves. The measures set out in the CEMP should be set within the context of the current climate. Due to the short temporal phase of construction, it is anticipated that these measures would appropriately address climate change risks during the construction phase. The construction phase has therefore been scoped out of the CCR and ICCI assessments.

18.6 Methodology

GHG assessment

18.6.1 A GHG assessment was undertaken in 2017 which quantified the whole life carbon footprint of the project based on the preliminary design. This included capital, operational and user carbon emissions over a 60-year appraisal period. The results of this assessment will be updated to account for revised assessment years in the traffic model.

18.6.2 The GHG emissions will be quantified using the principal steps outlined in Publicly Available Specification 2080:2016 Carbon Management in Infrastructure (PAS 2080), as shown in Figure 1

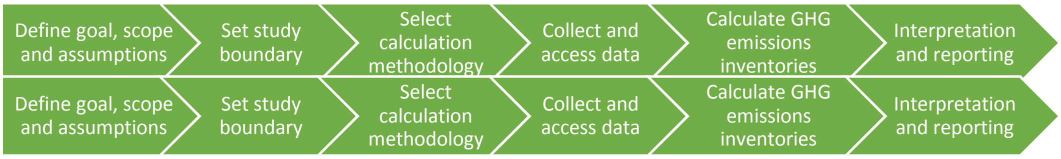

Figure 1 Principal steps of GHG emissions quantification

18.6.3 The scope of the assessment is summarised in Figure 2 below

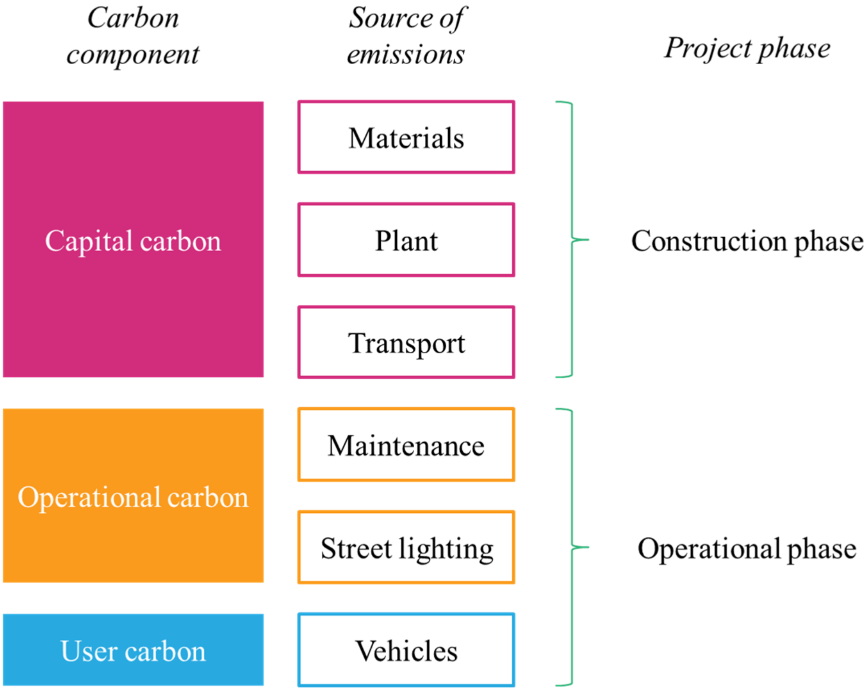

Figure 2 Scope of carbon assessment

18.6.4 The GHG emissions from the development will be calculated by converting ‘activity data’ (such as energy consumption and transport kilometres travelled) into quantities of GHG emissions through the application of emissions conversion factors.

18.6.5 The emissions conversion factors used to complete the calculations are expected to include the following:

a) Inventory of Carbon and Energy (ICE) developed by the University of Bath: Sustainable Energy Research Team, version 2.0, updated in 2011

b) Greenhouse gas reporting: conversion factors 2018, published in June 2018 by the UK Department of Business, Energy and Industrial Strategy (BEIS)

c) Environmental Product Declarations (EPDs) – specifically for methacrylate resin products

d) Energy and Emissions Projections, published in 2015 by the Department of Energy and Climate Change (DECC).

18.6.6 The IEMA guide to assessing greenhouse gas (GHG) emissions and evaluating their significance[81] publishes the over-arching principle:

"The GHG emissions from all projects will contribute to climate change; the largest inter-related cumulative environmental effects…as such any GHG emissions or reductions from a project might be considered to be significant…"

18.6.7 In accordance with this guidance, any carbon emissions associated with the proposed development can be deemed significant. Accordingly, initiatives to mitigate emissions will be integrated into design, as discussed in Section 13.

CCR assessment

18.6.8 The approach and methodology for the climate change resilience assessment is as follows:

a) analysis of relevant climate change and weather data, emissions scenarios and probability levels;

b) assessment of climate hazards;

c) identification of potential risks from these climate hazards to the assets and occupants of the proposed development;

d) consideration of the resilience of the proposed development within the context of any incorporated mitigation measures, including resilience measures which are embedded within the design due to regulations and design guidelines; and

e) identification of need for any further resilience measures to protect the proposed development against the effects of climate change.

18.6.9 The significance of the risks identified in the CCR assessment is based on the likelihood of a hazard having an impact on the proposed development, and the consequence of the impact. The potential likelihood and consequence of

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[81] IEMA (2017) Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance

impacts to the proposed development will be assessed using a qualitative five-point scale.

ICCI assessment

18.6.10 The approach and methodology for the ICCI assessment is as follows:

a) analysis of relevant climate change and weather data, emissions scenarios and probability levels;

b) consideration of potential climate change impacts for all environmental topics;

c) assessment of each environmental topic's respective significant effects and the corresponding mitigation measures identified by each topic;

d) assessment of any potential in-combination climate change impacts and effects given existing mitigation measures (i.e. mitigation measures identified by each environmental topic);

e) assessment of whether there are any significant in-combination climate change effects, based upon whether potential in-combination climate change impacts are assessed to have a high likelihood or consequence;

f) consideration of additional mitigation measures to address significant in-combination climate change effects, beyond those existing mitigation measures identified by other environmental topics; and

g) inclusion of allowances for future mitigation measures and monitoring, to ensure continued resilience of receiving environment.

18.6.11 The outcomes of the ICCI assessment will be the categorisation of each environmental topic based on the following significance criteria:

a) many potential in-combination climate change impacts with high consequences;

b) some potential in-combination climate change impacts with high consequences;

c) some potential in-combination climate change impacts with low consequences; and

d) no potential in-combination climate change impacts.

18.7 Potential mitigation

GHG assessment

18.7.1 PAS 2080 outlines the GHG emissions reduction hierarchy shown in Figure 3. This will be adopted when identifying opportunities to reduce emissions over the life of the project.

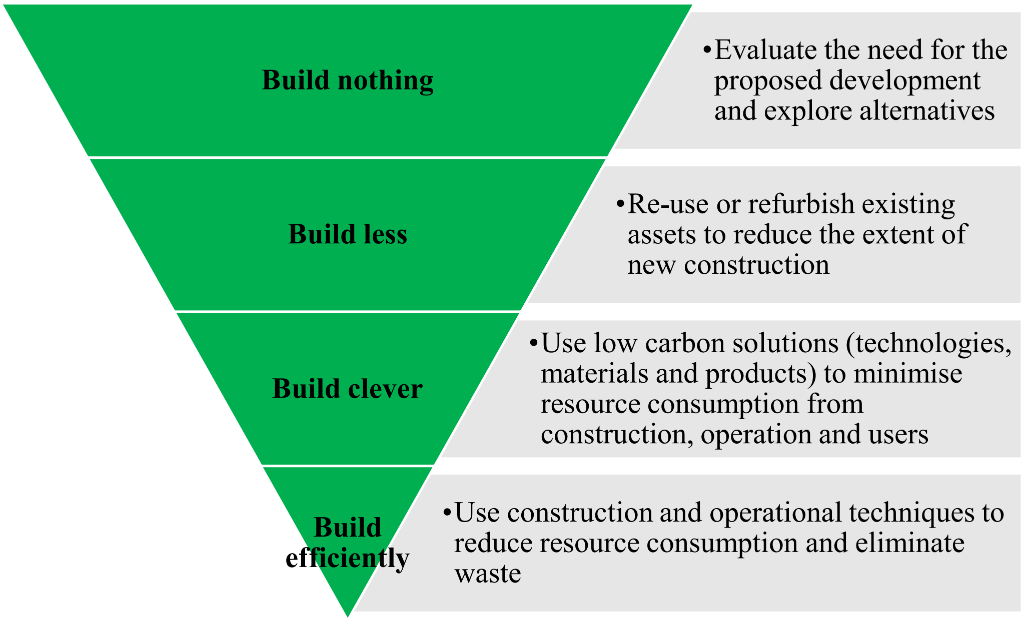

Figure 3 Carbon emissions reduction hierarchy[82]

18.7.2 The GHG emissions assessment will be used to identify the greatest sources of GHG emissions and opportunities to reduce them. Measures proposed to mitigate the impact of GHG emissions from the construction of the proposed development may include:

a) Reduce the quantity of materials required through efficient design;

b) Implement the principles of 'designing out waste' to reduce the embodied emissions used to manufacture materials that are subsequently wasted;

c) Select alternative materials that have a lower emissions intensity, e.g. recycled materials, cement substitutes; and

d) Select local material suppliers to reduce the transport distances and associated emissions from freight.

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[82] Construction Leadership Council & the Green Construction Board (2016) PAS 2080:2016 Carbon management in infrastructure. BSI Limited, London, UK.https://shop.bsigroup.com/forms/PASs/PAS-2080/ [Accessed June 2018]

18.7.3 Measures proposed to mitigate the impact of GHG emissions from the operation of the proposed development may include:

a) Select energy efficient infrastructure, equipment and fittings in order to reduce energy demand during operation;

b) Select durable materials with low requirements for maintenance and replacement over the operational life of the development, with consideration of appropriate selection of materials based on the design life of the asset; and

c) Develop strategies to encourage the use of low carbon transport modes in line with the Active Travel Act, including active and public transport, in order to reduce user emissions.

The ability to influence and reduce GHG emissions is most effective during the design stage, therefore the assessment provides an opportunity to maximise this benefit.

CCR and ICCI assessments

18.7.4 Measures to improve the resilience of the development to future climate change impacts should be integrated into the design. These may include[83]:

a) Designing the development to address flood risks – including locating the development to minimise risk, implementing sustainable drainage systems (SuDS) principles in drainage design, consideration of flood-tolerant construction, temporary and permanent flood defences and post-flood recovery measures.

b) Designing the development to manage water efficiently – implementing sustainable drainage systems (SuDS) principles in drainage design.

c) Selecting weather-resistant materials and fixings – including consideration of effects of extended wetting and heat in causing accelerated material degradation.

18.7.5 In order to avoid maladaptive outcomes that limit future adaptation options, further measures to mitigate the impacts identified in the CCR and ICCI assessments will be recommended if a significant impact is identified. For the ICCI assessment, these will be developed in conjunction with the relevant EIA topic leads.

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[83] Technology Strategy Board (2010) Design for Future Climate Report: Opportunities for Adaptation in the Built Environment

18.8 Conclusion

18.8.1 An assessment of climate change should be carried out because of the potential adverse effects in terms of contribution of GHG emissions to climate change.

18.8.2 The CCR and ICCI assessments will provide an indication of the risks to the asset from climate change and in-combination impacts on receptors due to climate change and the scheme, however it is not considered likely that there would be significant adverse effects following mitigation for either of these aspects.

19 Risk of Major Accident or Disaster

19.1 Subject introduction

19.1.1 EIA Regulations 2017, require an assessment to be completed of the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project during construction and operation to risks of major accidents or disasters which are relevant to the project concerned.

19.1.2 Neither the regulations nor the EU Directive define the scope or method to be used in the assessment. However, IEMA provide useful outline guidance in an EIA Quality Mark Article[84]. The article provides useful definitions:

a) Major Accident: uncontrolled occurrence in the course of the construction or operation of a development, leading to serious danger to the environment, which may be either immediate or delayed.

b) Examples: large-scale fire, structural collapse, explosion, or transport accident.

c) Disaster: This is an external event (i.e. not directly caused by the development) leading to serious danger to the environment, which may be either immediate or delayed.

d) Examples: natural sources such as coastal flooding, adverse weather, ground movement; man-made sources such as escalation of a fire from an adjacent facility, dam collapse etc.

19.1.3 EIA should always be proportionate and so the intention is that this chapter of the ES will address the major risks that are actually relevant to the Scheme, where the resilience of the A40 is of importance to the region. For example, flood risk from surface water, major road accidents resulting in road closures are relevant, while volcanic eruptions, famine and plagues of pests are not. Table 23 sets out a long list of potential major accidents and disasters and highlights those that are relevant.

19.1.4 Emerging EIA practice excludes health and safety matters from this assessment as they are covered elsewhere by detailed legislation.

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[84] https://www.iema.net/assets/uploads/EIA%20Articles/AMEC%20What%20is%20this%20MADness.pdf | Amec Foster Wheeler. 2018.

19.2 Study Area

19.2.1 The study area is definable only after any potential major accident or disaster that could arise were identified as relevant to the project and which could result in serious danger to the environment. However, in each case the project is either the source or is subjected to the of the accident or disaster resulting in adverse effects on the environment.

19.3 Completed and planned surveys

19.3.1 No surveys are required for this assessment, which will be completed using the results of consultations and desk study.

19.4 Consultations

19.4.1 Consultation with statutory or non-statutory consultees would be required to obtain data on sources of risks and consequences. The Local Authority, Natural Resources Wales and Traffic Wales are important sources of data and advice.

19.5 Methodology

19.5.1 The Method of assessment has several stages:

a) **Screening of relevant threats**: based on the National Risk Register of Civil Emergencies[85]);

b) **Consideration of vulnerabilities:** how site location and adjacent landuse makes the project vulnerable to the risk of accidents and disasters;

c) **Scoping of low and high risks to the project**: using source-pathway-receptor risk matrix approach where the project becomes a pathway that increases risk as a result of the changes brought about);

d) **Consideration of high risks:** based on risk factors, avoidance, prevention and mitigation;

e) **Cross referencing** of identified risks to other ES chapters, as appropriate;

f) **Examination of remaining risks.**

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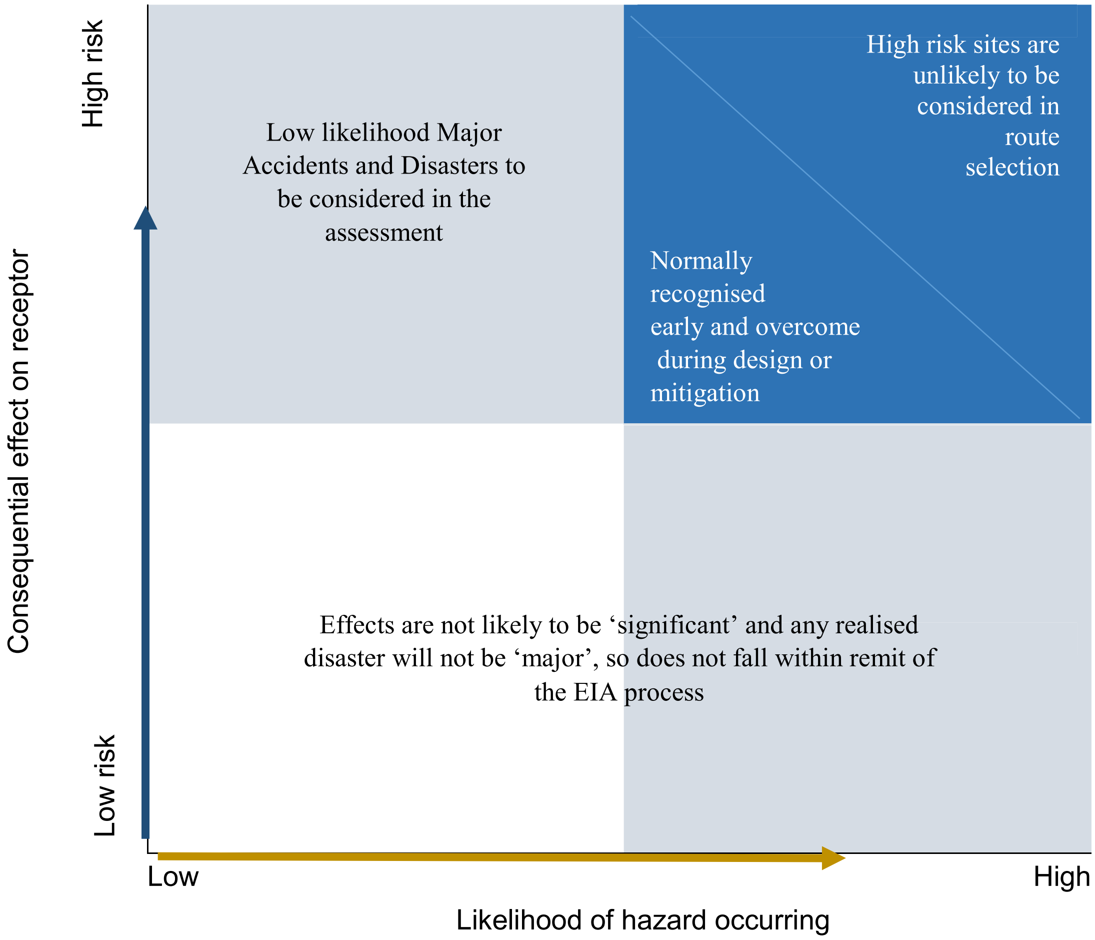
[85] Cabinet Office 2015.

19.5.2 The aim of the EIA is to introduce mitigation measures that:

a) Reduce the likelihood of hazard;
b) Reduce the magnitude of the hazard on the development if it is realised;
c) Break the pathway between the hazard and the development;
d) Increase the resilience of the development to the hazard;
e) Reduce the magnitude of the triggered effect;
f) Reduce the vulnerability of the receptor to the triggered effect;
g) Break the pathway between the development and the receptor.

19.5.3 The EIA process will evaluate the exposure and vulnerability of the development to each of the hazards on the list, identify the potential major accidents or disasters associated with each, and assess the risk of likely significant environmental effects that would be caused. Figure 4 shows how these potential impacts are considered. The result is that the assessment will address high risk, but low likelihood events; however, there are no defined thresholds above or below which an event is not considered.

Figure 4 Assessment of risk of major accident and disaster



19.6 Significance criteria

19.6.1 ‘Significant adverse effects’ are considered to mean: “The loss of life or permanent injury, and/or permanent or long-lasting damage to an environmental receptor[86]”

19.7 Potential effects

19.7.1 Table 23 shows a checklist of hazards that is broadly based on the list provided in the UK National Risk Register 2015[87], with those that are likely to be relevant to the A40 Scheme highlighted.

19.7.2 The potential effects of the Scheme will be those that arise from the highlighted hazards in Table 23.

19.7.3 The potential consequences of riparian or surface water flooding will be addressed in the ES Chapter 7 - Road drainage and Water Environment.

Table 23 Checklist of hazards

Type of hazard			**Type of hazard**	
Geophysical	Earthquake Landslide Tsumani Volcanic eruption		**Biological**	Infectious animal disease epidemic Infectious human disease epidemic Pest plague
Hydrological	Coastal Flood **Riparian/Surface water flood**		**Manmade**	Conflict, war and terrorism Cyber-attack on critical services Displaced population Disruptive industrial action Famine and food insecurity Industrial accidents Poor air quality events Public disorder Electricity failure **Transport accidents** Widespread failure of services
Climatological	Drought Extreme temperatures Wildfire			
Meteorological	**Heavy snow** Hurricane, storms and gales Severe space weather Storm surge			

19.7.4 The potential effects of the Scheme would be those that arise from the highlighted hazards in Table 23. In particular, the effects of severe heavy snow, or transport accidents that could result in closure of the road are

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[86] IEMA (2017) EIA Quality Mark Webinar: Major Accidents and Natural Disasters in EIA. 13th July 2017.

[87] National Risk Register Of Civil Emergencies 2017 edition, Cabinet Office.

considered of greatest concern to the potentially isolated community in the villages and to the wider travelling public.

Heavy Snow:	a very rare occurrence which is normally cleared within a short timescale so that the roads can resume near-normal use.
Transport accidents:	**Serious accidents with and without fatalities** that close the road are infrequent. When the road is closed traffic can be diverted onto other routes with little or no effect on travellers. The effect is not considered significant **Serious accidents resulting in pollution** to the environment are infrequent. The proposed Scheme would include measures to contain and limit the spread of liquid pollutants released onto the road. The emergency services are trained and equipped to deal with these events and the effect on the environment is not considered significant.
Riparian or surface flooding:	The potential consequences will be addressed in the Road drainage and Water Environment Chapter. A Flood Consequence Assessment has shown that there is a low risk of flooding to the proposed Scheme.

19.8 Conclusion

19.8.1 An assessment of the potential effects of Major Accidents and Disaster is not required and so has been scoped out.

20 Population and Health

20.1 Subject introduction

20.1.1 An assessment of population and health is a means of assessing the health consequences of a proposed project at the population level and to use this information to feed back into the design to maximise the positive and minimise the negative health impacts of the proposal.

20.1.2 Health assessment is multidisciplinary and cuts across the traditional boundaries of health, public health, social sciences and environmental sciences. The most commonly used definition of health assessment is taken from the World Health Organisation (WHO) Gothenburg Consensus Paper: *'……a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population'.88*

20.1.3 The broader understanding of health is captured by the WHO definition: ‘Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’.89

20.1.4 Environmental, social, economic and fixed factors, which are collectively known as ‘health determinants’ influence health and well-being. The key determinants of health can be characterised as:

a) Pre-determined factors such as age, genetic make-up and gender are fixed and strongly influence a person’s health status;

b) Social and economic circumstances such as poverty, unemployment and other forms of social exclusion strongly influence health, and improving them can significantly improve health;

c) How the environment in which people live, work and play is managed - its air quality, built environment, water quality – can damage health, or provide opportunities for health improvement;

d) Lifestyle factors such as physical activity, smoking, diet, alcohol consumption and sexual behaviour, can have significant impacts on health;

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[88] WHO European Centre for Health Policy (1999). Health impact assessment: main concepts and suggested approach. Gothenburg consensus paper. WHO Regional Office for Europe.

[89] World Health Organisation (WHO) (2007). Constitution of the World Health Organisation, Geneva, 1946.

e) Accessibility of services such as the National Health Service (NHS), education, social services, transport (especially public transport) and leisure facilities influence the health of the population.

20.1.5 Of these, only the pre-determined factors are unlikely to be influenced by a development proposal. The health assessment will therefore consider all relevant health determinants other than the pre-determined factors.

20.2 Consultation

20.2.1 No consultation has been carried out in relation to population and health. During the assessment it is proposed that the public health teams within the local authority will be consulted to obtain agreement on the approach to the assessment and to obtain any data relating to the local study area that would be useful to the assessment.

20.3 Surveys

20.3.1 It is not proposed that any surveys be carried out for the purpose of the population and health assessment. All data used will be third party data that has been sourced via a desk study and consultation with the local authority public health teams.

20.4 Assessment methodology

Policy review

20.4.1 National, regional and local policies, plans and strategies relevant to health, including National Institute for Health and Care Excellence (NICE)90 public health guidance will be reviewed to provide a rationale for the health assessment. This will also be framed within the context of the Well-being of Future Generations Act, 2015. The policy review for the assessment will include local policies relevant to health such as:

a) Health and well-being strategies; and

b) Sustainable community strategies.

20.4.2 The aim will be to identify the local health policy and review how A40 proposals may impact on local policies, both positively and negatively.

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[90] https://www.nice.org.uk/guidance/published?type=ph

Geographical scope

20.4.3 The geographical scope of the assessment will vary between different health determinants being assessed, however generally data will be assessed from the ward level (Lampeter Velfrey, Narberth Rural, Narberth and Whitland) and from the wider Pembrokeshire area as relevant. This will be aligned with the geographical scope of the community and private assets assessment.

Baseline data gathering

20.4.4 Baseline data will be collated from a range of sources to provide an overview of the existing population, existing health profile, socioeconomic conditions in the local community and the physical environment in the locale.

20.4.5 This gathering of baseline data will be coordinated with other workstreams within the EIA such as community and private assets assessment and the air and noise assessments.

20.4.6 The data reviewed will include, but is not limited to:

a) Public Health Wales publications such as Welsh Health Survey lifestyle Trends (2015);

b) Health Board Maps, Demography (2016);

c) Office for National Statistics, Census 2011 data

20.4.7 Public Health Wales has recently (2017) published a set of National Indicator Projections by local authority91[91] This includes a tool for showing projections for five key public health indicators. These indicators include:

a) Estimated proportion of adults who reported to be overweight or obese, observed 2003-2013 to projected 2016 – 2025;

b) Estimated proportion of adults who reported eating less than the recommended five portions of fruit and vegetables a day, observed 2008 - 2015 to projected 2016 – 2025;

c) Estimated proportion of adults who self reported to be current smokers, observed 2003 – 2015, projected 2016-2025;

d) Healthy life expectancy at birth (years), observed 2005 – 2010, projected 2016 – 2025; and

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[91] Public Health Wales Observatory, Public Health Outcomes Framework, 2017 - http://www.publichealthwalesobservatory.wales.nhs.uk/phof2016

e) Percentage of babies born with a low birth weight, observed 2006 – 2015, projected 2016 – 2025.

20.4.8 These data will also be reviewed and used as part of the baseline for the assessment.

Identification of health determinants

20.4.9 As discussed above, health determinants are factors that can influence the health of a community. Guidance produced by the NHS London Healthy Urban Development Unit has produced an assessment matrix (known as HUDU Rapid Health Impact Assessment Matrix)92 which identifies a list of potential health determinants that may be relevant to a given project. Table 24 lists out the health determinants which at this stage were identified as being relevant to the A40 scheme. These may be amended following a baseline review.

Table 24 Health determinants identified as relevant to the A40 Scheme

Health determinant from HUDU matrix	Relevant to Construction?	Relevant to Operation?
Housing quality and design		
Access to healthcare services and other social infrastructure	✓	✓
Access to open space and nature	✓	✓
Air quality, noise and neighbourhood amenity	✓	✓
Accessibility and active travel	✓	✓
Crime reduction and community safety	✓	✓
Access to healthy food		
Access to work and training	✓	✓
Social cohesion and lifetime neighbourhoods	✓	✓
Minimising the use of resources	✓	✓
Climate change	✓	✓

Local community to be considered

20.4.10 The health assessment will consider health and well-being status and current health problems of all people within the local community. However, vulnerable and/or disadvantaged groups can often experience health impacts more acutely than other groups within communities. The identification of vulnerable groups will also include consideration of people with protected

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[92] NHS London Healthy Urban Development Unit (HUDU), (2013). Planning for Health 'Rapid Health Impact Assessment Matrix'.

characteristics, as defined by the Equality Act 2010 and will therefore be able to consider whether there are any equality issues from the scheme that will need to be addressed.

Linking health determinants to health impacts

20.4.11 Using available literature, including previous health studies and recent research, an evidence base will be collated to identify links between the selected determinants and health impacts.

20.4.12 Impacts may be direct or indirect and links may be causal or compounding. Key reference material is likely to include:

a) Government health policies, programmes and strategies;

b) Previous health assessments for masterplans;

c) Public health reports and research papers from a range of sources, including:
    i. Public Health Wales;
    ii. WHO;
    iii. National Institute for Health and Care Excellence (NICE);
    iv. Health Development Agency (HDA).

20.5 Significance criteria

20.5.1 There is no established or widely accepted framework for assessing the ‘significant’ health effects of a development proposal. The health significance of an environmental impact is typically a function of the ‘magnitude’ and ‘duration’ of the change to health determinants, the level of exposure of the population to this change and the sensitivity of the people (receptors or population) who will experience the effect. Consideration is also given to any vulnerable groups within the population which may be particularly affected by changes to health determinants.

20.5.2 Assessment is made as to whether the effect on health determinants is:

a) Direct or indirect;

b) Positive or negative; and

c) Permanent or temporary.

20.5.3 This approach permits the assessment to provide a relative scale of effects in order to give a sense of the significance of the potential health effects.

20.5.4 The significance matrix set out in Table 25 considers the impact magnitude on health determinants against the geographical extent of exposure in the population at different geographical levels (i.e. National, Regional and Local) in order to identify the overall significance of an impact. It is not considered that there would be any effects that would be experienced on an international level from this project, so this geographical scope has not been included in this instance.

20.5.5 Where available, details of impact magnitude has been identified from other environmental assessments of the ES. It should also be noted that within the Local population exposure there may be a range of exposure from lots of the local population affected, to only a few within the local population affected. This is the reason for a range of significance levels for each impact magnitude within the local population exposure column. Within the assessment, clarification for which local geographical exposure is identified will be explained.

Table 25 Impact Significance Martix

	Geographical extent of exposure		
Impact magnitude on health determinant	**National**	**Regional**	**Local**
Very high	Major	Major	Major
High	Major	Major	Moderate- Minor
Medium	Moderate	Moderate	Minor-Negligible
Low	Moderate	Minor	Neutral
Very low	Minor	Minor	Neutral

20.5.6 The level of significance determined above can be described in more detail based on significance criteria as set out in Table 26.

Table 26 Impact Significance Martix Details

Significance level	Criteria
Major +++/--- (positive or negative)	Health effects are categorised as a major positive if they prevent deaths/prolong lives, reduce/prevent the occurrence of acute or chronic diseases or significantly enhance mental well-being would be a major positive. Health effects are categorised as a major negative if they could lead directly to deaths, acute or chronic diseases or mental ill health. The exposures tend to be of high intensity and/or long duration and/or over a wide geographical area and/or likely to affect a large number of people (e.g. over 500) and/or sensitive groups e.g. children/older people. They can affect either or both physical and mental health and either directly or through the wider determinants of health and well-being. They can be temporary or permanent in nature. These effects can be important local, district, regional and national considerations. Mitigation measures and detailed design work can reduce the level of negative effect though residual effects are likely to remain.
Moderate ++/-- (positive or negative)	Health effects are categorised as a moderate positive if they enhance mental well-being significantly and/or reduce exacerbations to existing illness and reduce the occurrence of acute or chronic diseases. Health effects are categorised as a moderate negative if the effects are long-term nuisance impacts, such smell and noise, or may lead to exacerbations of existing illness. The negative impacts may be nuisance/quality of life impacts which may affect physical and mental health either directly or through the wider determinants of health. The exposures tend to be of moderate intensity and/or over a relatively localised area and/or of intermittent duration and/or likely to affect a moderate-large number of people e.g. between 100-500 or so and/or sensitive groups. The cumulative effect of a set of moderate effects can lead to a major effect. These effects can be important local, district and regional considerations. Mitigation measures and detailed design work can reduce and in some/many cases remove the negative and enhance the positive effects though residual effects are likely to remain.
Minor/Mild +/- (positive or negative)	Health effects are categorised as minor/mild either, positive or negative, if they are generally lower level quality of life or well-being impacts. Increases or reductions in noise, odour, visual amenity, etc. are examples of such effects.

Significance level	Criteria
	The exposures tend to be of low intensity and/or short/intermittent duration and/or over a small area and/or affect a small number of people e.g. less than 100 or so. They can be permanent or temporary in nature. These effects can be important local considerations. Mitigation measures and detailed design work can reduce the negative and enhance the positive effects such that there are only some residual effects remaining.
Neutral/No Effect~	No health effect or effects within the bounds of normal/accepted variation.

20.6 Potential Mitigation Measures

20.6.1 Where impacts are identified in the population and health assessment, recommendations will be proposed to reduce any negative impacts and maximise any positive impacts on health outcomes from the proposed A40.

20.6.2 Recommendations will be fed into the design process through on-going discussions and meetings with the design team to ensure that issues related to health influence the final design.

20.6.3 Where mitigation has been identified through other EIA topic assessments (e.g. air and noise) that will serve to improve health outcomes, this mitigation will be cross-referenced within the health assessment.

20.6.4 The responsible organisation(s) and the timing of actions required to implement any recommendations made will be identified.

21 Cumulative Effects

21.1 Subject Introduction

21.1.1 Cumulative effects result from multiple actions on receptors or resources occurring in combination over time. This topic must address the two types of cumulative impact described below. The different characteristics of the assessments are most simply addressed by presenting them in separate chapters. Chapter 17 will set out the broad method of assessment and the refers the reader the two chapters 18 and 19 which assess these two types separately. The conclusions of the two assessments would then set out at the end of Chapter 17.

Type (i) **Cumulative Effects from a Single Scheme (Inter-relationships):** is the assessment of effects on receptors or receptor groups, such as local residents, users of local rights of way or services, which may be affected by different environmental effects generated by the Scheme simultaneously or concurrently. This is sometimes referred to as the 'inter-relationships' between different environmental effects. This assessment includes consideration of particular locations where several effects, for example noise, air quality and visual change, may all occur. Refer to Chapter 18.

Type (ii) **Cumulative Effects from Different Schemes** is the assessment of effects of the Scheme together with other proposed (but not yet built) developments, where there is the potential for impacts to overlap spatially or temporally. Refer to Chapter 19.

21.2 Legislation and Policy Context

21.2.1 The EIA Directive requires the EIA to consider cumulative effects and interrelationships. Cumulative effects result from multiple actions on receptors and resources and over time and are generally additive or interactive (synergistic) in nature. Cumulative impacts can also be considered as: '…impacts resulting from incremental changes caused by other past, present or reasonably foreseeable actions together with the project.' (European Commission 1999).

Planning Policy Context

21.2.2 The adopted Pembrokeshire County Council Local Development Plan 2013 (PLDP) makes reference to the importance of cumulative effects. Other references to cumulative effects relate to a requirement for development near existing residential areas to not adversely affect 'local residential amenity, either in its own right or cumulatively with other uses'.

21.2.3 The adopted PLDP highlights the importance of ensuring that the cumulative effects of development in Monmouthshire and adjoining areas do not result in harm to internationally designated nature conservation sites. The Local Development Plan also states that development in neighbourhood centres, new retail and renewable energy schemes will be permitted provided that the development, either individually or cumulatively with other recently proposed development, does not undermine vitality, attractiveness or viability.

21.2.4 There are no specific local policies relating to cumulative effects in relation to new highway development.

21.3 Relevant Guidance for the assessment

21.3.1 A range of guidance is available on cumulative effects assessment but at present there is no single, agreed industry standard method.

21.3.2 Relevant guidance taken into account in this assessment is as follows.

HA205/08 Principles of Environmental Assessment – Assessment and Management of Environmental Effects (Highways Agency et al., 2008).

Advice Note 17: Cumulative effects assessment relevant to nationally significant infrastructure projects (Planning Inspectorate, 2015).

DMRB Guidance

21.3.3 The DMRB guidance sets out in HA 205/08 (Highways Agency et al., 2008) states that there are two types of cumulative effects to be considered in environmental assessment. As set out in Section 21 above, these are (i) cumulative effects from a single scheme (referred to as 'inter-relationships').

Planning Inspectorate guidance

21.3.4 In light of the concise guidance provided in DMRB and the relevance of this more recent advice note to a major infrastructure scheme, this is considered to be the most applicable and up to date guidance and will be followed for this assessment. The Planning Inspectorate provide guidance on the approach to Type (ii) cumulative assessment.

21.4 Study Area

21.4.1 The study area for the cumulative and in combination effects assessment has been based on the zones of influence of the environmental effects of the Scheme. These will be presented in tables. The information within this chapter would be based on the baseline data and assessments provided in the topic chapters 7 to 16.

21.5 Consultation

21.5.1 Consultation regarding cumulative effects would include agreeing a list of other proposed developments for inclusion in the cumulative effects assessment. DMRB guidance states that in each case, other schemes to be considered in the assessment of cumulative effects should be determined in consultation with the local planning authority and other statutory bodies. A summary of the consultation with stakeholders undertaken for the cumulative effects assessment would be provided.

21.6 Assessment Criteria and Assignment of Significance

21.6.1 The assessment does not aim to assign significance levels; instead it is used to identify where there is the potential for cumulative effects. A statement is made as to whether the cumulative effect would be worse or better than the effects predicted for the Scheme alone, whether the cumulative effects have the potential to be more significant than the effects of the Scheme alone and, if so, whether this would be adverse or beneficial.

21.6.2 The key difficulties in any cumulative effects assessment relate to the level of detail available in relation to other proposed developments and the reliance that would need to be made on environmental assessments carried out by others.

21.6.3 For those applications at earlier stages of development or those for which EIA has not been undertaken, professional judgement and knowledge of the wider study area are employed to consider the receptors or resources that may be affected by the Scheme and the other development in question.

21.6.4 The above considerations, together with the lack of a definitive and agreed process for the assessment of cumulative effects, leads to difficulty in assigning a level of significance to cumulative effects. Nevertheless, the aim of the assessment is to present the findings of the EIA as a whole and to identify cumulative effects on particular receptors or groups of receptors. This is beneficial to understanding the environmental effects of the Scheme as a whole both alone and together with other proposed developments.

21.7 Baseline

21.7.1 For Type (i) cumulative effects, the baseline will be the identified through knowledge of the proposed Scheme and by reference to the specialist assessments under each topic heading. For Type (ii) cumulative effects the baseline will be identified by consulting the Planning Authorities to obtain details of relevant developments within the study area. A screening process would be employed to identify those Major Developments that need to be taken into consideration.

21.8 Potential effects

21.8.1 This assessment considers receptors or receptor groups, such as local residents, users of local rights of way or services that may be affected by different environmental effects generated from the Scheme simultaneously or concurrently. This may include, for example, particular locations where noise, air quality and visual change may all occur at the same time. To differentiate this assessment from the cumulative effects assessment with other proposed developments, these are referred to as ‘inter-relationships’ or ‘inter-related effects’. All of these effects would be derived from the Scheme.

21.8.2 People living locally to the Scheme may be affected adversely or beneficially. The new section of trunk road would enable traffic related effects to move from a more densely populated residential area to a less populated one. Those people living near the existing A40 trunk road would see beneficial changes in relation to noise levels and air quality but a more limited visual change. The cumulative beneficial effects have the potential to be more significant than the individual effects of the Scheme.

21.8.3 Despite the lower density of dwellings near the new section of trunk road, there are new receptors that would experience an increase in noise as a result of the new section of motorway. Although air quality changes would not breach environmental standards, there would be a change in air quality near the new section of trunk road. Changes in views from some dwellings nearby would also result from the introduction of the new section of road and would also be a new effect for these receptors. The cumulative adverse effects have the potential to be more significant than the individual effects of the Scheme and would be new significant effects for those living near the new trunk road.

21.8.4 There are a number of types of cumulative effects likely to occur during the lifetime of the Scheme. These include cumulative effects due to loss of land agricultural land and various farm holdings; and the loss of terrestrial habitat for protected species. The majority of potential cumulative impacts could arise as a result of proposed housing or solar farm developments in the vicinity of the Scheme.

21.8.5 In terms of landscape effects, other proposed development would add further urbanisation to certain landscape character areas (LCAs) and, in other areas, would be in keeping with landscape character (for example, further built development in an already urbanised area) and would not result in a significant cumulative effect on landscape. Similarly, for views, the introduction of more development and vertical elements (such as wind turbines) in some areas would not present a noticeable cumulative visual effect, while in other locations, where development represents a more noticeable change from the baseline, there may be an increase in adverse visual effects on residential receptors, users of Public Rights of Way and road users.

21.8.6 Cumulative effects between the Scheme and other planned or proposed developments may occur in respect of the setting of several cultural heritage assets.

22 Conclusion

22.1.1 The topics listed in Table 27 include all those addressed in this report. Those topics scoped-in for consideration in the EIA for the Scheme are indicated with an asterisk (*).

Table 27 Topic Chapters

Topic Chapter	**Scoped in?**	**To be covered in:**
Geology and Soils	*	Chapter 6 of the ES
Road Drainage and Water Environment	*	Chapter 7 of the ES
Nature Conservation (Biodiversity)	*	Chapter 8 of the ES
Landscape and Visual	*	Chapter 9 of the ES
Archaeology and Cultural Heritage	*	Chapter 10 of the ES
Community and Private Assets	*	Chapter 11 of the ES: Non-Agricultural Chapter 12 of the ES: Agricultural
Air Quality	*	Chapter 13 of the ES
Noise and Vibration	*	Chapter 14 of the ES
All Travellers	*	Chapter 15 of the ES
Materials	*	Chapter 16 of the ES
Heat and Radiation		Not included in the ES
Population and Human Health	*	Chapter 17 of the ES
Risk of Major Accident and Disaster		Not included in the ES
Climate Change	*	Chapter 18 of the ES
Cumulative Effects	*	Chapter 19 to 21 of the ES
Management of Environmental Effects	*	Chapter 7 of the ES

22.2 Monitoring of mitigation

22.2.1 Based on the findings of the scoping exercise and the proposed content of the ES set out in Table 27, it is considered that monitoring is likely to be required for all significant pre-mitigation impacts of the scheme. All of these impacts and proposed mitigation were set out in the draft ES chapters. The objective of monitoring is to demonstrate the effectiveness of the proposed measures and to identify if any further mitigation is required to meet the mitigation objectives.

Geology and soils

22.2.2 The assessment indicates that there are potential water-related effects in construction that would require monitoring. During construction excavated materials and wastes would arise from excavation. Monitoring of materials is set out below under paragraph 22.2.12.

Road drainage and water environment

22.2.3 No significant effects are expected, but during construction there is potential for effects on groundwater (refer to Geology and soils) paragraph 22.2.2.

Ecology

22.2.4 European Protected Species (EPS) licences are likely to be required for the project during construction. Licences would include a requirement for monitoring, in particular:

a) Use of mammal crossings (underpasses and tunnels) bats, otter, dormouse, badger

b) Replacement badger sett use

c) Use of bat boxes

d) Habitat: see 22.2.5

Landscape and visual impact

22.2.5 The need for monitoring of landscape mitigation is based on two main requirements:

a) The achievement of the target percentage cover of grassed areas and planting within 15 years of aftercare in accordance with as set out in DMRD Volume 10, with proportionate interim targets during the 5 years of contract aftercare;

b) Achievement of the objectives of mitigation for significant effects by the Design Year, with proportionate interim targets during the 5 years of contract aftercare;

Cultural Heritage

22.2.6 None required for archaeology within the land take of the Scheme. Monitoring required for the mitigation of impacts on the settings of designated and HER sites. This mitigation will be provided under the landscape and visual impact, see paragraph 22.2.5.

Community and private assets

22.2.7 Monitoring required for the achievement of mitigation for the significant impact on Bethel Chapel, see landscape and visual impact assessment in paragraph 22.2.5.

Air Quality

22.2.8 During construction, there is potential for the mobilisation of dust due to the nature of the works to construct the Scheme. The potential effect of this dust mobilisation is soiling upon receptors within the vicinity of the works. The assessment of construction dust will determine the scale of these potential effects and will aid in identifying appropriate mitigation measures. The mitigation measures are designed so that any residual effect is not significant.

22.2.9 During operation, it is anticipated that much of the traffic that currently passes through Llanddewi Velfrey would bypass the village. By moving this traffic further away from receptors improvements in air quality can be expected. Where the Scheme brings traffic closer to receptors a deterioration in air quality can be expected. In both circumstances, it is anticipated that air quality would remain below the air quality standards.

Agricultural Assessment

22.2.10 Post-construction monitoring required to ensure that measures to maintain access to farms and fields meet the mitigation objectives.

Noise and Vibration

22.2.11 The prediction and assessment methodologies set out in Section 14.5 would be used to support the verification of the effectiveness of mitigation measures.

22.2.12 Welsh Government has a duty to assess noise levels following the opening of the Scheme to traffic. The purpose of this is to establish the buildings which previously did not qualify for an original offer of carrying out or making a grant in respect of carrying out noise insulation work, but which would have become eligible by virtue of increased traffic flow.

All Travellers

22.2.13 No monitoring required because no significant pre-mitigation effects are likely. Monitoring of landscape measures that provide a setting for footpaths would be carried out, see paragraph 22.2.5.

Materials

22.2.14 Procedures would be adopted by the Contractor prior to construction to control and reduce the use of materials. This would be monitored and documented in the Site Waste Management Plan (SWMP) for the Scheme which would form part of the CEMP. The SWMP would detail the estimated quantities of waste material and the opportunities for reuse, recycling, recovery or disposal.

22.2.15 Materials would be responsibly sourced (i.e. must have a certified provenance, traceability and sustainability) where possible, in order to reduce the impact on material resources.

Population and Human Health

22.2.16 No significant adverse effects are likely and so no monitoring is proposed.

Climate Change

22.2.17 No monitoring is proposed.

Appendix: Drawings

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement

Appendix 4.2: Scoping Responses

From:	Edwards, Louise
To:	Andrew Sumner
Subject:	RE: A40 Llanddewi Velfrey Improvements: Environmental Liaison Meeting 23rd August 2017 11am
Date:	03 October 2017 14:58:56
Attachments:	image001.png image002.jpg image003.jpg image004.jpg

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Hi Andrew

We have assessed the Scoping opinion dated 04/08/17 and agree with the proposed level of survey work to be undertaken, specific topic area comments are as follows.

Nature Conservation
Species
We have no comment to make on the scoping document as we have previously informed Pete Wells of the surveys which are required for the scheme. We request to again be consulted following completion of surveys prior to the publication of the Environmental Statement (ES). We welcome ongoing discussions throughout the process and note that mitigation and enhancement measures will be discussed through the Environmental Liaison Group

Designated Sites
We are satisfied with the level of surveys undertaken to date and note that the potential for effects on European designated sites will also be addressed in the Assessment of the Implications on European Sites (AIES).

Lichens.
We would like to see a lichen survey undertaken that maps out what is there along the proposed route, what might be at risk of damage as a result of the scheme (either through direct damage through felling or by impact from vehicular emissions). Consideration of any sensitive species that may require translocating and how you will mitigate loss.

Landscape and visual

We are generally in agreement with the methodology proposed for the Landscape and Visual Impact Assessment, but have the following detailed recommendations:

Please ensure that the most recent updated versions of LANDMAP and relevant LANDMAP Guidance Notes are being used in the assessment.

We recommend that the ES should include an assessment of the landscape and visual effects in relation to the principles of Sustainable Management of Natural Resources and the Well-being goals, as set out in the Environment Act and Well-being of Future Generations Act.

Regional Landscape Character Areas published by CCW, please note that Natural Resources Wales (NRW) has published National Landscape Character Areas for Wales.

We recommend that the ES take account of any Local Landscape Character Assessments. Please refer to Pembrokeshire County Council.

We refer to paragraphs 10.4.13 and 10.4.15, we recommend that 5 categories of sensitivity are used to allow greater accuracy of assessment – High, High-Medium, Medium, Medium-Low and Low. This would allow greater accuracy of differences of sensitivity to be identified.

The LVIA should include an assessment of the impact of lighting and effects on tranquillity.

An assessment of cumulative effects needs to be included within the LVIA, to include other existing and proposed infrastructure and built development which has the potential for cumulative effects with the proposed scheme.

Please note that advice relating to historic landscape and landscapes included in the Register of Landscapes of Historic Interest in Wales will be provided by Dyfed Archaeological Trust.

Road Drainage and Water Environment.
The proposed route of the road is not within the Development Advice Maps, which are used in conjunction with Technical Advice Note 15 Development and Flood Risk and does not affect main rivers. Therefore, we can confirm that No Flood Consequence Assessment is required.

You are advised to speak to Pembrokeshire County Council's land drainage department for any advice on culverting or other activities likely to affect ordinary watercourses.

The design of the scheme to be included within the ES should include the location and construction of soft and hard surface water drainage features to deal with construction runoff waters and water from the built road.

We refer to paragraph 8.7.14, please explain what is meant by the term 'spillage risk return period'? It is our understanding that you can calculate return periods for flood risk but how does it work with accidental spillages?

I'm happy to put this into a formal letter if you require it.

I hope the above is helpful, please do not hesitate to get in touch with me if I can assist you further.

Kind regards
Louise

Louise Edwards
Teitl swydd/Job title: Senior Development Planning Advisor - Uwch Ymgynghorydd Cynllunio Datblygu
Cyfoeth Naturiol Cymru / Natural Resources Wales
Ffôn/Tel: 03000 65 3573

E-bost/E-mail:
louise.edwards@cyfoethnaturiolcymru.gov.uk louise.edwards@naturalresourceswales.gov.uk

Gwefan / Website:
www.cyfoethnaturiolcymru.gov.uk / www.naturalresourceswales.gov.uk

Ein pwrpas yw sicrhau fod adnoddau naturiol Cymru yn cael eu cynnal, gwella a'u defnyddio yn gynaliadwy, yn awr ac i'r dyfodol.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future.

From: Andrew Sumner
Sent: 10 August 2017 14:51
To: Emails Redacted for privacy purposes

Subject: A40 Llanddewi Velfrey Improvements: Environmental Liaison Meeting 23rd August 2017 11am

Good afternoon

Further to my invitation to the second A40 Llanddewi Velfrey ELG meeting, which I confirm will be held on the 23rd August 2017 at 11am, at the Natural Resources Wales offices in Haverfordwest. The address is given below.

We will circulate an agenda shortly before the meeting.

For your information, I attach drafts of

- Meeting agenda
- Minutes from the previous meeting (including the agreed ELG Objectives)
- EIA Scoping report

We will be providing a buffet lunch at around 12 noon.

Natural Resources Wales address:
Llys Afon (Hawthorn Rise)
Haverfordwest
Pembrokeshire
SA61 2BQ
United Kingdom

We look forward to seeing you at the meeting.
Regards
Andrew

Andrew Sumner
Principal Landscape Architect
Richards, Moorehead & Laing Ltd

Telephone: 01824 704366 ext. 109

Mobile: 07702 369308

cid:image004.jpg@01D19CB8.AE402550

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Impact Assessment: Screening Report (and Record of Determination)

A40LVP-RML-EGN-SWI-RP-LE-0005

P09 | S4
28/11/18

P04	18/09/17	REVISED TO ADDRESS COMMENTS FROM ECAT	AS
P03	24/08/17	REV3	AS
P02	16/08/17	REV 2	AS
P01	14/08/17	PRELIMINARY VERSION	AS
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1 Purpose of this report

1.1.1 This Screening Report describes the approach taken with regards to determining whether an Environmental Impact Assessment (EIA) is required.

1.1.2 The applicable determining legislative instruments are: the Highways Act 1980; EU Directive 2014/52/EU of 2014 (which amended the 2011 Directive); and the Environmental Impact Assessment (Miscellaneous Amendments relating to Harbours, Highways and Transport) Regulations 2017.

1.1.3 In accordance with the provisions under the EIA Regulations, a determination must be made to confirm whether a proposed project constitutes an EIA development i.e. whether an EIA process is required, and a statutory Environmental Statement (ES) must be prepared and accompany the consent process for a proposed scheme.

1.1.4 The project would be delivered in accordance with the Design Manual for Roads and Bridges (DMRB): Volume 11 Environmental Assessment guidance. This report has been developed in accordance with the requirements of DMRB Volume 11 Section 2 Part 3 (HD47/08) and IAN 126/09(W).

1.1.5 The following information is provided within this report (as required by Directive 2011/92/EU as amended by Directive 2014/52/EU) as transposed through the Highways Act (1980) and The Environmental Impact Assessment (Miscellaneous Amendments Relating to Harbours, Highways and Transport) Regulations 2017, which came into force in December 2017. This screening report gives due consideration to the specific requirements Article 4, Annex IIA and Annex III.

1.1.6 Article 4(4) states:

> *"Where Member States decide to require a determination for projects listed in Annex II, the developer shall provide information on the characteristics of the project and its likely significant effects on the environment. The detailed list of information to be provided is specified in Annex IIA. The developer shall take into account, where relevant, the available results of other relevant assessments of the effects on the*

> *environment carried out pursuant to Union legislation other than this Directive. The developer may also provide a description of any features of the project and/or measures envisaged to avoid or prevent what might otherwise have been significant adverse effects on the environment."*

1.1.7 Annex II.A requires:

1.1.8 A description of the project, including in particular:

a) a description of the physical characteristics of the whole project and, where relevant, of demolition works;

b) a description of the location of the project, with particular regard to the environmental sensitivity of geographical areas likely to be affected.

c) A description of the aspects of the environment likely to be significantly affected by the project.

d) A description of the measures and/or features which are proposed to avoid or prevent significant adverse effects.

e) A description of any likely significant effects, to the extent of the information available on such effects, of the project on the environment resulting from:

  i. the expected residues and emissions and the production of waste, where relevant;

  ii. the use of natural resources, in particular soil, land, water and biodiversity.

f) The criteria of Annex III shall be taken into account, where relevant, when compiling the information.

2 Scheme Context and Programme

2.1 Introduction

2.1.1 Following the completion of a study looking at a range of transport options, the Transport Framework for Wales (2001) identified that the A40 west of St Clears was in need of improvements.

2.2 Location of the project

2.2.1 The Scheme lies on the A40 Trunk Road entirely within the eastern portion of the County of Pembrokeshire in South West Wales.

2.2.2 A number of options were considered for this Scheme and these would all commence on the existing A40 at Penblewin Roundabout and terminate on the A40 Trunk Road at Bethel Chapel, which lies approximately 1km to the east of Llanddewi Velfrey. A plan showing the location of the route is provided in Appendix 1.

2.2.3 The proposed 4.3km Improvement Scheme consists of a 2.2km bypass of the village of Llanddewi Velfrey, which traverses the northern slopes of a prominent ridge, and a 2.1km improvement that continues west, on lower-lying ground, from the small settlement of Ffynnon to Penblewin roundabout on an alignment that is parallel and close beside the existing road.

2.3 Development of the Scheme

2.3.1 In March 2002, the Trunk Road Forward Programme (TRFP) outlined that *Improvement of the A40 trunk road, whether it be to single or dual carriageway standard, is beneficial in economic terms'* and stating that *'The A40 in West Wales forms the lowest standard section of the Trans-European Road Network in the United Kingdom.* This early work steered the decision to pursue road-based enhancements on the A40 and a Route Options Report (ROR) was subsequently commissioned in 2004 to explore single and dual carriageway options. This considered a total of eight options to bypass the village of Llanddewi Velfrey with the section from Ffynnon Wood to Penblewin included as a maintenance scheme.

2.3.2 Each of the options were appraised using the STAG appraisal guidance and the 2004 ROR concluded that a number of route options could be discarded on the basis of cost, environmental impact and not addressing the identified problems; whilst other routes that would address the problems and performed better in the appraisal process, were taken forward for further consideration in a Technical Appraisal Report (TAR) later in 2004.

2.3.3 As part of the 2004 studies, a number of horizontal alignments were developed to determine optimum routes that would minimise agricultural severance, avoid sensitive ecological features and large earthworks. In the same year, a DMRB Stage 2 Environmental Appraisal Report (EAR) was also completed and a Business Case was developed and formed the basis of a submission to the Assembly Minister.

2.3.4 Following the findings of the appraisal within the 2004 studies, the Welsh Government announced the publication of an addendum to the 2002 Trunk Road Forward Programme and this included two major improvement schemes for the A40 west of St Clears:

a) **A40 Penblewin – Slebech Park improvement** - completed in March 2011; and

b) **A40 Llanddewi Velfrey to Penblewin improvement** - focus of this report.

2.3.5 Following this announcement, an addendum to the 2004 Technical Appraisal Report was completed in 2006. Two further route options were considered with single carriageway and 2+1 carriageways considered. The two options considered further were:

a) **Option 5**, **The Central Route** – close to the existing trunk road network;

b) **Option 8**, **The Northern Route** – that took a route around the north of Blaen-pen-troydin wood and Llanddewi Velfrey village centre.

2.3.6 In addition, consideration was given to the section between Ffynnon Chapel and Penblewin Roundabout which would be the same for both schemes. The 2006 study explored:

a) **Online improvements** following the existing alignment;

b) **Online 2+1 standard**; and

c) **Offline 2+1 standard**.

2.3.7 The 2006 report recommended that all of the above options should be taken forward for public consultation. A consultation process was subsequently completed in 2006 over an eight-week period with a public exhibition held in Llanddewi Velfrey on 13 and 14 September 2006. In summary, the consultation sought views on the following route options:

Blue route:	a bypass option to the north of Llanddewi Velfrey from Gwyndy Farm to Ffynnon Wood.
Red route:	an option which follows closely the existing trunk road.
Orange route:	online improvement of the existing trunk road between Ffynnon Wood and Penblewin Roundabout.
Purple route:	offline improvement between Ffynnon Wood and Penblewin Roundabout.

These routes are shown in the Design Options Report published in 2015; a copy of which is contained in Appendix 3.1.

2.3.8 The consultation showed clear public support for improving the section of the A40 between Gwyndy Farm and Penblewin Roundabout. There was a clear preference expressed for the Blue route, however no clear preference emerged for either the Purple or Orange routes. The consultation showed there was strong support for the proposed bypass of Llanddewi Velfrey between Gwyndy Farm and Ffynnon Wood. Of the options presented, the Blue Route was preferred. Whilst there was also overall support for improvements to the section of A40 between Ffynnon Wood and the Penblewin Roundabout, there was no clear preference expressed on the routes presented.

2.3.9 Following this consultation, the Llanddewi Velfrey to Penblewin Scheme was included within the reprioritisation of the TRFP in 2008 and has since received continued ministerial support.

2.3.10 Publication of Preferred Route occurred in 2010, with a Report on the previous Public Consultation in 2006 published in February of 2010. The Deputy First Minister decided to adopt the Blue Route as the Preferred Route to bypass Llanddewi Velfrey and the Purple Route as the Preferred Route between Ffynnon Wood and Penblewin. The TR111 Preferred Route Plan was published to protect the entire route for planning purposes under the Town and Country Planning (General Development Procedure) Order 1995. This means that the Local Planning Authority must refer to the Welsh Government all future planning applications that are near the Preferred Route. The TR111 plan was deposited at the Pembrokeshire County Council offices in Haverfordwest, in the Post Office in Narberth and the Welsh Government offices in Cardiff.

2.3.11 The TR111 Plan showing the line of the Preferred Route is included in Appendix 3.2.

2.3.12 In July 2013, Edwina Hart, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. This statement included:

> *"Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements."*

2.3.13 A Strategic Outline Case for the A40 Llanddewi Velfrey to Penblewin Improvement was produced by the Welsh Government in June 2014. It concluded that the Scheme would be likely to provide benefits that outweighed its costs with a Benefit to Cost Ratio (BCR) of around 1.1[1]. It was suggested that the figure understated the level of benefits of the Scheme as it only considered the Scheme in isolation and, as the BCR is calculated at a UK level, underestimated the local benefits. It was set out that:

> *"The allocation of additional CRC funding would ensure increased certainty for the delivery of the A40 Llanddewi Velfrey to Penblewin Scheme in accordance with the commitments made in the National Transport Plan. In addition, it would enable re-allocation of Transport Capital funding to other projects where budgetary constraints present a significant risk to the delivery of commitments made within the Prioritised National Transport Plan (PNTP)."*

2.3.14 The proposals for A40 improvements were further expressed by the Welsh Government in November 2014 following the announcement of the closure of the Milford Haven Refinery. Reflecting on this announcement, the Minister made the following oral statement in Plenary:

> *"In terms of transport links… I have instructed my officials to accelerate to the fullest extent possible the programme for*

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[1] Welsh Government A40 Llanddewi Velfrey to Penblewin Improvement Strategic Outline Case June 2014.

> *delivering improvements at Llanddewi Velfrey. I have also asked my officials to conduct further urgent work to explore additional ways to improve the A40, including the potential for dualling.”*

2.3.15 A study in 2015 considered options for improvement of the A40 including the A40 Llanddewi Velfrey to Penblewin improvement, applying the Welsh Transport Planning and Appraisal Guidance (WelTAG) in 2008. This included the committed scheme which had emerged through previous development work and was referenced within the Pembrokeshire LDP. WelTAG is an appraisal method for assessing proposed strategies, plans and schemes. It is intended to provide information about significant economic, environmental and social impacts so that decision makers can judge the merits of proposals using a consistent approach.

2.3.16 The study concluded:

> *“There remains a good case for proceeding with the A40 Llanddewi Velfrey to Penblewin improvement Scheme, using the 2+1 configuration which is currently included in the National Transport Schedule [and] The Scheme includes unambiguous lengths for overtaking, would address community severance in the village of Llanddewi Velfrey and deliver small improvements to journey times, journey reliability and road safety on the A40”.*

2.3.17 In February 2017, the Welsh Government appointed Carillion - with Arup and RML as their technical advisors - to develop the design of the proposed A40 Llanddewi Velfrey to Penblewin Improvements up to publication of draft Orders. The contract was awarded on the basis of a northern bypass for Llanddewi Velfrey from Gwyndy Farm to Ffynnon Wood and an offline improvement from Ffynnon Wood to Penblewin. The original contract required the team to build on the previous work, and to carry out a WelTAG Appraisal in accordance with the new 2017 draft Guidance. The WelTAG appraisal approach was applied to identify the problems on the existing A40, Scheme objectives and solutions to be incorporated within the Scheme.

2.3.18 Since the liquidation of Carillion in January 2018, a new contract was awarded to Arup - supported by RML - to complete the WelTAG process and to continue with developing the Scheme.

2.3.19 The WelTAG Stage 1 built on previous development work, taking into account the outcome of the 2006 consultation work, along with a do minimum option (to assess the current conditions in a future year taking into account planned and committed measures) and a public transport intervention. The WelTAG Stage 1 Report recommended Highway Option A for further consideration from those described below:

Option 1: Do Minimum: limited intervention reflecting the existing situation with the addition of any planned or committed measures as identified in the Pembrokeshire LDP.

Option 2: Public Transport Improvements: improvements to existing public transport services which would increase the frequency and operating hours of the bus service #322 between Carmarthen and Haverfordwest.

Option 3: Highway Option A: An offline option taking a route north of Llanddewi Velfrey (along a similar line to the previous Blue option) and reflecting previous public opinion, along with an offline improvement between Ffynnon Wood and Penblewin Roundabout (along a similar line to the previous (Purple option), offering maximum extents of 2+1 carriageway.

Option 4 – Highway Option B: An offline option taking a route north of Llanddewi Velfrey (along a similar line to the previous Blue option) and reflecting previous public opinion. The option would then re-join the existing A40 in the Ffynnon Wood area with limited interventions proposed between Ffynnon Wood and Penblewin (along a similar line to the previous Orange option).

2.3.20 WelTAG Stage 2 involved the assessment of three different variations on Highway Option A which included alternative alignments and junctions.

a) A four-armed roundabout provided at either end of the Scheme, with no intermediate junction, but a parallel road from Penblewin to provide local access to Ffynnon and several access roads that would be severed by Highway Option A.

b) A four-armed roundabout would be provided at either end of the Scheme, with intermediate T-junctions to allow local traffic to join from the north (Ffynnon), and south (Llanddewi Velfrey). A parallel road from Penblewin would also provide local access to

Ffynnon and several accesses that would be severed by Highway Option A.

c) A four-armed roundabout would be provided at the western end of the Scheme and T-junctions at the eastern end of the Scheme, with intermediate T-junctions to allow local traffic to join from the north (Ffynnon), and south (Llanddewi Velfrey). A parallel road from Penblewin would also provide local access to Ffynnon and several accesses that would be severed by Highway Option A.

2.3.21 A 'do minimum' option was also appraised. This reflected the existing situation with only limited intervention on the A40, but also taking account of any planned or committed measures as identified in the Pembrokeshire LDP. The full assessment is set out in the published WelTAG Stage 1 and Stage 2 reports.

2.3.22 The appraisal showed that variation (3) provided the best long term, sustainable solution. It met most of the objectives and, alongside variation (2), best addressed social and cultural criteria. All options performed badly against environmental criteria, but variation (3) performed better than the others regarding effects on air quality and noise. Variation (3) also performed best on economic criteria. The WelTAG Stage 2 report recommended that variation (3) be taken forward for WelTAG Stage 3 appraisal.

2.4 The problems

2.4.1 Consultation with key stakeholders, including the Local Authority, Welsh Government Departments and the Regional Transport Planner, identified the following problems. The Project Objectives (Section 3.2) and Environmental Objectives (Section 3.3) are cross-referenced below to demonstrate how the Welsh Government intend to address the identified problems. The statement 'data gathered for the Scheme' refers to the WelTAG Stage 1 Impact Assessment Report.

a) The road is substandard with a narrow carriageway, numerous private means of access directly from the carriageway and narrow verges.

Evidence: The road is substandard and where overtaking provision does exist it is currently not spread along the length of the A40 such as there are long lengths in each direction with no safe overtaking opportunities.

Scheme Objectives 01 & 04

Environmental Objectives A16, A19

b) **Where overtaking provision exists, it is not spread along the length of the A40 such as there are long lengths in each direction with no safe overtaking opportunities. Limited overtaking opportunities lead to poor journey time reliability and driver frustration.**

Evidence: The A40 currently offers limited areas which allow safe unambiguous overtaking opportunities. There is inconsistency in the level of overtaking provision between the eastbound and westbound directions.

Journey time reliability is a problem when drivers get stuck behind a slow-moving vehicle and cannot overtake. As section 3.2.53-62 explains, the types of accidents occurring demonstrate the risks drivers take because they are frustrated by lack of overtaking opportunities. 43% of accidents occurred due to vehicles veering onto the opposite side of the carriageway.

The 2015 study and associated business survey confirmed that there is a perception that the employment areas in the region are considered to be remote as a result of the low standard of accessibility by road, including the lack of safe overtaking opportunities, which causes delays when there are slow moving vehicles, creating increased journey times

Scheme Objectives s 01, 02 & 03

c) **Convoys of heavy goods vehicles from the ferry ports and slow-moving agricultural vehicles contribute to periods of platooning and journey time unreliability, which is exacerbated with limited overtaking opportunities.**

Evidence: Traffic data (see section 3.2 of the IAR) shows a small peak in traffic in the eastbound direction which links in with the arrival of ferry traffic.

Speeds along the A40 vary when activity at the Port is high, with industrial and commercial vehicles, as well as tourists using the A40 as a strategic link.

Platooning, exacerbated by the mix of traffic including large agricultural vehicles, causes delays.

Journey time unreliability is worst on Friday PM peaks, caused by long distance commuters returning home to the County and weekend visitors arriving.

Scheme Objectives 01, 02, 04 & 08

Environmental Objectives A15, B1, B2, B5

d) **Seasonal spikes in traffic volumes along the A40 especially during the summer months leads to slow moving traffic causing journey**

time unreliability, which is exacerbated with limited overtaking opportunities.

Evidence: Journey speeds and unreliability of journey times are a greater problem in summer months when there is an increase in traffic levels caused by tourists.

Traffic data (see section 3.2 of the IAR) shows traffic volumes in August are some 26% higher than the annual average.

This increase in traffic volumes and associated increase in slow moving vehicles such as caravans is known to exacerbate some the journey time unreliability and safe overtaking problems on the A40.

Scheme Objectives 01, 02, 04 & 08

Environmental Objectives A15, A16, B1, B2, B5

e) **The community of Llanddewi Velfrey is severed by the A40, which reduces accessibility, increases risks of non-motorised user accidents and results in noise and air pollution.**

Evidence: Vehicles travel through the populated area of Llanddewi Velfrey at speeds of up to 40mph, which impacts on physical linkages as well as the overall amenity of the settlement. This causes severance.

Conflict is known to occur in relation to Non- Motorised Users (NMUs) crossing the A40 within the settlement of Llanddewi Velfrey and also NMUs using the sub-standard footways on sections of the A40 within the study area.

Section 3.4 of the IAR explains that where the road passes through the village there are undesirably high noise levels for outdoor spaces and high levels of indoor noise assuming standard glazing arrangements.

Whilst no monitoring of air quality has yet been undertaken in the vicinity of the route, traffic passing through would contribute to air pollution.

Scheme Objectives 01 to 08

Environmental Objectives A15, B1, B2, B5, B6, B9

f) **There are many side road junctions and direct accesses to properties and agricultural fields off the A40, which contributes to operational problem when traffic slows to allow vehicles turn off the road, or with slow moving vehicles pull out into the road.**

Evidence: Within the 5km section of the Scheme there are approximately 35 accesses or side roads directly onto the trunk road. This contributes to journey time unreliability and risk of accidents when traffic joins or leaves the main carriageway. Data gathered for the Scheme demonstrates how how existing visibility splays at priority junctions along the A40 and conflicts between vehicles approaching behind those waiting to turn from the main A40 carriageway with substandard design issues may have contributed to fatalities and serious accidents occurring.

Scheme Objectives 01, 02, 04

Environmental Objectives A16, A19, B5, B6, B9

g) **A mix of traffic types, including agricultural vehicles, using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents. The new road will provide separate routes to access private properties and fields.**

Data gathered for the Scheme shows a traffic make-up of 74% cars, 18% LGV and 8% HGV. The A40 is also used by slower moving agricultural vehicles as well as seasonal tourist traffic (including caravans). This make up contributes to problems associated with platooning and overtaking.

Scheme Objectives 01, 02, 04, 05, 06 & 08

Environmental Objectives A15, A16, A19, B1, B2, B5, B6, B9

h) **A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.**

Data gathered for this Scheme shows higher than average car ownership and lower than average numbers of households without access to a car. Public transport data illustrates that services in the study area are generally infrequent and operate fairly short hours of service; this, combined with non-competitive journey times when compared car-based journeys makes public transport an unattractive journey choice.

Scheme Objectives 01, 02, 03, 06, 07

Environmental Objectives B5, B6, B9

2.5 Scheme objectives

2.5.1 A number of transport planning objectives were developed iteratively during previous development work and engagement on the A40 project, aiming to address one or more of the identified problems. During the early stages of Key Stage 3, the problems and objectives were refreshed during a focused workshop event with key stakeholders to take into account the WelTAG 2017 guidance and Well-being of Future Generations (Wales) Act well-being goals. The Scheme objectives are:

O1 To improve network resilience and improve accessibility along the east-west transport corridor to key employment, community and tourism destinations.

O2 To improve prosperity and provide better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard, Milford Haven and Pembroke Dock.

O3 To reduce community severance and provide health and amenity benefits.

O4 To reduce the number and severity of collisions.

O5 To promote active travel by cycling, horse riding and walking to provide opportunities for healthy lifestyles.

O6 To deliver a scheme that promotes social inclusion and integrates with the local transport network to better connect local communities to key transport hubs.

O7 Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.

O8 Give due consideration to the impact of transport on the environment and provide enhancement when practicable.

2.6 Environmental Objectives

What we want to achieve

A ***Avoid or mitigate impact to provide:***

i. Minimise net loss of important habitat.
ii. Maintenance of existing habitat connectivity.
iii. No adverse impact on biodiversity.
iv. Protection of watercourses and water quality.
v. Effective landscape integration.
vi. Effective visual screening of the new road.
vii. An overall reduction in visual impact caused by through traffic.
viii. Safe carriageway crossings.
ix. Zero waste to landfill.
x. Minimal carbon footprint.
xi. Protect farms and other local businesses.
xii. Avoid or mitigate impact on cultural heritage to provide no permanent adverse impact on historic environment assets.

B ***Benefits to be achieved by the Scheme***

xiii. Overall reduction in traffic noise for residential properties.

xiv. Improved air quality for the residents of Llanddewi Velfrey.

xv. Habitat creation and improved habitat connectivity integrated effectively with the landscape through good design.

xvi. Improve the impact of road drainage on water quality.

xvii. Improve access to, and enhance enjoyment of, the landscape and of any visible historic assets associated with the road corridor.

xviii. Enabling walking cycling and healthy lifestyles.

xix. Support education, learning and community involvement by maximising educational opportunities based on cultural and natural heritage assets.

xx. Research effective soil and vegetation management as a means of reducing whole life cost of the soft estate.

xxi. Support community life and economic viability through enhanced cohesion and destination creation.

2.6.1 We want to achieve mitigation and benefits by aligning with the ways of working set out in the Well-being of Future Generations Act:

a) Compliance with legislation.

b) Delivery of Welsh Government policy.

c) Work effectively together throughout the development of the project.

d) To offer a full and open exchange of information and views during project development to make sure that the right project for Wales is published.

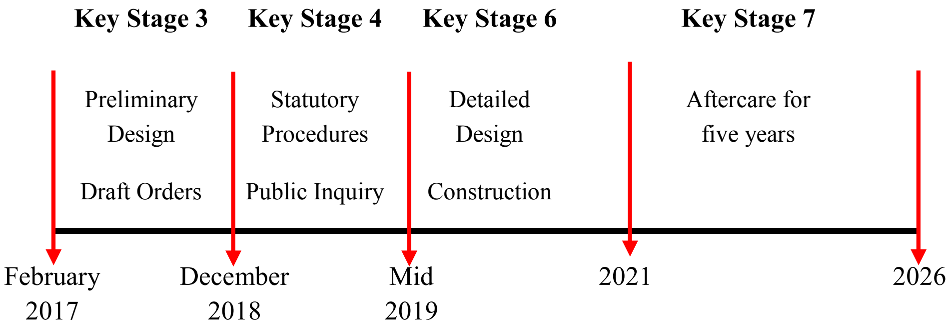
e) To work together to develop deliverable and effective environmental mitigation.

2.7 Programme

2.7.1 The Preferred Route Announcement was made in February 2010. Procurement of Services for the current contract began in early 2016 and were completed with the appointment of Carillion in February 2017. Subsequently, as a consequence of Carillion not being able to continue with the contract, a new contract was established with Arup in August 2018 and work recommenced, although this circumstance led to a delay in taking the Scheme to draft Orders.

2.7.2 The key dates for progressing the contract are set out in Table 1.

Table 1 Project Timescales



3 Description of the project

3.1.1 A 4.3km length of the A40 Trunk Road would be improved. Currently the road is a single carriageway with few places for overtaking. The road has poor visibility and has a large number of accesses to fields, farms and private property opening straight onto the road. During the summer, the amount of traffic can increase considerably compared to the winter. This road A40 runs through the village of Llanddewi Velfrey, splitting the community in two.

3.1.2 The proposed improvements include a 2.2 km northern bypass to the village of Llanddewi Velfrey and a 2.1 km improvement that continues west to Penblewin Roundabout on an alignment that is parallel and close beside the existing road. The Scheme would provide overtaking opportunities in both directions.

3.1.3 Starting in the west, at the existing Penblewin Roundabout, the Scheme would require an enlarged roundabout to accommodate the necessary five arms connecting with the A478 and the existing detrunked A40 connecting with the existing service area. The Improvement Scheme would leave the roundabout immediately to the north of the existing A40 and extend, in parallel, westward on an embankment and then almost at grade, for a distance of 1.2 km. The existing road would be detrunked to provide local access to properties to the south. A number of Private Means of Access (PMA) and field gates would be severed on the north side, so a single lane road would be constructed to carry local traffic to these PMAs and fields. A balancing pond would be required at around chainage 300 to receive road drainage for discharge into a minor watercourse which flows south.

3.1.4 The landscape is gently undulating hedged pastureland rising to the north and sloping southwards towards a minor water course to the south.

3.1.5 At chainage 1,200 there is a junction on the existing A40 with a minor county road on the south side. There is a small former gate lodge which is of some heritage value, although not designated. On the north side there is a PMA and public bridleway. The proposed improvement would close both routes. In mitigation, the existing detrunked road would connect to the southern local road at the former junction, while the proposed new single lane local road would link to the northern

PMA. An equestrian underpass would be constructed to carry the bridleway under the proposed A40.

3.1.6 From chainage 1,200 to 1,900, the proposed Scheme would use the line of the existing A40, although the improved alignment would deviate to north and south of the existing carriageway, which is on embankment as it passes through the small settlement of Ffynnon and through Ffynnon Wood. Construction is likely to require the felling of some woodland trees. Watercourses cross the existing road here, but the proposed Scheme would not require any changes to the existing culverts.

3.1.7 A new staggered junction would be required between chainage 1,900 and 2,100 to allow access on the north side to Ffynnon and to several more isolated properties on the north side of the road. The south arm of the junction would provide a link to the detrunked A40 through the village of Llanddewi Velfrey. A balancing pond would be required on the south side to receive highway drainage for discharge into a minor watercourse which flows west.

3.1.8 From chainage 2,100 the proposed road would continue in a straight alignment, leaving the line of the old A40, which curves southwards to along the crest of a prominent ridge to pass through Llanddewi Velfrey. The new road would traverse the north side of the ridge, with gradient of the slope steepening to the east. To maintain the vertical and horizontal alignment the carriageway would require a cutting up to 4m deep and then embankment up to 8m high. A farm underpass would be required to link farms on the north with severed land to the south. The underpass would also carry a public footpath.

3.1.9 Further east, the ridge is increasingly deeply incised with small wet, wooded valleys and intervening pastureland. The bypass curves southwards as it continues to traverse the ridge first into a cutting to pass under a county road which links Llanddewi Velfrey to Llanfallteg to the north. The road would be carried over the bypass on a new bridge.

3.1.10 Continuing eastwards the bypass crosses several small wooded valleys on a major embankment of up to 15m height and would require the clearance of woodland and the construction of culverts to cross minor watercourses. Mammal underpasses are proposed along the route to mitigate for the severance of the woodland wildlife corridors. An underpass would also be required to carry several diverted public footpaths under the Scheme. A balancing pond would be required on the north side to receive highway drainage for discharge into a minor watercourse which flows north.

3.1.11 Continuing east, the new carriageway would pass into a deep cutting and then return to the alignment of the existing A40. This would require a new four-arm roundabout connecting with the detrunked A40 serving Llanddewi Velfrey and a Private Means of Access to Bethel Chapel and a number of properties to the north. The southern link would tie-in to the detrunked A40 through Llanddewi Velfrey. Eastwards, a 500m length of improved carriageway would tie-in with the existing A40. A balancing pond would be required on the south side to receive highway drainage for discharge into a minor watercourse which flows north.

4 The Screening Process

4.1.1 Although the proposed project does not constitute an Annex I project, Annex II projects are defined as all projects not listed within Annex I of the EIA Directive that are not considered to be strictly maintenance projects. In order to confirm whether the project is considered a 'relevant project' under EIA Regulations, the thresholds of size and environmental sensitivity are applied. Essentially an Annex II 'relevant project' is defined as:

4.1.2 a project for constructing or improving a highway where the area of the completed works together with any area occupied during the period of construction or improvement by requisite apparatus, equipment, machinery, materials, plant, spoil heaps or other such facilities exceeds 1 hectare or where any such area is situated in whole or in part in a sensitive area.

4.1.3 The proposed project is not situated within a '*sensitive area'*, as defined by the EIA Regulations as amended. The project size does exceed 1 hectare and thus the proposed project is classified as a '*relevant project'*. All '*relevant*' Annex II projects require a determination to be undertaken to confirm whether the project is considered likely to have a significant environmental effect. This examines the characteristics of the proposed project in terms of its location and the potential impacts that may arise and is informed by the selection criteria in Annex III of the EIA Directive.

Annex III selection criteria for screening decisions

1. Characteristics of projects

The characteristics of projects, having regard in particular to:

a) the size of the project;
b) the cumulation with other projects;
c) the use of natural resources;
d) the production of waste;
e) pollution and nuisances; and
f) the risk of accidents, having regard in particular to substances or technologies used.

2. Location of project

The environmental sensitivity of geographical areas likely to be affected by projects, having regard in particular to:

a) the existing land use;
b) the relative abundance, quality and regenerative capacity of natural resources in the area; and
c) the absorption capacity of the natural environment, paying particular attention to the following areas:
    i. wetlands;
    ii. coastal zones;
    iii. mountain and forest areas;
    iv. nature reserves and parks;
    v. areas classified or protected under legislation (including European sites);
    vi. areas in which environmental quality standards laid down in a legislation of the Communities have already been exceeded;
    vii. densely populated areas; and
    viii. landscapes of historical, cultural or archaeological significance.

3. The potential impact

The potential significant effects of projects, in relation to criteria set out und and 2 above, having regard in particular to:

a) the extent of the impact (geographical area and size of the affected population);
b) the impact on other member States;
c) the magnitude and complexity of the impact;
d) the probability of the impact; and
e) the duration, frequency and reversibility of the impact.

5 Characteristics of the location of the proposed project

5.1 Context within South West Wales

5.1.1 The Scheme lies between Carmarthen in Carmarthenshire and Haverfordwest. The Preseli Hills lie 12km to the north and Carmarthen Bay is 10km to the south. Two kilometres to the west are the upper reaches of the Afon Cleddau, while the closest boundary of the Pembrokeshire Coast National Park (PCNP) lies 7km away to the south-west.

5.2 Landscape setting

5.2.1 The setting of the proposed Scheme is a rural, lowland agricultural landscape with a dispersed population and scattered small villages. The landform is composed of a sequence of interlocking ridges with convex upper slopes and low-lying valleys with winding flashy rivers. Many of the larger older settlements and roads following the ridgelines. The land is mainly down to improved grassland for cutting or grazing, with fields divided by hedges and hedgebanks with small areas of woodland mainly on the steeper slopes. There is some arable cultivation on better soils, generally on lower, shallower slopes.

The Llanddewi Velfrey Ridge

5.2.2 The existing A40 runs east to west along a ridge with Llanddewi Velfrey at the east end. The proposed route of the Llanddewi Velfrey bypass would follows the north slope of the ridge, which are broken by several narrow steep-sided and wooded valleys containing small watercourses fed by a line of springs.

Llanddewi Velfrey

5.2.3 The village of Llanddewi Velfrey was originally a scattering of settlement centred around the medieval church which stands on the south-facing slope of the ridge. When the 18th century turnpike and then the current ridge-top road was made in the 19th century, the centre of settlement migrated northwards to form a linear development, known as Commercial, along both sides of the A40 an important junction with the Llanfallteg Road. This linear settlement expanded north and south along side roads. The northern part extends north along the Llanfallteg Road and west along the A40 and includes residential properties, a village hall, the former Parc Y Llan Inn, which is now a restaurant. The southern part of the settlement consists of suburban residential development focused around the Service Station and shop on the A40.

Watercourses

5.2.4 The watercourses flow from the north slopes of the ridge in a north-westerly direction into the Afon Cleddau, or south-easterly into the Afon Taf. The estuaries of both of these rivers are part of marine Special Areas of Conservation (SAC).

Habitats and protected species

5.2.5 There are five Special Areas of Conservation (SAC) within 10km of the proposed Scheme and a further two SACs designated for bats within 30km of the site. There is one Special Protection Area within 10km of the site, but no Ramsar Sites are present within this 10km distance. There are no other locally designated nature conservation sites.

5.2.6 The habitats along the route support populations of European Protected Species (EPS), including bats, otter, dormouse and barn owl. There are populations of badger and reptiles.

Heritage Designations

5.2.7 There are a number of Listed Buildings (LB), for example the War Memorial (Grade II) beside the A40 in Llanddewi Velfrey and Ffynnon Baptist Chapel (Grade II) beside the A40 in Ffynnon Wood. In the winder setting, there are several Scheduled Ancient Monuments (SAMs), for example Llanddewi Gaer Promontory Fort which lies on higher ground to the south of the Scheme. There are also a wide range of non-designated archaeological sites that fall within the 600m wide corridor, for example there are a number of burnt mounds of Prehistoric origin along the Llanddewi Velfrey ridge, with some that are likely to be directly affected by the Scheme.

Landscape Designations

5.2.8 Within the 5km study area, there is one Registered Historic Park and Garden, Blackaldern, to the south of the Scheme near Narberth. There are no Historic Landscape Areas. The Pembrokeshire Coast National Park is also outside the study area.

Prevailing weather conditions

5.2.8.1 The area receives a typical maritime climate characterised by weather that is often cloudy, wet and windy, but mild. Air quality is good and the Scheme does not pass through or near any Air Quality Management Areas (AQMA).

5.2.9 Weather conditions are fairly typical for the region, with an annual rainfall of 1,038mm, with November being the wettest month of the year. Over the year, the mean annual temperature is 11^{o}C ranging from a low of 4^{o}C and a high of 19^{o}C. The coldest month on average is February. The prevailing winds are from the west and south-west with wind speeds averaging 12mph over the year. The windiest month is December.

Noise Action Plan Priority Areas (NAPPA)

5.2.10 There are no Noise Action Plan Priority Areas in the area of the Scheme.

6 Characteristics of the Potential Impacts

6.1 Geology and soils

6.1.1 The Scheme would cross a ridge formed predominantly of mudstone. Ground investigations were completed over the last two to three years which showed that the rock is of sufficient quality to be used to form embankment and cutting slopes of 1:2.5, although some steeper slopes of 1:2 may be possible. These 1:2.5 slopes would increase land take over the more normal slopes of 1:2. The Scheme passes close to an area of safeguarded aggregates of regional importance and directly effects an area of sand and gravel considered to be of national importance.

6.1.2 Soils in the area are derived from boulder clay and alluvium in the limited areas where these occur, and otherwise from weathering of the mudstone/shale and occasional bands of sandstone. The soils are therefore comprising mainly well-drained medium-textured soils of variable depth over shales. The Predictive Agricultural Land Classification (ALC) for Wales (2017) shows that the soils along the Scheme are of subgrade 3b ‘Moderate’ quality, with patches of Grade 4 ‘Poor’ quality. This grading is a result of soil wetness.

6.1.3 The adverse effects on geology and soils would mainly occur during construction and so proposed mitigation would include normal best practice in soil handling, with minimal access beyond areas to be excavated; to strip and store topsoil for reuse on-site or for use elsewhere, such as on agricultural land; and to place and prepare soils in suitably dry conditions so that there are no lasting adverse effects.

6.1.4 The effects on Geology and soils are therefore not considered to be significant, with neutral to slightly adverse effects.

6.2 Road drainage and the water environment

6.2.1 A water resources survey was conducted by questionnaire and farm interviews and a desk study provided information on the routes of watercourses and the locations of springs.

6.2.2 Cutting into the landform on sidelong ground just below the spring line of the Llanddewi Velfrey ridge, the Scheme could disrupt or otherwise adversely affect groundwater. A number of minor watercourses emerge as springs along the ridge and would be culverted to pass under the proposed Scheme. During construction of the Scheme, waterborne silt disturbed during earthworks, could have an adverse effect on watercourses, downstream, or on the Special Areas of Conservation (SAC), which lie downstream.

6.2.3 Effective silt control during construction, provision of balancing ponds with penstocks for pollution control, alternative water supplies for any properties drawing on groundwater are proposed as mitigation.

6.2.4 The effects on drainage and water are not considered to be significant, although the impact of construction could be significant if adequate mitigation is not in place.

6.3 Nature Conservation (biodiversity)

6.3.1 Surveys conducted in 2016 and 2017 to investigate for the presence of bat species, badger, otter, great crested newt, dormouse and reptiles were completed by the end of the 2017 surveys season. These have shown that there are no great crested newts, but that the other species listed are present, along with barn owls.

6.3.2 The landscape of hedged improved pastureland with minor watercourses and woodland provide habitat suited to various Protected Species, in particular badger, bats, dormouse, otter and barn owl, potentially severing commuting routes and isolating populations from foraging areas. Furthermore, the populations of these species could be adversely affected if individuals are killed by collisions with vehicles on the proposed carriageway.

6.3.3 Section 7 of the Environment (Wales) Act (2016) requires Welsh Ministers to publish, review and revise lists of living organisms and types of habitat in Wales, which they consider are of key significance to sustain and improve biodiversity in relation to Wales. These Priority Species and Habitats are listed as those currently covered by the NERC Act Section 42. These include species potentially affected by the Scheme, in particular bat species, otter and dormouse. Priority Habitats potentially effected including hedgerows and wet woodland.

6.3.4 Greater and Lesser Horseshoe Bats are considered likely to be crossing the A40 during commuting between the Bosherton Lakes SAC to the south and the Pembrokeshire Bats Sites SAC to the north. Several roosts in buildings lie alongside the proposed route and a number of mature trees are considered to have potential for use by roosting bats.

6.3.5 The route would also cross several small watercourses that flow into the Rivers Cleddau and Taf. The potential links between the Scheme and the designated areas are the watercourses and the potential flightlines/commuting routes, roosts and foraging areas of the bat species. The designated sites are:

a) Cleddau rivers SAC: qualifying features: Annex 1 habitats: watercourses, raised bogs and alluvial forests. Annex II species: brook, river and sea lamprey, Bullhead and Otter;
b) Pembrokeshire Bat Sites and Bosherton Lakes SAC: qualifying features: Annex 1 habitat: hard oligo-mesotrophic lakes. Annex II species: Greater Horseshoe Bats, Lesser Horseshoe Bats and Otter;
c) Pembrokeshire Marine SAC: qualifying features: Annex I: estuaries, shallow inlets and bays, mudbanks, sandbanks, coastal lagoons, reefs. Annex II species: grey seal, shore dock, sea and river lamprey, allis and twaite shad and otter; and
d) Carmarthen Bay & Estuaries SAC: qualifying features: Annex I and II: as Pembrokeshire marine SAC.

6.3.6 Provision of underpasses, compensation habitat in the form of woodland and hedge planting are considered necessary mitigation. Silt control during construction and pollution control penstocks on balancing ponds should control waterborne pollution which might otherwise adversely affect the various SAC downstream of the Scheme.

6.3.7 The Scheme is considered likely to have a significant impact on ecology and nature conservation, particularly in the context of the greater and lesser horseshoe bats. The impacts would be greatest during construction.

6.4 Landscape and views

6.4.1 Summer and winter landscape and visual surveys were completed during March and July 2017 in accordance with the Guidelines for Landscape and Visual Impact Assessment Revision 3 (GLVIA3) published by the Landscape Institute and the Institute of Environmental Management and Assessment in 2013. The surveys showed that the Scheme would be visible from the north, potentially over a distance of several kilometres from some elevated viewpoints within the Preseli

Hills. Otherwise viewpoints are more local, from residential properties and public footpaths.

6.4.2 A tree survey was also completed in July 2017. Trees in woodland and in hedges would be felled where these fall within the construction area of the proposed Scheme. This would also include any trees identified in detailed preconstruction surveys, diseased or hazardous because they are dead or unstable. At this stage, the exact numbers of trees to be felled cannot be determined.

6.4.3 Pembrokeshire Coast National Park lies in excess of 7 km to the north, west and south. The northern portion, which contains the Preseli Hills is over 11km to the north and whilst there is a potential view of the Scheme from the higher peaks of the Preseli Hills, the distance makes a view of the Scheme very unlikely.

6.4.4 The alignment requires cuttings and embankments that would disrupt the north slopes of a low ridge. These changes to the landform could be visible to scattered properties to the north and possibly also to areas of Llanddewi Velfrey to the south. Crossing several small valleys, the route would cut through woodland, hedges and agricultural land.

6.4.5 Mitigation in the form of low false cuttings in some locations, planting to provide screening and integration into the landscape, and reinstatement of grassland on disturbed areas would be provided.

6.4.6 The impact of the large earthworks on the landscape and views and the views of traffic on the new road, is considered to be a significant change on the landscape and views, particularly during construction and during the first 15 years of establishment and growth of mitigation.

6.5 Archaeology and cultural heritage

6.5.1 A desk study of known heritage sites was completed and a geophysical survey of the Scheme footprint carried out in summer 2017.

6.5.2 There would be no direct effect on Scheduled Ancient Monuments (SAM) or Listed Buildings, although the route could have an adverse impact on the setting of around 57 heritage sites within 250m of the route. Of these, there are 2 SAMs (Caerau Gaer and Llanddewi Gaer) and 5 Listed Buildings (Ffynnon Baptist Chapel and the War memorial are beside the existing road) and various other archaeological sites and historic monuments. A Prehistoric Burnt Mound, which is not statutorily designated, located slightly to the east of Pen-troydin-fâch Farm, is likely to be directly affected by the route.

6.5.3 Historic Hedgerows, as defined in the Hedgerow Regulations 1997, have been addressed in Chapter 8 of the ES, Ecology, and Nature Conservation. For this , surveys of all hedgerows were completed in 2016. A single important hedgerow was identified within the route corridor.

6.5.4 For sites likely to be disturbed by the Scheme, mitigation in advance of construction works but implemented by the construction contractor, would include archaeological investigations such as a watching brief during soil stripping, trial trenching, detailed investigations and recording of sites, would be provided. Mitigation to adverse effects on the settings of sites would include landscape planting.

6.5.5 The impacts on cultural heritage were not considered to be significant.

6.6 Community and Private Assets

6.6.1 A desk study of community assets was completed and confirmed by a drive through survey. A series of farm interviews were completed. Questionnaires were distributed to landowners and responses collated. There is no ‘best and most versatile land’ (Grades 1, 2 and 3a) affected by the Scheme.

6.6.2 Community Assets would be affected where severance is caused to routes to and from these. The removal of traffic on the existing A40 through Llanddewi Velfrey would significantly reduce community severance and allow public transport to enhance access to community facilities in the surrounding area.

6.6.3 The Scheme would adversely affect eight farm businesses by taking land and severing or affecting access routes to fields.

6.6.4 A new farm underpass, a new minor county road and PMAs to fields and farms would mitigate some of the impacts of the Scheme, although land loss cannot be mitigated.

6.6.5 The impacts have the potential to be significant on some farm businesses.

6.7 Air Quality

6.7.1 Air quality monitoring was carried out in 2017. The Scheme does not pass through any Air Quality Monitoring Areas and the background air quality is considered to be high.

6.7.2 During construction, the extensive earthworks and earthmoving that would be required for the Scheme could generate air borne dust with adverse effects on the local population. When construction is complete, this effect would diminish. When the new road is open to traffic, most local residents in the village of Llanddewi Velfrey should also benefit from improvements in air quality as a consequence of moving the sources of NO_x from vehicle emissions further from residential areas.

6.7.3 Air quality is not considered to be a significant impact of the Scheme, although there is potential for some local improvements close to the existing A40.

6.8 Noise and Vibration

6.8.1 Background noise monitoring was undertaken from a number of receptor locations along the existing A40 during 2017.

6.8.2 Noise and vibration from construction activity could have an adverse effect on the local population. Whilst most local residents in Llanddewi Velfrey would benefit from reductions in traffic noise, once the new road is open to traffic, several properties would be closer to traffic on the new route and so could suffer some adverse effects.

6.8.3 No specific noise mitigation is currently being considered, A low noise surfacing is proposed for the entire A40 route within the Scheme where noise and engineering benefits are considered beneficial.

6.8.4 The impact of noise and vibration is not considered likely to be significant on local residents. The bypass section around Llanddewi Velfrey has the potential to have an adverse effect on tranquillity for some dwellings that lie close to the route, while for residents of the village, the reduction in traffic on the detrunked A40 has the potential to increase tranquillity. Wildlife would be similarly affected by traffic noise, with the Scheme passing through previously undisturbed areas of habitat.

6.9 All travellers

6.9.1 A desk study has identified Public Rights of Way (PROW) around the Scheme. These link the scattered settlements around the village of Llanddewi Velfrey. Counting and observation surveys carried out in spring and summer 2017 found that these routes have very little use. A single bridleway crosses the Scheme close to Ffynnon. During the Public Information Exhibition in April 2017, groups and individuals expressed interested in the use of bridleway and public footpaths. Many of the footpaths are overgrown.

6.9.2 Several PRoWs would be stopped-up, or diverted, to crossing points. Three underpasses are proposed: one the bridleway at Ffynnon and two others at the convergence points of diverted PRoW. None of these would be provided with night time illumination.

6.9.3 The village of Llanddewi Velfrey is divided by the busy A40. The bypass would reduce this community severance by removing through traffic from the village and allow any detrunking works - that might be required - to be carried out.

6.9.4 The existing A40 has poor visibility and lacks opportunities for overtaking. The frustration and delay this bring about is considered to be a cause of driver stress. The proposed improvement would improve the journey for vehicle travellers on the A40.

6.9.5 In accordance with the Active Travel (Wales) Act 2013, the Scheme could provide benefits to local people through the development of circular footpath and cycle routes, improved conditions for pedestrians and cyclists in the village and along the detrunked road. Equestrians would be provided with a longer length of bridleway and a safe crossing through the underpass.

6.9.6 The Scheme is likely to be of benefit to travellers, once construction is completed. The benefits could potentially have a significant local impact.

6.10 Materials

6.10.1 The Scheme has been designed in sufficient detail to achieve a balance between the volume of rock and soil excavated from the site and the volume of materials used to form embankments and for soiling completed landscape areas. There is capacity for excavated fill material - that is unsuitable for embankment construction - to be used in landscape measures. In the interests of providing low fertility verges, topsoil would be used in specific areas where high fertility is required. This would result in a surplus of topsoil.

6.10.2 Other bulk construction materials such as aggregate for concrete and materials for construction of the carriageway would be brought to the Scheme from sources within Wales, unless only available from a more distant source.

6.10.3 Under current legislation and understanding, waste material is considered to be '*any substance or object which the holder discards or intends or is required to discard.*' The term 'discard' includes the disposal, recovery or recycling of a substance. Waste categories are likely to include vegetation, redundant road signs, lighting columns, excess topsoil, and surface planings from redundant carriageway. Waste would be managed in accordance with the Waste Hierarchy with as much as possible reused within construction. Waste that cannot be reused would be taken to a local recycling facility. Quantities of waste requiring disposal are anticipated to be relatively small.

6.10.4 The Scheme is considered unlikely to have a significant impact on material resources or on the environment as a result of waste management.

6.11 Population and Human Health

6.11.1 A health assessment looks at how impacts arising from a proposed development are likely to result in changes to health determinants, i.e. factors that influence health and well-being, and therefore have an effect on health outcomes within the local population. In relation to the Scheme, there is potential for the health of the population within local communities to be influenced as a result of predicted likely environmental, social and economic Scheme impacts. For example, the Scheme is designed to reduce journey times, improve road safety, reliability and resilience, improve air quality and reduce noise disturbance for the areas adjacent to the existing A40 and are therefore likely to influence the health and well-being of the local population. It may also impact on assets which influence health outcomes such as provision, quality and accessibility of public rights of way for non-motorised users.

6.11.2 These health effects, which are focused on the final state of the Scheme, are likely to be beneficial for the population due to the improvements that are proposed. However, during construction, there may be potential for adverse effects on health due to construction noise, road journey disruption and access restrictions. These would need to be investigated and any mitigation measures identified in order to reduce the adverse effects to below significant levels and to enhance beneficial effects.

6.12 Climate Change

6.12.1 Climate change impacts are considered across three aspects:

a) Greenhouse gas emissions – the potential greenhouse gas emissions associated with the construction and operation of the proposed development;

b) Climate change resilience – the effectiveness and feasibility of adaptation measures integrated into the proposed development to avoid or reduce hazards and/or increase resilience of the proposed development to climate change impacts; and

c) In-combination climate change impacts – the combined effect of the proposed development and potential climate change impacts on the receiving environment during construction and operation.

6.12.2 A carbon assessment was undertaken in 2017 which quantified the whole life carbon footprint of the project based on the preliminary design. This included capital, operational and user carbon emissions.

6.12.3 The carbon assessment showed that emissions from vehicles using the road account for the vast majority of emissions over the project life. These emissions are slightly higher with the Scheme (compared to without the Scheme) due to an increase in average speeds, based on the traffic forecast models, and also a very slight increase in vehicle kilometres travelled due to the alignment of the proposed road.

6.12.4 The IEMA guide to assessing greenhouse gas (GHG) emissions and evaluating their significance[2] publishes the over-arching principle:

6.12.5 “The GHG emissions from all projects will contribute to climate change; the largest inter-related cumulative environmental effects…as

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[2] IEMA, 2017, Environmental Impact Assessment Guide to: Assessing Greenhouse Gas Emissions and Evaluating their Significance

such any GHG emissions or reductions from a project might be considered to be significant…”

6.12.6 In accordance with this guidance, any carbon emissions associated with the Scheme can be deemed significant.

6.12.7 The assessment of climate change resilience and in-combination climate change impacts includes consideration of the current climate conditions and projected future climate conditions. For the location of the A40, trends in climate variables have included increased mean and extreme high temperatures, increased mean daily rainfall in the winter and number of days with heavy rain, and increase in extreme weather events.

6.12.8 In terms of climate change resilience, the key risks are likely to be associated with flooding, which should be mitigated through the Flood Risk Assessment.

6.12.9 In term of in-combination climate change impacts, it is likely that mitigation measures proposed in each topic would reduce the in-combination impacts to below levels considered significant.

6.13 Heat and Radiation

6.13.1 The Infrastructure Planning (EIA) Regulations 2017 introduced the requirement for the emission of heat and radiation to be considered. The Scheme does not introduce any new sources of heat and radiation during construction or operation. In addition, there are no sensitive receptors (for example, hospitals or schools) within the route corridor. Hence the proposed Scheme would not create any new sources of heat and radiation. On that basis, with no sensitive receptors, the Scheme is not considered likely to increase the generation or release of heat and radiation.

6.14 Risk of Major Accident and Disaster

6.14.1 The Scheme is not considered likely to increase the risk of major accidents and disasters, or the effects of such events on the environment.

6.14.2 The potential risks of major accident or disaster in the area of the Scheme considered to be relevant are: the effects of severe heavy snow, or transport accidents that could result in closure of the road or cause pollution events as a consequence of spillages.

6.14.3 Whilst there is evidence of landslips in the wider area, the Scheme would be constructed with the risk of land instability taken into consideration so that embankment and cuttings slopes would be stable.

6.14.4 The current section of the A40 is considered to be substandard and has a perceived problem with regard to overtaking opportunities and associated risks of accidents. Accidents along this stretch of the A40 numbered 10 in the years 2010 to 2015.

6.14.5 The Scheme is designed to current standards, so the risk of accidents is no greater than on the existing road. The procedures for dealing with heavy snowfall, major road accidents and pollution within the road are well established and the road would not be closed for long periods. Alternative routes - using other roads - exist for diverted traffic.

6.14.6 The Stage 2 Economic Assessment Report assesses the impact of accidents on the Scheme. The assessment reports that the 2+1 carriageway provides a length of safe, unambiguous overtaking opportunities. This would reduce the number of risky manoeuvres on the road and generally contribute to reducing the potential of accidents. In addition, the bypass of Llanddewi Velfrey would reduce vehicular traffic going through the village centre, therefore reducing the interface between traffic on the A40 and NMUs within the village. This would create a safer village environment and reduce the potential of accidents.

7 Consultations

7.1.1 The sequence of consultations is set out chronologically below.

7.1.2 Early studies for this Scheme began in 2006 and involved consultations with statutory consultees and the local community. The public consultation for these early studies took place in September 2006 and views were sought on the four different route options that had been developed. The results showed that there was support for improvements between Penblewin and Ffynnon, and for a bypass to Llanddewi Velfrey.

7.1.3 The consultations in 2006 included meetings to discuss the options with Pembrokeshire County Council, Carmarthenshire County Council, Countryside Council for Wales (Haverfordwest and Llandeilo), Environment Agency and the Pembrokeshire Coast National Park. The purpose of these meetings was to discuss their requirements for any environmental assessment. An environmental scoping workshop was held during the consultations to enable the environmental team to present the scoping proposals.

7.1.4 Natural Resources Wales (now incorporating the Environment Agency Wales and Countryside Council for Wales) were consulted during early 2016, in a series of meetings held to discuss the Scheme and the need for ecology surveys. The agreed suite of ecology surveys was completed in accordance with Design Manual for Roads and Bridges (DMRB) and confirmed the presence of European Protected Species (EPS) along the route.

7.1.5 Welsh Government decided to progress with the Scheme and appointed an Early Contractor Involvement team in February 2017. Based on the results of the 2006 consultations, the options for improvements between Penblewin and Ffynnon, and for a bypass to Llanddewi Velfrey were taken forward, with a Public Information Exhibition held in Llanddewi Velfrey Community Hall over two days in April 2017. The public were invited and over 170 people attended. The results showed that there was overwhelming support for what is now the Preferred Route shown in the TR111 Drawings.

7.1.6 A formal Public Consultation on the Preferred Route was held in October 2017. The public were invited with local people and Statutory Consultees receiving written invitations. The event was well attended and responses were taken into consideration resulting in modifications to the design.

7.1.7 A programme of Environmental Liaison Group (ELG) meetings started in April 2017. These were attended by the Natural Resources Wales (NRW), Cadw, Pembrokeshire County Council (PCC), South Wales Trunk Road Agency (SWTRA) and Welsh Government. A key outcome of the first meeting was the development of a set of project environmental objectives. The ELG were invited to attend the two public exhibitions held in April and October 2017.

7.1.8 A separate meeting with NRW to discuss protected species surveys was also held in July 2017 to agree the scope of further ecological surveys.

7.1.9 A second ELG meeting was held in August 2017 with the same organisations attending. The Scheme design and progress on environmental surveys and monitoring was presented. An invitation to provide written responses on a draft EIA Scoping Report was also made. Due to delays caused by the change of project team, the draft Scoping was subsequently amended to reflect the new EU Directive published in December 2017. The third ELG meeting was held in August 2018.

Future Consultations

7.1.10 Future ELG meetings will be held on a quarterly basis once progress on the Scheme has progressed towards detailed design and construction. A further public exhibition and consultation period is anticipated following the publication of the draft Orders and Environmental Statement. Publication is expected to be late 2018/early 2019.

8 Conclusions

8.1.1 The significant effects of the Scheme are considered to be:

a) Potential impacts on protected species, in particular greater and lesser horseshoe bats, due to loss of habitat, connectivity and increased risk of collision with vehicles;

b) The potential impact on the qualifying habitats and species of Special Areas of Conservation connected by bat flight lines, otter migrations, and pollution carried by tributary streams that pass through the study area;

c) Impacts on the landscape and views from the large earthworks and traffic on the immediate setting with potential impacts on wider views and more distant designated landscapes and on heritage sites;

d) Impacts on farm businesses due to land loss, severance and loss of access routes;

e) Impacts on travellers from the potentially beneficial effects of the Scheme; and

f) Any carbon emissions associated with the Scheme can be deemed significant;

8.1.2 It is considered unlikely that there would be any adverse emissions, wastes or overuse of non-renewable resources associated with this project.

8.1.3 Under the EIA Directive 2011/92/EU as amended, the proposed works are not an Annex I development. However, the works are an Annex II relevant development because the total area of the Scheme would exceed the 1ha threshold and therefore have undergone the determination process.

8.1.4 The determination concludes that the proposed works are: of more than local importance, are not set within a sensitive location and are anticipated to have significant adverse effects on the receiving and surrounding environment. To ensure that all environment effects are considered during the design process, a Statutory Environmental Assessment has been undertaken on the proposed project.

8.1.5 In line with best practice requirements and to ensure that all environmental effects are identified, and the appropriate level of assessment applied, a Scoping Report has been produced and agreed with the Statutory Environmental Bodies before the Environmental Assessment process is commenced.

8.1.6 The characteristics of the potential impacts of the Scheme were identified and as a result, topics were scoped in and scoped out of the assessment. Further justification for this is detailed in the Scoping report.

8.1.7 Topics scoped in to the EIA:

a) Geology and Soils
b) Road Drainage and the Water Environment
c) Nature Conservation
d) Landscape
e) Archaeology and Cultural Heritage
f) Community and Private Assets
g) Air Quality
h) Noise and Vibration
i) All Travellers
j) Materials
k) Population and Human Health
l) Climate Change

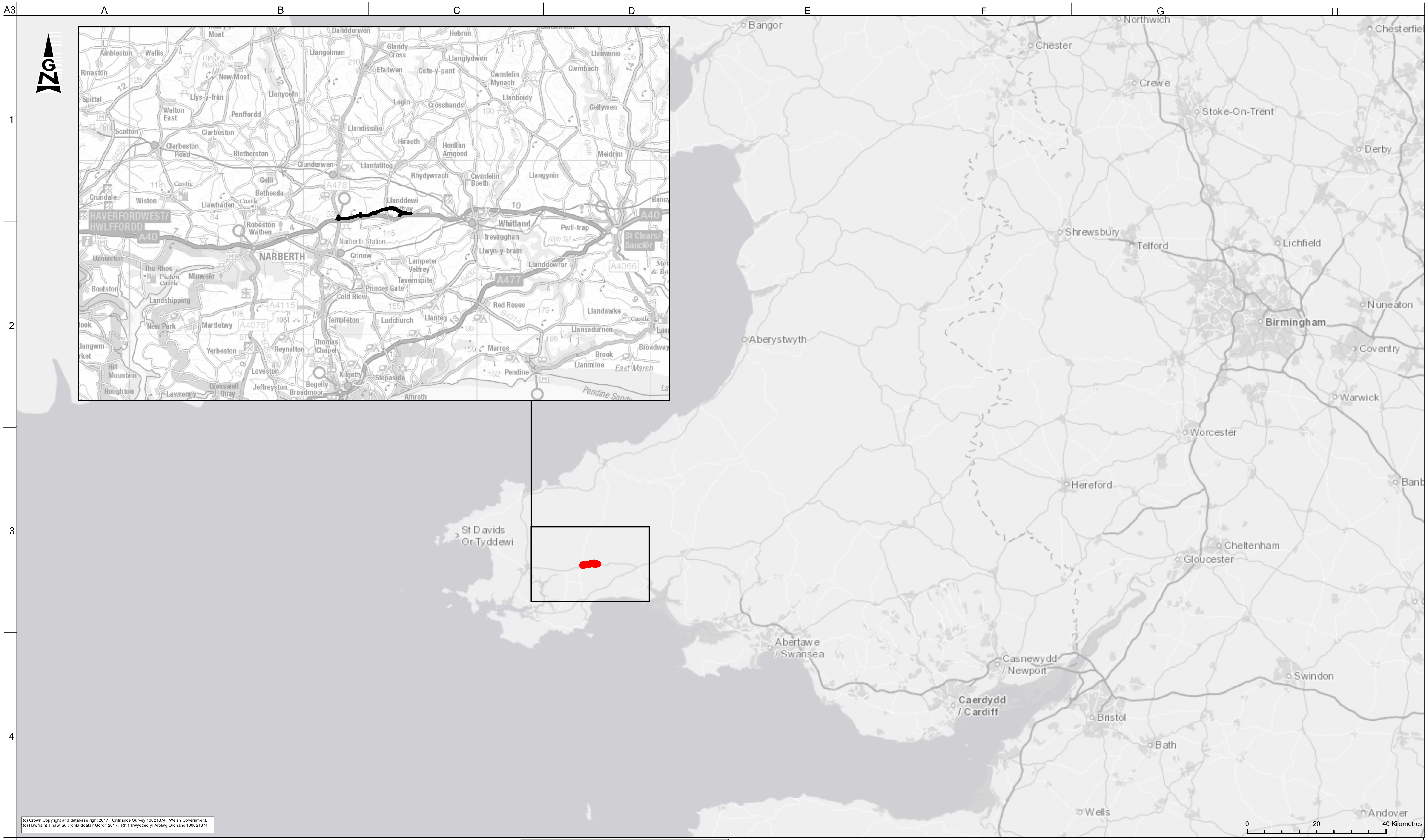
8.1.8 Topics scoped out of the EIA:

a) Heat and Radiation
b) Risk of Major Accident and Disaster

Appendix 1

Location Plan

See Figure 1.1



LEGEND

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P01	18/09/18	UPDATE FOLLOWING COMMENTS	EB	AS	TE	GD

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN
IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

ARCADIS
MOTT MACDONALD

Delivery Team
RICHARDS MOOREHEAD & LAING LTD
PLANNING | LANDSCAPE | ENVIRONMENT

Drawing Title
FIGURE 1.1
SCHEME LOCATION

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A3 1:1,000,000

Rev	By	Chkd	Appd	Auth
P01	EB	AS	TE	GD
	Date 18/09/18	Date 18/09/18	Date 18/09/18	Date 18/09/18

Name
A40LVP - RML - GEN - SWI - DR - J - 0001
Project | Originator | Volume | Location | Type | Role | Number

Appendix 2

Record of Determination (draft)

ANNEX A: Record of Determination, Welsh Assembly Government, Transport, Housing and Regeneration.
For use with Annex II relevant projects only

Name of project: A40 Llanddewi Velfrey to Penblewin Improvements	**Location** (including national grid reference): A40 Trunk Road approx. 17km east of Haverfordwest and 26km west of Carmarthen. OS Grid Reference: 214870,216820

Qualifying criteria for Annex II relevant project: (please tick which are relevant)

Improvement element of project is >1ha	√	Project is located within 'sensitive' area		Other with potential for significant effect (e.g. adjacent to sensitive site)	√

A. Description of project:

The proposed improvements include a 2.2km northern bypass to the village of Llanddewi Velfrey and a 2.1km improvement that continues west to Penblewin Roundabout.

Starting in the west, the improvement Scheme would leave the roundabout immediately to the north of the existing A40 and extend, in parallel, for a distance of 1.2km with separated access routes to properties to north and south. At chainage 1,200, there is a junction on the existing A40 with a minor county road on the south side. An equestrian underpass would be constructed to carry the bridleway under the proposed A40.

From chainage 1,200 to 1,900, the proposed Scheme would use the line of the existing A40, to pass the small settlement of Ffynnon. A new staggered junction would be required between chainage 1,900 and 2,100 to allow access on the north side to Ffynnon and on the south side to the detrunked A40 through the village of Llanddewi Velfrey.

From chainage 2,100, the proposed road would continue east traversing the north side of the Llanddewi Velfrey ridge. The bypass curves southwards as it continues to traverse the ridge first into a cutting to pass under a county road which links Llanddewi Velfrey to Llanfallteg to the north. The road would be carried over the bypass on a new bridge. Continuing east, the new carriageway would return to the alignment of the existing A40 at a new four-arm roundabout with links into Llanddewi Velfrey and to Bethel Chapel.

B. Description of local environment, including statutory and non-statutory designations:

The setting is a rural, lowland agricultural landscape with a dispersed population and scattered small villages. The Preseli Hills lie 12km to the north. Carmarthen Bay is 10km to the south. 2km to the west are the upper reaches of the Afon Cleddau, while Pembrokeshire Coast National Park (PCNP) lies 7km away. The land is down to pasture with fields divided by hedges. The existing A40 runs east to west along a ridge, while the proposed route follows the north slopes, which are broken by a number of narrow steep-sided and wooded valleys containing small watercourses.

These watercourses flow west into the Afon Cleddau or south east into the Afon Taf. The estuaries of both of these rivers are part of Special Areas of Conservation (SAC). The habitats along the route support populations of European Protected Species (EPS), including bats, otter, dormouse and barn owl. There are populations of badger and reptiles. The Pembrokeshire bat sites and Bosherton Lakes SAC lies further away. There are a number of Listed Buildings (LB) and non-designated archaeological sites that fall within the 600m wide corridor.

C. Summary of main environmental effects of project:

The Scheme would disrupt the natural landform of the north slopes of the low ridge which could be visible to scattered properties to the north, and would cut through woodland, hedges and agricultural land which provide habitat suited to various European Protected Species (EPS), in particular bats, dormouse, otter and barn owl, potentially severing commuting routes and isolating populations from foraging areas. Cutting into the landform on sidelong ground could disrupt groundwater and the route would cross several small watercourses that flow into the Rivers Cleddau and Taf. During construction, the Scheme could have an adverse effect on SACs which lie downstream as a result of waterborne silt during earthworks. Potential impacts on populations of bats, in particular the lesser and greater horseshoe species which are associated with SACs to the north and south, could be adversely affected by severance of flight lines. Dormice are considered likely to use local habitats and populations could be separated if connectivity habitat is severed. Otter have been recorded on local watercourses that the Scheme would cross.

The route could adversely affect some agricultural properties by taking land and severing or affecting access routes.

The route would also cross several Public Rights of Way (PRoW). However, when completed, the bypass would reduce community severance by reducing vehicular traffic in the village of Llanddewi Velfrey. Construction materials would need to be brought to site by HGVs and there would be disruption of local traffic. Earthworks would cause noise and could generate air borne dust with adverse effects on the local population. Whilst most local residents should also benefit from improvements in air quality and reductions in traffic noise when the new road is operational, several properties lying close to the route with potential to suffer adverse effects of traffic noise.

There are no SAMs or LBs that are directly affected, although the route could have an adverse impact on the setting of around 57 heritage sites within 250m of the route. Of these, there are 2 SAMs (Caerau Gaer and Llanddewi Gaer) and 5 Listed Buildings (Ffynnon Baptist Chapel and the War memorial are beside the existing road) and various other archaeological sites and historic monuments. A Prehistoric Burnt Mound would be directly affected by the route.

Proposed mitigation and avoidance measures include false cuttings and extensive woodland, hedgerow planting and areas of grassland to provide some screening of traffic and to integrate the cuttings, embankments, structures and carriageway with the landscape. These would also benefit wildlife by providing replacement EPS habitat for areas lost to the Scheme and connectivity for species along the roadside, with underpasses providing routes under the road. Measures to improve connectivity and access for non-motorised users would be enhanced by creating links, circular routes and safe crossings on the A40. Attenuation basins and pollution control devices would be provided on road drainage to mitigate potential adverse effects on flood risk and accidental spillage. The design has achieved a cut and fill balance which would minimise the need for import of material and the export of waste. Construction would be carried out with measures to minimise the effects of construction noise, dust and silt.

D. Details of extent of environmental impact assessment work undertaken and summary of any consultation undertaken with the statutory consultation bodies

Previous work on the Scheme included various desk studies and reports, with a number of ecological and other environmental surveys between 2004 and 2007. A list of these reports and the dates of publication are set out in Section F. The Environmental Assessment Report (EAR) assesses the likely impacts of the preliminary alignment design conducted to develop a Route Option sufficiently for the WelTAG Stage 2 assessment process ('Route Selection' stage) to be completed. The relevant predicted impacts are assessed on a precautionary basis. They do not take account of mitigation which would typically be incorporated in a fuller design as potential impacts are more clearly quantified. Walkover surveys and public data resources have allowed consideration of environmental constraints within the proposed alignment corridor, as required for each environmental topic. In 2016, Mott Macdonald carried out traffic surveys, a further suite of ecology surveys (scope agreed with Natural Resources Wales (NRW) and completed in accordance with Design Manual for Roads and Bridges (DMRB)). The data from these surveys was provided in a GIS format. These surveys confirmed the presence of EPS along the route.

E. Determination decision, statement of case in support of this decision that EIA is required:

Under the EIA Directive 2014/52/EU, amending the 2011 Directive, the proposed works are not an Annex I development. However, the works are an Annex II relevant development because the total area of the Scheme would exceed the 1ha threshold and therefore have undergone the determination process.

It has been identified that there are a number of sites that are subject to Article 6 (3) of the Habitats Directive. The information contained within the EAR identified that the Scheme could have significant effects in relation to Natura 2000 sites (in line with Annex III of the EC Directive). The EAR also provides information that further supports the conclusion that there would be the potential for significant further environment impacts in relation to a number of topics, including (but not exhaustively) ecology, agriculture, air quality, motorised and non-motorised users and community impacts. The proposed project is therefore an 'EIA Development' and a statutory EIA process should be undertaken.

File references of supporting documentation for future reference:

- Stage 1 Corridor Appraisal Report (and revision) PB 2003 and 2004
- Route Options Report (2 volumes) PB 2004
- Safety of Children, Pedestrians and Cyclists report PB 2004
- Stage 1 and Stage 2 Environmental Assessment Report (EAR) PB /TACP 2006
- Design Options Report (Vol 1 & 2) PB June 2015
- Preliminary Sources Study Report Mott MacDonald 2015

Consideration by Welsh Minister's Nominee of whether an EIA is required

I have determined, following discussions with the Welsh Assembly Government's /Trunk Road Agent's Environmental Advisor that a statutory Environmental Impact Assessment is/is not required for this project.

Signature Project Director: Dated:

Authorisation to publish Notice of Determination:

Signature Welsh Ministers' Nominee: Dated:

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Appendix 4.4 Annex IV to Directive 2014/52/EU

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1 EU DIRECTIVE 2014/52.EU ANNEX IV

The following text is taken from the Official Journal of the European Union dated 25 April 2014, to show the requirements for Information for the Environmental Impact Assessment Report

DIRECTIVE 2014/52/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 16 April 2014

amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment

Annex IV

INFORMATION REFERRED TO IN ARTICLE 5(1)

(INFORMATION FOR THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT)

1. Description of the project, including in particular:

   (a) a description of the location of the project;

   (b) a description of the physical characteristics of the whole project, including, where relevant, requisite demolition works, and the land-use requirements during the construction and operational phases;

   (c) a description of the main characteristics of the operational phase of the project (in particular any production process), for instance, energy demand and energy used, nature and quantity of the materials and natural resources (including water, land, soil and biodiversity) used;

   (d) an estimate, by type and quantity, of expected residues and emissions (such as water, air, soil and subsoil pollution, noise, vibration, light, heat, radiation) and quantities and types of waste produced during the construction and operation phases.

2. A description of the reasonable alternatives (for example in terms of project design, technology, location, size and scale) studied by the developer, which are relevant to the proposed project and its specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects.

3. A description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge.

4. A description of the factors specified in Article 3(1) likely to be significantly affected by the project: population, human health, biodiversity (for example fauna and flora), land (for example land take), soil (for example organic matter, erosion, compaction, sealing), water (for example hydromorphological changes, quantity and quality), air, climate (for example greenhouse gas emissions, impacts relevant to adaptation), material assets, cultural heritage, including architectural and archaeological aspects, and landscape.

5. A description of the likely significant effects of the project on the environment resulting from, inter alia:

   (a) the construction and existence of the project, including, where relevant, demolition works;

   (b) the use of natural resources, in particular land, soil, water and biodiversity, considering as far as possible the sustainable availability of these resources;

   (c) the emission of pollutants, noise, vibration, light, heat and radiation, the creation of nuisances, and the disposal and recovery of waste;

   (d) the risks to human health, cultural heritage or the environment (for example due to accidents or disasters);

   (e) the cumulation of effects with other existing and/or approved projects, taking into account any existing environmental problems relating to areas of particular environmental importance likely to be affected or the use of natural resources;

   (f) the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change;

   (g) the technologies and the substances used.

   The description of the likely significant effects on the factors specified in Article 3(1) should cover the direct effects and any indirect, secondary, cumulative, transboundary, short-term, medium-term and long-term, permanent and temporary, positive and negative effects of the project. This description should take into account the environmental protection objectives established at Union or Member State level which are relevant to the project.

6. A description of the forecasting methods or evidence, used to identify and assess the significant effects on the environment, including details of difficulties (for example technical deficiencies or lack of knowledge) encountered compiling the required information and the main uncertainties involved.

7. A description of the measures envisaged to avoid, prevent, reduce or, if possible, offset any identified significant adverse effects on the environment and, where appropriate, of any proposed monitoring arrangements (for example the preparation of a post-project analysis). That description should explain the extent, to which significant adverse effects on the environment are avoided, prevented, reduced or offset, and should cover both the construction and operational phases.

8. A description of the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project to risks of major accidents and/or disasters which are relevant to the project concerned. Relevant information available and obtained through risk assessments pursuant to Union legislation such as Directive 2012/18/EU of the European Parliament and of the Council (*) or Council Directive 2009/71/Euratom (**) or relevant assessments carried out pursuant to national legislation may be used for this purpose provided that the requirements of this Directive are met. Where appropriate, this description should include measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for and proposed response to such emergencies.

9. A non-technical summary of the information provided under points 1 to 8.

10. A reference list detailing the sources used for the descriptions and assessments included in the report.

Footnotes

(*) Directive 2012/18/EU of the European Parliament and the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (OJ L 197, 24.7.2012, p. 1).

(**) Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations (OJ L 172, 2.7.2009, p. 18).

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Appendix 4.5 Competent Experts

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1 List of Competent Experts

In accordance with the requirements of EU Directive 2014/52/EU the following competent experts were involved in the Environmental Impact Assessment and in the preparation of this Environmental Statement.

	Name & Role	**Role in preparing the Environmental Statement**	**Qualifications**	**Other relevant information**
A	Andrew Sumner Environmental Coordinator	Chapters 1, 2, 3, 4	DipLA Glos (4-year Honours Degree equivalent and Post-graduate Diploma) Chartered Member of the Landscape Institute	38 years' experience as a landscape Architect with 29 years on Welsh Highways and EIA. Experience of Environmental Coordinator role since 2004 on the M4 Widening ECI, A470 Blaenau Ffestiniog Improvements D&B, A483 Glandyfi D&B, A55 Junctions 15&16 ECI/Design Commission.
B	Allan Pitt Senior Planner	Chapter 5 Legislation and Policy Context	BSc City and Regional Planning, from Cardiff University School of City and Regional Planning MSc Regeneration Studies Member of the Royal Town Planning Institute Member of the Institute of Economic Development. Corporate Member, Consultation Institute	Planning, development and regeneration advice. Allan has a comprehensive knowledge of planning policy. Takes a leading roles in delivery of major transport plans and programmes. A key role in delivering the major M4 infrastructure project for the Welsh Government through the draft Plan, draft Orders and Public Inquiry processes.
C	Mark Cooper Lead Geotechnical Engineer	Chapter 6 Geology and Soils Technical reviewer for chapters on materials, Geology and Soils and groundwater aspects of Drainage and Water Environment	MEng MICE Member of the Institution of Civil Engineers CEng	15 years of relevant experience, and 10 years of post-chartership experience

	Name & Role	**Role in preparing the Environmental Statement**	**Qualifications**	**Other relevant information**
D	Max Rooksby Senior Environmental Scientist	Chapter 7 Road Drainage and Water Environment & Water Framework assessment	MEng (Hons) Civil Engineering MCIWEM (member Chartered Institute of Water and Environmental Management), C.WEM (Chartered Water and Environmental Manager)	Relevant experience: Dyfi Bridge, Welsh Government: lead the Drainage and Water Environment Impacts Assessment for the new bridge M4 south of Newport, Welsh Government: managed the initial Road Drainage and Water Environment package of works. 5Cheddar Reservoir 2 (CR2), Bristol Water: c6oordinated the Water Impact Assessment and provided technical review of all related reports for CR2 in support of the successful planning application in December 2013. M4 Steel Works Access Road - Corridor Enhancement Measures, Welsh Government. coordinated the Drainage and Water Environment Impacts Assessment, for inclusion in the project EIA. A8 Dualling, Road Service Northern Ireland: coordinated the Drainage and Water Environment Impacts Assessment,
E	Pete Wells	Chapter 8 Ecology and Nature Conservation	BSc (Hons) Biology - University of Wales, Aberystwyth MSc Environmental Science - University of Aberdeen Member of the Institute of Ecology and Environmental Management (MIEEM) Chartered Environmentalist (CEnv)	Relevant Experience: A487 New Dyfi Bridge - Pete lead ecological inputs to the A487 New Dyfi Bridge Scheme in Mid Wales. This includes co-ordination of ecological surveys, preparation of an ES chapter for ecology, and development of mitigation measures. He has also prepared the Statement to Inform an Appropriate Assessment for the Scheme. M4 Junction 28 Tredegar House Improvements- Pete co-ordinated the ecological input to the non-statutory EIA for improvement works to three junctions including Junction 28 of the M4. This has included habitat and dormouse

	Name & Role	**Role in preparing the Environmental Statement**	**Qualifications**	**Other relevant information**
				surveys and the development of mitigation and compensation measures for dormice. Pete has been the ecologist on several other highway schemes namely: A8 Belfast to Larne, Northern Ireland; A26 Dualling, Northern Ireland; New M4, Newport South Wales.
F	Andrew Sumner (see row A)	Chapter 9 Landscape and Visual Effects	(see row A)	(see row A)
G	David Maynard Archaeologist and Heritage Specialist	Chapter 10 Archaeology and Cultural Heritage	BA (Hons) Prehistory and Archaeology, 2:1, 1981. Certificate in Practical Archaeology, credit, 1978. Member of the Chartered Institute for Archaeologists (MCIfA), 2000. Member of the Institute of Leadership and Management (MInstLM), 2010. Institute of Leadership and Management Level 4 Award, 2010. ICOMOS, UK member.	Local resident of the area, with much background information. Long experience of working on road schemes in Wales, including: A55 DBFO improvement on Anglesey, 1999, A470, Penloyn to Tan Lan improvements, 2003 A487 Glandyfi Improvements, 2010
H	Martin Gallimore Public Liaison Officer	Chapter 11 Community and Private Assets	BEng (Hons) MEng Civil Engineering, CEng CEnv MICE (Institution of Civil Engineers)	Relevant experience: HS2 formulating and delivering the Community Engagement Strategy and Community Liaison Plans for a £1.4bn, 80km section of the HS2 Phase 1 project, through impacted rural communities.

	Name & Role	**Role in preparing the Environmental Statement**	**Qualifications**	**Other relevant information**
				A465 Heads of the Valleys Section 3: Brynmawr to Tredegar: Sustainable Communities Manager for Carillion for delivery of Community Benefits and community engagement
I	Tony Kernon Agricultural Specialist	Chapter 12 Community and Private Assets: Agriculture	BSc(Hons) Rural Land Management, University of Reading MRICS (Member of the Royal Institution of Chartered Surveyors) FBIAC (Fellow of the British Institute of Agricultural Consultants)	Tony has been undertaking assessments of the effects of road developments for almost 30 years, since he was first involved in the A55 dualling proposals across Anglesey. He has undertaken an estimated 40 road scheme assessments, many across Wales. Tony undertakes most of the interviews with farmers where there is potential for a significant impact and has been involved in many Public Inquiries.
J	Lesley-Anne Stone Senior Air Consultant	Chapter 13 Air Quality	BSc Mathematics and Meteorology Chartered Environmentalist Chartered Scientist Member of the Institute of Environmental Sciences Member of the Institute of Air Quality Management	10 years' experience in air quality assessment. She has worked at Arup since July 2012 and has worked on air quality assessments for various business sectors including a number of highways scheme across the UK. She has a robust knowledge of assessment techniques and air quality policy/guidance applicable in Wales and works closely with environmental officers for Welsh Government responsible for air quality
K	Greg Harris Noise and Vibration Consultant	Chapter 14 Noise and Vibration	Diploma in Acoustics and Noise Control MSc in Acoustics and Noise Control Member of the Institute of Acoustics	30 years' experience in environmental noise research and consultancy, specialising in highway noise assessment, in research, consultancy over the last 18 years. Member of the review panel for revision draft of the noise assessment guidance within the Design Manual for Roads and Bridges (2006). Drafted guidance on the design of highway noise screening for the Design Manual for Roads and Bridges (2011). Recent schemes include the A465 Dualling (Brynmawr to Tredegar in South Wales, the A8

	Name & Role	Role in preparing the Environmental Statement	Qualifications	Other relevant information
				Dualling (Coleman's Corner to Ballyrickard Road) in Northern Ireland, A30 improvements Chiverton to Carland Cross in Cornwall.
L	Thomas Edwards Design Project Manager, Senior Engineer	Chapter 15 All Travellers	MEng (Hons) Civil Engineering CEng MICE (Institution of Civil Engineers) MCIHT (Chartered Institution of Highways and Transportation)	Oversaw development of the Preliminary Design, preparation of the Environmental Statement and preparation of the draft Orders. Relevant experience: M4 Corridor Around Newport: Land and Orders Manage. Delivered all aspects of the draft Orders including land referencing, Compulsory Purchase Order, Line and Scheme Orders and Side Roads Orders on time to a challenging programme. Coordination Environmental, Engineering and Construction teams A465 Heads of the Valleys Section 3: Brynmawr to Tredegar: Responsible for the NMU Design on the Scheme.
M	Tim Wilkinson Senior Engineering Geologist	Chapter 16 Materials	BSc (Hons) Geology MSc Applied Environmental Geology Chartered Geologist	Engineering geologist for 16 years with experience in contaminated land assessments, geotechnical investigation and design. 11 years' experience of EIA for highways and other developments
N	Rowena Ekermawi	Chapter 17 Population and Human Health	BSc in Environmental Biology MSc in Environmental Assessment and Management. She is currently working towards a Master in Public Health. Chartered Environmentalist	16 years' relevant experience including EIA. Has led on health impact assessment work for a number of EIA projects.

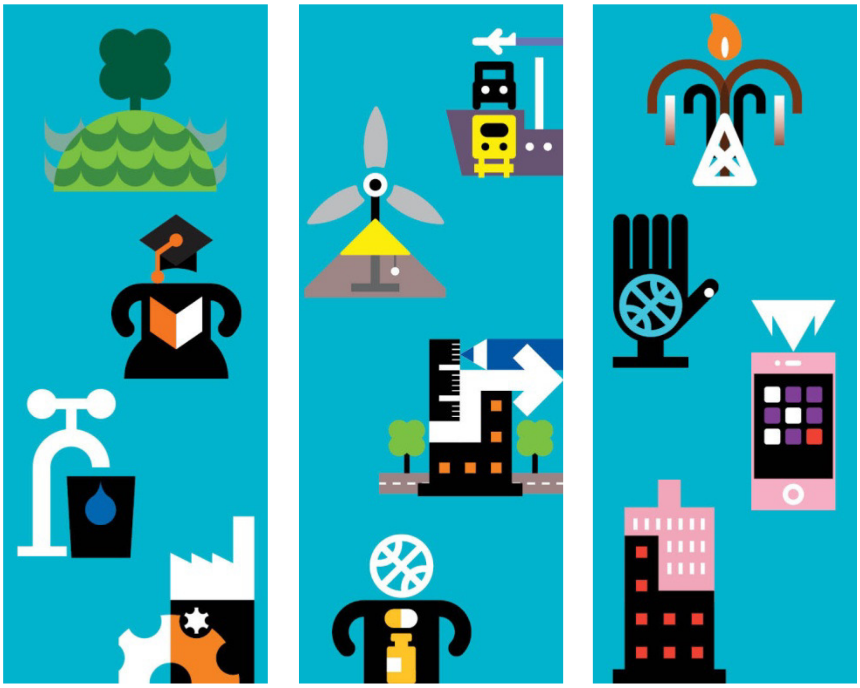
	Name & Role	**Role in preparing the Environmental Statement**	**Qualifications**	**Other relevant information**
O	Kara Brussen Sustainability Consultant	Chapter 18 Climate Change	BEng (Env), BA IEMA Practitioner member	4 years' experience relating to climate change and infrastructure sustainability
P	Andrew Sumner (see row A)	Chapter 19, 20 and 21 Cumulative Effects (same scheme)	(see row A)	(see row A)
Q	Shan Wyn Jones Principal Planner	Chapter 21 Cumulative Effects (other developments)	B. A (Honours); MCD Full Chartered Membership of the Royal Town Planning Institute	30 years' experience as a planner in various planning authorities in Wales. Undertook specialism in EIA legislation, as part of MDC qualification Experienced in EIA as a practitioner and assessor of EIA proposals at a Local Planning Authority level.
R	Andrew Sumner (see row A)	Chapter 22 Management of Environmental Effects	(see row A)	(see row A)

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement

Appendix 6.1: Preliminary Sources Study Report, Mott MacDonald, March 2016



A40 Llandewi Velfrey to Penblewin Improvement

Preliminary Sources Study Report

March 2016

Welsh Government

Mott MacDonald

A40 Llandewi Velfrey to Penblewin Improvement

Preliminary Sources Study Report

March 2016

Welsh Government

Mott MacDonald, Fitzalan House, Fitzalan Road, Cardiff CF24 0EL, United Kingdom
Tŷ Fitzalan, Heol Fitzalan, Caerdydd CF24 0EL, Y Deyrnas Unedig
T +44 (0)29 2046 7800 **F** +44 (0)29 2047 1888 **W** www.mottmac.com

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	March 2016	B Smith	P Fellows	P Maliphant	First issue

Information class: Standard

Contents

1 Introduction

1.1 Background

The A40 forms the key link road between south-east Wales and Haverfordwest and in turn the ports of Fishguard and Milford Haven in addition to connecting central and north Pembrokeshire, aiding the regional tourist economy.

In December 2004 the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study came about as a result of a number of previous reports that all concluded that the A40 needed improvement.

In December 2004 the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvement would use the 2+1 configuration allowing overtaking on the two lane direction, prohibited in the one lane direction and would be delivered in the following phases:

- A40 Penblewin - Slebech Park
- A40 Llanddewi Velfrey - Penblewin.

The first of these projects, Penblewin - Slebech Park, was completed in March 2011.

In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

'Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements.'

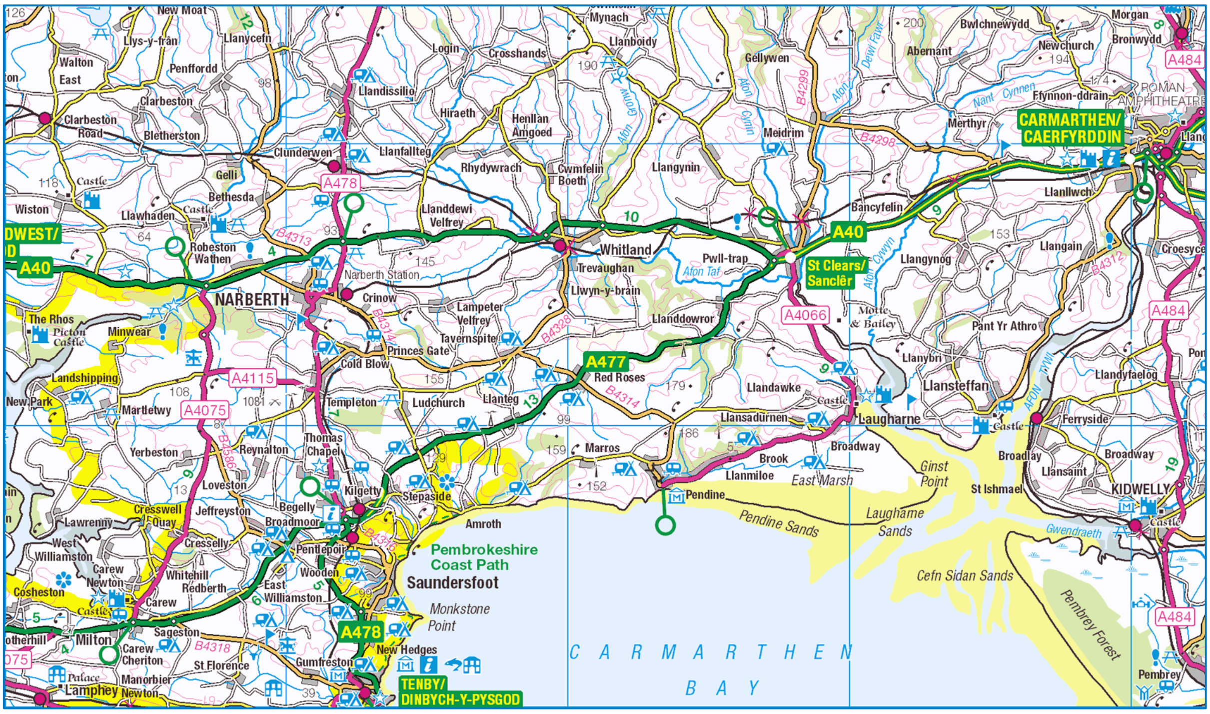
On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary

'In terms of transport links,….I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey.'

The A40 west of St Clears has been identified as a route which requires improvement in the Consultation Draft Welsh Government National Transport Plan 2015 supported by the National Transport Plan (NTP). One of the main aims of the National Transport Finance Plan (NTFP) under 'Targeted investment in infrastructure' is 'To improve reliability, journey times and safety along the east-west corridor in South Wales'.

The A40 Llanddewi Velfrey to Penblewin Improvement Scheme is included as a 'committed scheme' in the NTFP.A site location plan is presented in Figure 1.1.

Figure 1.1: Site Location Plan



Source: https://www.ordnancesurvey.co.uk/opendata/viewer/

Mott MacDonald Ltd. (MM) has been appointed by the Welsh Government to undertake continued studies for the preferred alignment option for the A40 Llanddewi Velfrey to Penblewin Improvement Scheme. The preferred route for the project was announced in March 2010 (Figure 1.2, Appendix D) and identifies a 2.5km bypass to the north of the village of Llanddewi Velfrey and a 2.5km section of on and slightly off line improvement west of Ffynnon Wood, where the bypass would re-join the existing trunk road at Penblewin roundabout. A new roundabout next to Bethel Chapel, a large embankment and cutting to the offline section and a new bridge carrying the Llanfallteg road are the key features of the scheme.

In line with the Ministerial ambition *'to accelerate to the fullest extent possible'* delivery of the scheme the Welsh Government presented a Project Director's Indicative Programme identifying the requirement for early engagement of an Early Contractor Involvement (ECI) team. Preliminary investigations following appointment identified a total lack of site specific ground investigation data for the scheme and an absence of reporting to comply with DMRB, Vol 4, Section 1, Part 2, HD22/08 'Managing Geotechnical Risk'. At a Pre-Tender Risk Workshop on 1st December 2015 the 'insufficient ground investigation available at start of ECI contract' leading to 'inconsistency in tender assumptions' was identified as the highest cost impact risk for the scheme. It was agreed that this risk must be mitigated pre tender and that it would be essential to 'undertake a preliminary ground investigation'. Issue of the tender for appointment of the ECI team has been delayed pending completion of these investigations and the associated HD22 reports.

1.2 Scope and Objectives

Mott MacDonald was appointed to the role of Designers Geotechnical Adviser (DGA) to complete required HD22 reports (Statement of Intent (SOI) and Preliminary Sources Study Report (PSSR)) and assist in the design, procurement and supervision of a Preliminary Ground Investigation (PGI) as a Compensation Event to its original commission. This report comprises the output from the Preliminary Sources Study.

The aspiration of the Welsh Government is provide sufficient desk study and site specific ground investigation data to inform tender responses from the ECI team who, on appointment, would take on full responsibility for the effective and efficient management of geotechnical risk through scheme design, consenting and construction. This study and the associated Preliminary Ground Investigation are therefore constrained by:

- Time – to minimise the delay to the procurement of the ECI team;
- Access – during the period of the study no access was legally possible to land in private ownership
- Cost – to align with the Welsh Government procurement ambitions the scope of the Preliminary Ground Investigation was required to be constrained to a maximum (estimated) cost of £110,000.

Where these constraints have impacted on the completeness of this study this matter has been highlighted in the text of this report and the ECI team will be required to further review the outputs from this study and complete any further studies and investigations considered essential in agreement with the Overseeing Organisations Geotechnical Adviser (OGGA). Following appointment of the ECI team they will take on the role of DGA and Mott MacDonald will revert to its original appointment as OOGA.

To meet scheme objectives this report is focused on time constrained transfer of readily available geotechnical information and collection of scheme specific GI data to allow tenderers to present a robust Initial Target Cost with a costed risk register mitigated by the availability of such preliminary data. The appointed ECI team will then be in a position to take on board the management of geotechnical risk including full design responsibility and liability.

This report therefore summarises the findings of a desk based review of readily available information; identifies potential geotechnical and geoenvironmental hazards associated with the site and makes recommendations for a preliminary site specific ground investigation which will target key areas for investigatory works. The factual ground investigation report obtained from the preliminary ground investigation will be included in the Early Contractor Involvement (ECI) contractor tender documentation to provide increased certainty within the target price and affording the opportunity to refine the earthworks design to minimise scheme cost and achieve cut/fill balance for the scheme. The scope of this report aligns with the employers ambition to identify 'opportunities to innovate the standard in order to ensure that the reporting burden is commensurate with the level of risk' and ensure that geotechnical risks are being appropriately managed within the context of the project ambitions, programme and risks as agreed previously with Welsh Government.

1.3 Other Relevant Information

This PSSR has been written in accordance with DMRB, Vol 4, Section 1, Part 2, HD22/08 'Managing Geotechnical Risk'

Due to the scheme involving mainly large earthworks (cuttings and embankments) likely to involve excavations below groundwater level and structures which will involve data analysis to confirm the design, it is recommended that the scheme is classified as Geotechnical Category 2 as defined in HD22.

2 Sources of Information and Desk Study

2.1 Sources of Information

The following sections provide a summary of the sources of information used to prepare this PSSR.

2.1.1 Existing Reports

- Mott MacDonald Ltd, March 2016: A40 Llanddewi Velfrey to Penblewin Statement of Intent;
- WSP Parsons Brinckerhoff, June 2015: A40 St Clears to Haverfordwest Study Design Options Report Volume 1 and 2, Final;
- Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final;
- Parsons Brinckerhoff Ltd, July 2006: Welsh Assembly Government A40 West of St Clears Llanddewi Velfrey to Penblewin Addendum to Technical Appraisal Report Volume 1 R9;
- Parsons Brinckerhoff Ltd, August 2006: Llanddewi Velfrey Stage 2 Scheme Assessment Report v2;
- Parsons Brinckerhoff Ltd, September 2006: Welsh Assembly Government A40 West of St Clears Llanddewi Velfrey to Penblewin Addendum to Technical Appraisal Report Volume 2;
- Atkins Ltd, November 2005: A40 Trunk Road Penblewin to Slebech Park Improvement Preliminary Sources Study Report, Final;
- Parsons Brinckerhoff, December 2004: Welsh Assembly Government A40 West of St Clears Route Options Report Volume 1 Rev 10;
- Parsons Brinckerhoff Ltd, December 2004: Welsh Assembly Government A40 West of St Clears Technical Appraisal Report Volume 1 Rev 7 and 2;
- Parsons Brinckerhoff, December 2003: A40 West of St Clears Economic Assessment Report;
- Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631; and
- Welsh Government, December 2015: Volume 2B Site Information, of the Welsh Government A40 Llandewi Velfrey to Penblewin Improvement Engineering and Construction Contract Option B

At the time of writing there was no additional information available on the Highways Agency Geotechnical Data Management System (HA GDMS) or the Welsh Assembly Geotechnical Data Management System (WA GDMS).

The following report is presented fully as Appendix A:

> *Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final.*

The following report is presented fully as Appendix B:

> *Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631.*

2.1.2 Resources

- British Geological Survey (BGS) Online Data Portal http://mapapps2.bgs.ac.uk/geoindex/home.html;
- BGS Lexicon of Named Rock Units: http://www.bgs.ac.uk/lexicon/;
- BGS Mineral Resources Wales: http://www.bgs.ac.uk/mineralsuk/planning/resource.html#MRW;
- Coal Authority Interactive Map Viewer: http://mapapps2.bgs.ac.uk/coalauthority/home.html;
- British Geological Survey (BGS) Maps at 1:50,000 scale, Sheet 228 Haverfordwest, Drift (http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001719) and Solid (http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1002692) editions, and the associated Geological Memoir.
- Environment Agency, What's in Your Backyard: http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e ;and,
- Natural Resources Wales: https://naturalresources.wales/?lang=en.
- Environment Agency, What's in Your Backyard: http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e
- Welsh Government, Transport website: http://gov.wales/topics/transport/roads/schemes/a40-road/?lang=en;
- Old-Maps historical map archive: http://www.old-maps.co.uk/index.html;
- Ordnance Survey: http://www.ordnancesurvey.co.uk/opendata/viewer/;
- Zetica UXB Risk Maps: http://www.zetica.com/uxb_downloads.htm;
- Lle, Geo-Portal for Wales LiDAR Composite Dataset: http://lle.wales.gov.uk/Catalogue/Item/LidarCompositeDataset/?lang=en; and
- Landmark Information Group Limited (2015): Site at St Clears/Sancler Carmarthenshire Envirocheck Report, Ref. 75606557_1_1, Slices A-F;
- Highways Agency Geotechnical Data Management System (HA GDMS);
- Welsh Assembly Geotechnical Data Management System (WA GDMS).
-

2.1.3 Services Information

All available services information along the proposed alignment is presented within Volume 2B Site Information, of the Welsh Government A40 Llandewi Velfrey to Penblewin Improvement Engineering and Construction Contract Option B.

2.2 Desk Study

The Envirocheck Report (Ref. 75606557_1_1) presented in Appendix C, provides an indication of the site history and surrounding land uses available on the public registers. The report provides data from a number of service providers including the British Geological Survey (BGS) and Natural Resources Wales (NRW). Details of environmental searches within 1000m of the proposed alignment are provided below. All distances are relative to the proposed alignment:

- A total of 18 no. discharge consents within the search area, 11 no. within 250m;

- 1 no. local authority pollution prevention and control;
- 5 no. pollution incidents to controlled waters;
- 1 no. prosecutions relating to controlled waters;
- 4 no. water abstraction licences;
- No records of landfill sites or waste management facilities within the search area;
- 21 no. BGS recorded mineral sites;
- 2 no. natural cavities located 640m and 750m east of the alignment;
- The area is not within an area affected by coal mining;
- There are some areas within very low risk from collapsible ground stability hazards and moderate risk from compressible ground stability hazards within the search area;
- No ground dissolution hazards within the search area;
- There are some areas within very low to moderate risk from landslide ground stability hazards within the search area;
- There are some areas within very low to low risk from running sand ground stability hazards within the search area;
- There are some areas within very low risk from shrinking or swelling clay ground stability hazards within the search area; and
- No areas of sensitive land use.

3 Field Studies

3.1 Walkover Surveys

A limited access walkover survey was undertaken by a MM Engineering Geologist on 2nd December 2015 to examine geology, geomorphology, land use and access conditions for the preliminary ground investigation along the proposed scheme alignment. However, the survey was limited to areas of public accessibility only, i.e. roads and footpaths as legal access rights to land in private ownership had not been secured.

Table 3.1 summarises the walkover survey observations and should be read in conjunction with Figure 1.2, Appendix D.

Table 3.1: Site walkover survey observations

Approximate Scheme Chainage (Ch.)	Location	Observations
0 to 1800	Penblewin Roundabout to Fynnon Chapel Refer to Section 8 Plates 8.10 and 8.11	The proposed alignment generally follows the existing A40 alignment with sections located in the adjacent agricultural fields to the north. The existing A40 in this location is at grade with agricultural fields to the north and south. A parking area for heavy goods vehicles is located at approximate Ch.350 to the south. Several isolated properties are located adjacent to the A40 both to the north and south, including Trefangor Farm and Trefangor Cottage.
1800 to 2800	Fynnon Chapel to Pen-troydin-fawr Refer to Section 8 Plates 8.8 and 8.9	East of Ffynnon Wood where the Parc-y-delyn access track joins the existing A40, the proposed alignment goes offline to the north passing through an existing layby located in a woodland area and then crosses through undulating agricultural fields in a north east direction. At approximate Ch.2300 the proposed alignment crosses between Pen-troydin-fach to the north and Maes-y-ffynnon and Maes-y-Rhos to the south. The proposed alignment continues across agricultural fields towards Pen-troydin-fawr. At approximate Ch.2650 the field boundary is formed by a mature treeline running along a stream.
2800 to 3900	Pen-troydin-fawr to Bethel Chapel Refer to Section 8 Plates 8.2 to 8.8	Approximately 50m south of Pen-troydin-fawr the proposed alignment crosses the Llanfalteg Road then crosses through 200m of woodland. Approximate Ch.3000 is the most northern point of the proposed alignment, after which the alignment heads in a south east direction back towards the existing A40 near Bethel Chapel. The proposed alignment crosses 2no. streams at approximate Ch.3100 and Ch.3300. The majority of the alignment along this section is through agricultural fields and across several field boundaries comprising hedgerows and trees.
3900 (rejoins existing A40 for approximately 600m)	Bethel Chapel to Bryncoed Refer to Section 8 Plate 8.1	The proposed alignment re-joins the existing A40 approximately 200m west of Bethel Chapel at approximate Ch.3900. The existing A40 heads east progressing downhill from a section at grade, through a cutting then over an embankment to the west end of a 2+1 section located near Bryncoed.

3.2 Previous Ground Investigations

No publically available existing ground investigation information has been identified along the proposed scheme alignment. However, a search of the British Geological Survey (BGS) Online Data Portal indicated that there are several publically available exploratory hole logs approximately 500m east of the proposed Bethel Chapel roundabout. Pertinent ground conditions from referenced exploratory holes are presented below in Table 3.2:

Table 3.2: Summary of available exploratory hole logs (located approximately 500m east of the proposed Bethal Chappel roundabout).

Exploratory hole reference	Strata	Level (mAOD)	Description	Thickness (m)
BH SN11NE87	Topsoil	107.5 – 107.0	Yellow brown, sandy silt with gravel.	0.4 – 0.5
	Mudstone	107.0 – 105.5	Highly weathered, very weak to weak, thinly laminated silty mudstone with extremely to very closely space discontinuities. Some decalcified fossil horizons.	1.5
	Siltstone	105.5 – 102.5	Slightly to moderately weathered, weak to moderately weak, thinly laminated to very thinly bedded, very slightly calcareous, slightly sandy siltstone	>3.0
BH SN11NE88	Topsoil	115.3 – 115.1		0.2
	Siltstone	115.1 – 111.3	Moderately weathered, weak to moderately weak, very thinly laminated to thinly bedded, slightly sandy siltstone.	3.8
		111.3 – 100.3	Fresh to slightly weathered, weak to moderately strong, laminated to thinly bedded siltstone with some calcareous siltstone and argillaceous limestone.	>11.0

Source: BGS Online Data Portal: Borehole BGS reference SN11NE87 and SN11NE88.

In addition, the following Geotechnical/Ground Investigation Factual reports from adjacent schemes are appended fully:

- Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final. Appendix A; and
- Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631. Appendix B.

4 Site Description

4.1 Geography

With reference to Figure 1.2 (Appendix D) the proposed alignment extends online from the existing A40 Penblewin Roundabout eastwards the village of Llandewi Velfrey. West of the village near Ffynnon Chapel the proposed alignment goes offline to bypass the village to the north through open fields. The alignment then rejoins the existing A40 east of Llandewi Velfrey near Bethel Chapel.

4.2 Topography

With reference to Figure 1.3 (Appendix D), heading east from Penblewin Roundabout the topography of the online alignment is at grade (approximately 90 metres Above Ordnance Datum (mAOD)). At Ffynnon Chapel the alignment goes offline to the north and the topography gradually rises in elevation north-easterly towards Pen-troydin-fawr (approximately 100 mAOD). At approximate Ch.3000 the topography drops to approximately 80 mAOD (2 No. incised watercourses) then rises gradually to approximately 125 mAOD at CH. 3600. A Ch. 3000 the proposed road alignment also changes direction and heads south-easterly towards Bethel Chapel. After Ch.3600 the topography gradually drops to c120 mAOD at the proposed location of Bethel Roundabout and continues to drop eastwards along the proposed alignment where it rejoins the existing A40, at approximately 105 mAOD.

4.3 Historical Development

The following is a summary of ‘significant’ changes noted from historical Ordnance Survey mapping. A full list of the maps consulted and also the maps themselves are presented in the Envirocheck Report (Ref. 75606557-1-1) presented in Appendix C. Please refer to Figure 1.2 (Appendix D) for named locations.

There has been little development either on or off the proposed alignment route since 1888, the earliest historical mapping reviewed. An unnamed road is identified corresponding with the existing A40 alignment. Open fields, field boundaries and woodland areas have remained unchanged since 1888, being consistent with current status. Several quarries are labelled near the alignment, most notably 2 no. quarries near Ffynnon Chapel, approximately 30m to the north of Ffynnon Woods, and 1 no. quarry located near to the proposed Bethel Chapel roundabout, approximately 50m south west. All the aforementioned have ceased activity. 1 no. gravel pit is also noted at the current location of Maes-y-Rhos. None of the aforementioned quarries or gravel pits are located within 50m of the proposed alignment.

4.4 Geology

Published geological information BGS Sheet 228 Haverfordwest at a scale of 1:50,000) indicates limited superficial deposits covering the proposed alignment comprise Glacial Till/Glaciofluvial deposits; small areas of clays, sands and gravels.

Made Ground is not identified on the geological mapping.

BGS Sheet 228 indicates the solid geology beneath the site comprises Late Ordovician/Early Silurian period strata in the form of mudstones and conglomerates of the:

- Slade and Redhill Formation (mudstone): blue grey mudstone with frequent thin micaceous sandstone and calcareous bands; and
- Portfield Formation (mudstone) and Haverford Mudstone Formation (conglomerate): shale, sandstone and conglomerates which grade up into dark green mudstones into thinly bedded green mudstone with occasional bands of sandstone.

Two faults are identified crossing the alignment; both are northeast trending at Llanddewi Velfrey and at Penblewin. The area has undergone various stages of folding and faulting, as a result the regional and local strata dip in various directions. Recorded strata dips in the vicinity of the scheme vary from 48 degrees north to 50 degrees south south west.

Figure 1.4, Appendix D, presents extracts of the available geological information for the proposed alignment.

4.5 Hydrology and Hydrogeology

With reference to the Environment Agency/NRW Surface Water Maps presented as part of the Envirocheck Report (Appendix C) multiple small rivers are identified both to the north and south of the existing A40 and proposed alignment.

With reference also to Figure 1.2 (Appendix D), the proposed alignment crosses 4 no. 'main rivers'. At Ffynnon Bridge an unnamed 'Primary River' is crossed by the A40, this river progressing via 2 no. extended culverts, draining to the northeast and northwest of Ffynnon Wood.

Between Pen-troydin-fach and Pen-troydin-fawr (approximate Ch.2650) the proposed alignment crosses an unnamed tertiary river which flows from the southwest to the northwest. An unnamed secondary river is located within the valley to the east of Pen-troydin-fawr, along the proposed alignment (approximate Ch. 3000), with a second unnamed tertiary river located approximately 300m to the southeast.

Referring to the NRW flood risk maps (Appendix C) various sections of the existing A40 between Penblewin Roundabout and Ffynnon Wood are designated to be at low risk from flooding from surface waters. A 75m section located approximately 350m to the east of the Penblewin Roundabout north of the existing lorry parking is designated as high risk. South of the existing A40 at Ffynnon Woods at the aforementioned culvert, areas shown to be at high risk from flooding from surface waters are identified. The unnamed rivers at Ch.2650 and Ch.3000 are designated to be at low and high flood risk respectively. A small area located to the north of the A40 at Gwyndy Fach is shown to be at low to medium risk of flooding from surface waters.

The site is underlain by bedrock classified as a Secondary B Aquifer, defined as being 'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering'. The areas of superficial deposits are classified as being unproductive strata (low permeability deposits that have negligible significance for water supply or river flow) with the exception of a small section approximately 500m east of Penblewin Roundabout which is classified as a Secondary A Aquifer; defined as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important base flow to rivers'.

4.6 Geomorphology

Due to time constraints aerial photographs and other desk based sources for the site have not been studied.

Due to the limited access afforded during the site walkover survey, restricted to areas of public accessibility only, i.e. roads and footpaths, it was not possible to undertake a geomorphological exercise for the offline proposed alignment. The online proposed route alignment has been constrained by the A40 and associated infrastructure, localised residential dwellings and additional man-made features. Consequently, general geomorphological and geological mapping was not undertaken. However, some rock exposures can be seen within vehicular access lanes (refer to Photo. 8.3, section 8) and have been used to confirm the general nature of the underlying solid geology.

5 Ground Conditions

Existing ground investigation information is not available for the proposed alignment; however, existing reports (from adjacent schemes) and publically available borehole logs (located approximately 500m east of Bethel Chapel) are available. These have been used to evaluate the ground conditions that are likely to be encountered.

A summary of the available exploratory hole logs is presented in Section 3.2. In addition, the following Geotechnical/Ground Investigation Factual reports from adjacent schemes are appended fully:

- Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final. Appendix A; and
- Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631. Appendix B.

Based on available information the ground conditions are likely to consist of small areas of superficial deposits comprising topsoil and glacial till up to 0.5m in thickness. The underlying bedrock is likely to be composed of weak to moderately strong mudstones and siltstones with interbedded sandstone.

Groundwater levels are anticipated to be high in low lying areas. The superficial deposits and the weathered bedrock are likely to have low permeability but there may be perched groundwater where the strata are more permeable.

A Preliminary Ground Investigation (Annex A) is being procured to inform further assessment of the prevailing ground conditions along the alignment of the proposed improvement scheme by the ECI Contractor.

6 Preliminary Engineering Assessment

6.1 General

A preliminary engineering assessment has been undertaken using all available relevant data for the proposed alignment. Considerations are presented in the following sub-sections.

6.2 Cuttings

The proposed cuttings are up to 14m (nominally) deep. The largest two cuttings are located northwest of the Bethel Chapel roundabout and south of Pen-troydin-fawr (refer to Figures 1.2 and 1.3, Appendix D).

The majority of the excavated material is envisaged to be varying degrees of weathered rock varying in strength from very weak to strong, as detailed in Section 3.2. The excavatability of rock depends on the geotechnical properties of the material in conjunction with the type/size of plant and/or method of working chosen. A number of systems have been developed for assessing excavatability of rock, though no system is considered conclusive and only field trials can accurately determine whether a rock mass can be excavated by a particular working method/plant type. Blasting may be required in stronger material such as sandstone, siltstone or hard mudstone.

Further considerations for the cuttings follow:

- The base of excavations may heave due to the removal of overburden;
- Excavated slopes in weathered and/or fissured rock may require immediate support;
- The impact of long term weathering on cutting stability should be addressed during the earthworks design process; and
- Superficial deposits along the proposed alignment are expected to be minimal in depth and/or frequency.

The area has undergone various stages of folding and faulting, as a result the regional and local strata dip in various directions. The variations in both bedding directions and faulting must be considered when making an assessment of slope angles to limit slope instability issues.

Significant drainage may be required to control groundwater seepage in cut slopes, refer to Section 6.6..

In the absence of specific geotechnical data/parameters for the alignment, nominally cut slopes of between 1:1.5 to 1:2.5are anticipated to be feasible.

6.3 Embankments

Several embankments are proposed along the alignment, the highest of which (nominally 12m in height) is located north of Blaen-Pen-Troydin between Ch.3000 and Ch.3500 (refer to Figures 1.2 and 1.3, Appendix D).

It is envisaged that the embankment will be founded on rock, providing a suitable formation.

It is envisaged that the majority of excavated material from scheme cuttings will be suitable for re-use as General Fill on site. It is likely the derived fill will fall within the acceptable limits of Class 2 (Manual of Contract Documents for Highways Works; Volume 1 Specification for Highways Works) depending on the in-situ weathering state of the mudstone/siltstone, weather conditions during excavation/replacement and how the material is stored. The impact of long term weathering of site won materials on embankment stability should be considered during earthworks design. Some Class 1 fill may be recovered should stronger strata be encountered. Fill shall be placed under controlled compaction conditions in accordance with the Manual of Contract Documents for Highways Works; Volume 1 Specification for Highways Works.

In the absence of specific geotechnical data/parameters for the alignment, slope angles of 1:2.5 or shallower are anticipated to be feasible.

Surface water will need to be controlled over the embankment slopes to prevent erosion.

6.4 Pavement Assessment

The condition of the subgrade is dependent on the quality of existing material (sections at grade), the subgrade moisture content, trafficking, weather conditions, quality of fill material (embankments), formation conditions in cuttings. The majority of sub-formations at grade along the alignment shall be within mudstone formations. Local irregularities and mudstone weathering grades shall produce variable California Bearing Ratio (CBR) values. Significant quantities of Made Ground are not envisaged other than online i.e. existing pavement construction.

The in situ CBR values along existing at grade sections shall be investigated and clarified during the preliminary ground investigation. A conservative design CBR value shall allow for pavement construction to proceed under a greater range of weather conditions.

6.5 Structures

Several new structures shall be required along the proposed alignment. These are likely to include (but not be limited to) over bridges, culverts and underpasses, and shall be determined at a later stage.

Assessment should be made of the potential for aggressive ground conditions when considering the concrete classification for structures.

Spread foundations should prove suitable for structures associated with the proposed alignment, founded within the competent Portfield, Slade and Redhill and Haverford Formation mudstone deposits. Alternatively, or for founding substantial/sensitive structures, piles founded within the aforementioned mudstones should be considered.

6.6 Drainage

Groundwater is likely to be encountered near ground level in low lying areas and in proximity to existing streams/drainage features. Perched groundwater may be encountered within granular or fractured layers in the soil and rock.

The following minimum recommendations are presented for cuttings and embankments associated with the proposed alignment:

Cuttings - The potential for surface water erosion of cuttings should be removed by installing a lined cut-off ditch/channel or pipe drain at the top of the cut slope. Drainage of the cut slopes – batter drainage is not anticipated. However, observations of cuttings should be undertaken to evaluate significant/persistent seepage etc.

During construction, drainage to prevent surface water migration should be provided in the form of filter/carrier drains or open channels/lined ditches located in the verge as locally required.

Embankment - A cut off ditch (lined), channel or pipe drain should be located at the crest and toe of the embankment to prevent surface water erosion of the formed slope and softening of the subsoil at the strata at the toe. Where local topography falls towards an embankment, surface water should be collected by means of the aforementioned.

7 Comparison of Project Options and Risks

At the time of writing no factors have been identified that are likely to have a significant impact on the proposed scheme, construction or health and safety.

Potential geotechnical hazards identified in association with the scheme are summarised in the Geotechnical Risk Register presented in Table 7.5. The risk is assessed by interaction of an Impact Index and Likelihood Index, shown in Tables 7.1 and 7.2 respectively. Table 7.3 is the Risk Matrix, which shows the actual risk level, rated from "Severe" (maximum risk level) to "Negligible" (minimum risk level). Table 7.4 shows the designers actions based on the risk level.

Table 7.1: Impact Classification

Impact			**Cost**	**Time**	Reputation	**Health & Safety**	**Environment**
1	very low	negligible	negligible	negligible effect on programme	negligible	negligible	negligible
2	low	significant	> 1% budget	> 5% effect on programme	minor effect on local company image/ business relationship mildly affected	minor injury	minor environmental incident
3	med	serious	> 10% budget	> 12% effect on programme	local media exposure/ business relationship affected	major injury	environmental incident requiring management input
4	high	threat to future work and client relations	> 20% budget	> 25% effect on programme	nationwide media exposure / business relationship greatly affected	fatality	environmental incident leading to prosecution or protestor action
5	very high	threat to business survival and credibility	> 50% budget	> 50% effect on programme	permanent nationwide affect on company image/ significant impact on business relationship	multiple fatalities	major environmental incident with irreversible effects and threat to public health or protected natural resource

Table 7.2: Likelihood Classification

Likelihood		**Probability**
1	negligible/improbable	<1%
2	unlikely/remote	>1%
3	likely/possible	>10%
4	probable	>50%
5	very likely/almost certain	>90%

Table 7.3: Risk Matrix

		Impact				
		1	2	3	4	5
Likelihood	1	N	N	N	A	A
	2	N	A	A	H	H
	3	A	H	H	S	S
	4	H	H	S	S	S
	5	H	H	S	S	S

Table 7.4: Designers Action

Risk Level	Description	Action by Designer
N	Negligible	None
A	Acceptable	Check that risks cannot be further reduced by simple design changes
H	High	Amend design to reduce risk, or seek alternative option. Only accept option if justifiable on other grounds.
S	Severe	

Table 7.5: Preliminary Geotechnical Risk Register

Hazard		Consequence	Impact	Likelihood	Current Risk	Risk Type*	Potential Control Measures	Impact	Likelihood	Residual Risk
Ground conditions with variable strength and composition	Ground Conditions likely to be encountered: Made Ground Glacial Till/ Glaciofluvial Deposits Slade and Redhill Formation (mudstone) Portfield Formation and Haverford Mudstone Formation (mudstone)	Differential settlement; potential for failure of foundations/ infrastructure. Hard rock encountered in excavations. Delays during construction, cost implications.	4	3	S	C, T, R, H+S	Site specific PGI to be carried out for understanding of ground and groundwater conditions.	4	1	A
Pre-existing faulting and unfavourable hydrogeological or geological conditions and weathering profiles (including post construction). .	All ground conditions	Possible instability/ failure of temporary excavations/ earthworks/ permanent works.	3	3	H	C, T, R, H&S, E	Site specific PGI to be carried out for understanding of ground conditions.	3	2	A
Sulphate bearing/ aggressive ground conditions	Increased hazard associated with pyrite mudstones.	Corrosion and degradation of infrastructure materials.	3	3	H	C, T, R, H&S	Site specific PGI to be carried out to determine ground conditions for protection of buried concrete.	3	2	A
Ground contamination	Increased hazard associated with Made Ground including potentially infilled quarries.	Unidentified contamination. Potential risks to human health and the environment. Potential cost implications if deemed 'unsuitable' fill material etc.	2	2	A	C, T, E and H+S	Site specific PGI to be carried out for understanding of ground conditions	2	1	N

Hazard		Consequence	Impact	Likelihood	Current Risk	Risk Type*	Potential Control Measures	Impact	Likelihood	Residual Risk
Site won fill material unsuitable for reuse	All ground conditions	Alternative sources of fill material required. Additional disposal costs for unsuitable material. Delays during construction, cost implications. Cost of potential works to improve material characteristics.	4	3	S	C, T , E, R	Site specific PGI to be carried out for understanding of ground conditions and suitable testing of materials.	4	1	A
Unidentified services	Along full length of proposed alignment.	Potential damage to services causing delays during construction, cost implications. Damage to local drainage network including land drains leading to land owner issues, potential environmental impacts etc.	3	3	H	C, T, R, E, H&S	Early contact with service providers via enquiries. Contact landowners for existing drainage plans. Undertake service location inspection pits and utilise service detection equipment during all site activities.	3	2	A

* C=cost; T=time; R=reputation; H+S=health and safety; E=environmental

8 Drawings and Photographs

Photo 8.1: View from Bethel Chapel looking east along the existing A40

Photo 8.2: View from Bethel Chapel looking west along the existing A40

Photo 8.3: Rock outcrop located in a cutting along the unnamed road from Bethel Chapel to Caerau Farm

Photo 8.4: Potential access track to GI locations located south and west of Caerau Farm

Photo 8.5: Photo taken looking northeast across the proposed embankment at approximate Ch.3250

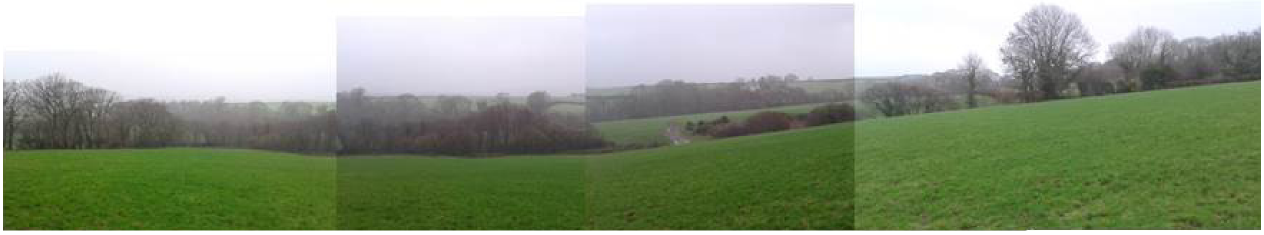


Photo 8.6: Photo taken looking west towards the stream crossing at approximate Ch.3000

Photo 8.7: Photo taken looking eastwards along the proposed alignment from approximate Ch.2850, south of Pen-troydin-fawr

Photo 8.8: Photo taken looking south towards Pen-troydin-fawr where the proposed alignment will cross (west-east) the existing unnamed road

Photo 8.9: Photo taken looking westwards from Pen-troydin-fawr towards Pen-troydin-fach (approximate Ch.2500)

Photo 8.10: Photo taken looking westwards along the existing A40 where the proposed offline alignment rejoins the existing A40 at approximate Ch.1800

Photo 8.11: Photo taken from the northeast corner looking southwest across the existing Penblewin Roundabout.

9 Annex A

9.1 Objectives and Format of Investigation

To assist with Early Contractor Involvement (ECI) a site specific Preliminary Ground Investigation (PGI) will be specified targeting key areas for investigatory works, e.g. cuttings, embankments, highway structures together with contamination testing and soil testing. The factual ground investigation report obtained will be included in the ECI contractor tender documentation to provide increased certainty within the target price while affording the opportunity to refine the earthworks design to minimise scheme cost and achieve cut/fill balance.

9.2 Special Problems to be Investigated

None.

9.3 Proposed Investigation

The proposed preliminary ground investigation shall include:

- Approximately 30 No. Machine excavated trial pits: to observe and record existing ground and groundwater conditions; and to take samples for laboratory testing;
- Approximately 17 No. Rotary percussive, cored boreholes: to provide information on the superficial and solid geology at depth and to allow installation of combined gas/groundwater monitoring wells (if required). Samples of the solid geology (rock) will be recovered for geotechnical laboratory analysis to determine geotechnical properties with *in-situ* standard penetration tests (SPT) carried out at regular intervals in suitable strata;
- Approximately 14 No. in situ California Bearing Ratio tests: to provide pavement design information;
- In-situ testing; is likely to include, but shall not be limited to:

  Standard Penetration Tests

  California Bearing Ratio

- Installation of combined gas/groundwater monitoring standpipe;
- Groundwater level monitoring and sampling;
- Laboratory geotechnical testing is likely to include, but shall not be limited to:

  Natural Moisture content (soil)

  Atterberg Limits

  Particle size distribution by wet sieving

  Organic matter content

  Consolidated undrained triaxial compression test with measurement of pore pressure

  Undrained shear strength in triaxle compression without the measurement of pore pressure

  Shear strength of a single 60 mm x 60 mm or 300 mm x 300 mm square specimen by direct shear

  Dry density/moisture content relationship

Single stage Consolidated Undrained triaxial with water pressure measurement

One-dimensional consolidation properties test period 5 days (Oedometer).

California Bearing Ratio

Natural moisture content (rock)

Point Load Indices

Unconfined compressive strength testing

- Laboratory chemical testing: Sulphate testing to BRE Special Digest 1; and
- Factual reporting.

Proposed PGI locations are shown on the following drawings at the end of this Annex:

Drawing No. 358432-MMD-00-XX-DR-C-0060 Proposed Exploratory Hole Location Plan (Sheet 1 of 3)

358432-MMD-00-XX-DR-C-0062 Proposed Exploratory Hole Location Plan (Sheet 2 of 3)

358432-MMD-00-XX-DR-C-0062 Proposed Exploratory Hole Location Plan (Sheet 3 of 3)

9.4 Site and Work Restrictions

Working site hours will be restricted to 08:00 to 16:00 hours Monday to Friday inclusive.

Weekend working is subject to approval from the Welsh Government.

Access routes shall be agreed with the Investigation Supervisor prior to works commencing: Only the agreed access routes shall be used, tracking along field boundaries (where applicable) as much as possible. Alternative access routes can only be used as agreed with both the land interest and the Investigation Supervisor. Any alternative agreed route shall be marked on a plan of the site and signed by the Contractor, Land Interest and Investigation Supervisor. Before making entry on to a particular Site area with any equipment the Contractor shall give the Investigation Supervisor at least 48 hours' notice of his intended date of entry and details of any equipment which may be taken on the Site.

When undertaking works within a site, the site entrance shall be left clear at all times. This particularly applies to work within fields. Vehicles should be parked on the road side where safe to do so, or within agreed locations within the site/field.

The Contractor shall give at least 48 hours' notice of his intended date of entry directly to the land interests and occupiers both at the site of each exploratory hole and on the access routes thereto. Arrangements shall be made by the Contractor and agreed with the land interests for the collection of keys for gates, movement of livestock etc. Notice shall be given by telephone or in person. If contact cannot be made with the land interests of a particular plot of land the land should not be entered, and the Contractor shall notify the Investigation Supervisor.

Contact details for the various land interests are to be provided during tender process.

If, when attempting to enter a particular site, access is not possible (locked gate etc.) then the Investigation Supervisor shall be notified, if the land interests cannot be contacted.

9.5 Specialist Consultations

The ground investigation will have to take into account the views and requirements of other interested parties, included but not limited to ecological and archaeological considerations.

9.6 Programme, Cost and Contract Arrangements

9.6.1 Preliminary Ground Investigation

A draft programme for the Preliminary Ground Investigation is provided in Table 9.1 below:

Table 9.1: Draft Preliminary Ground Investigation Programme

SCHEME	A40 Llanddewi Velfrey to Penblewin Improvement Scheme									
Week commencing	1	2	3	4	5	6	7	8	9	10
Activity										
Mobilisation	■									
Site works		■	■	■	■	■				
Laboratory Testing					■	■	■			
Draft Factual Report							■	■		
Final Factual Report									■	■

The start date for the Preliminary Ground Investigation shall be confirmed, although this is presumed to be March/April 2016. This date is provisional, the actual date is subject to land owner access agreement, the contractor is able to mobilise and all necessary permissions have been obtained.

9.6.2 Post Preliminary Ground Investigation Contract Arrangements

Following appointment of the ECI Contractor and during Key Stage 3 (Preliminary Design and Preparation of Orders) the Contractor should appoint a suitably qualified Designers Geotechnical Advisor (DGA) to oversee:

- Review of SOI, PSSR and results of Preliminary Ground Investigation and confirm the Geotechnical Category for the scheme.

- Review requirements for additional studies such as full site walkover, study of aerial photographs and geomorphological assessment as may be required and agreed with the OOGA;
- Management of Geotechnical Certification in consultation with the OOGA to identify opportunities to innovate the standard in order to ensure the reporting burden is commensurate with the level of risk.
- Completion of supplementary ground investigation(s) (in agreement with the OOGA) to augment the completed Preliminary Ground Investigation so as to provide sufficient ground data to effectively and efficiently manage the geotechnical risks and opportunities on site and to inform detailed design and design of required temporary works.
- Revision of Annex A of the PSSR in response to the requirement for supplementary ground investigation(s).
- Completion of the Ground Investigation Report (GIR) in accordance with DMRB, Vol 4, Section 1, Part 2, HD22/08 'Managing Geotechnical Risk'

During Key Stage 6 (Detailed Design) the ECI Contractor should:

- Complete the Geotechnical Design Report (GDR) in accordance with DMRB, Vol 4, Section 1, Part 2, HD22/08 'Managing Geotechnical Risk'

Following Key Stage 6 (Construction) the ECI Contractor should:

- Complete the Geotechnical Feedback Report (GFR) in accordance with DMRB, Vol 4, Section 1, Part 2, HD22/08 'Managing Geotechnical Risk'

The above should be completed in accordance with a programme agreed with the Welsh Government following appointment of the ECI Contractor. The programme is to be proactively managed in agreement with the Employers Agent and OOGA. Certification time limits will be aligned with the requirements set out in HD22/08. Costs will be included as part of the successful Contractors tender.

9.7 Reporting

9.7.1 Preliminary Ground Investigation

A Factual Report, to be produced by the Preliminary Ground Investigation Contractor upon completion of site works and laboratory testing. Digital data shall be provided in AGS format.

9.7.2 Post Preliminary Ground Investigation Reporting Requirements

As detailed in Annex A Section 9.6.2.

Appendices

Appendix A.	Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final
Appendix B.	Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631
Appendix C.	Envirocheck data
Appendix D.	Figures 1.2, 1.3 and 1.4

Appendix A. Atkins Ltd, February 2007: A40 Trunk Road Penblewin to Slebech Park Improvement Geotechnical Report, Final

Appendix B. Thyssen Geotechnical, October 1996: A 40 Robeston Wathen Bypass Ground Investigation Factual Report Volume 1 and 2, Report No. 7631

Appendix C. Envirocheck data

Appendix D. Figures 1.2, 1.3 and 1.4

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement

Appendix 6.2: Ground Investigation Factual Report, WYG, 2017

Llywodraeth Cymru Welsh Government

A40 Llanddewi Velfrey – Penblewin

Ground Investigation Factual Report

June 2017

Document Control

Document: Ground Investigation Factual Report

Project: A40 Llanddewi Velfrey

Client: Llywodraeth Cymru Welsh Government

Job Number: A096409

File Origin: N:\Environmental\projects\A096409 -A40 Llanddewi Velfrey - Penblewin\Report\A096409 A40 Llanddewi Velfrey FGIR V4 June 17.docx

Revision: V4 – Updated Final

Date: June 2017

Prepared by	Checked by	Approved By
Jon Barley **Graduate Geo-environmental Engineer**	**Paul Vincent** **Principal Engineering Geologist**	**Ian Viney** **Associate Director**

Prepared by	Checked by	Approved By
Jon Barley **Graduate Geo-environmental Engineer**	**Paul Vincent** **Principal Engineering Geologist**	**Ian Viney** **Associate Director**

Revision: Draft

Date: June 2016

Contents

Figures

Appendices

1 Introduction

1.1 Instruction

WYG Environment Planning Transport Ltd (WYG) were commissioned by the Welsh Government to undertake intrusive ground investigation work at the site of the proposed new bypass road from Llanddewi Velfrey to Penblewin.

1.2 Brief

A new 2+1 format bypass road 5km long is proposed to be constructed from Llanddewi Velfrey to Penblewin which aims to improve traffic flow and bypass historical areas of congestion. The road is proposed to include a number of engineering features which involve a single over bridge structure, box culvert underpass, large diameter culverts, proposed attenuation areas, deep cuttings and sizeable embankments. A ground and laboratory investigation to inform the design of the proposed development has been designed to identify any geotechnical risks and ensure effective design measures are in place. The investigation comprised the following key elements:

- 30 No. Machine excavated trial pits
- 17 No. Rotary percussive cored boreholes
- 14 No. In situ California Bearing Ratio tests
- In situ testing
- Installation of landgas and groundwater monitoring wells
- Groundwater level monitoring and sampling
- Geotechnical and environmental laboratory testing of soil samples
- A factual report.

1.3 Report Scope

This report summarises the work undertaken and includes the following key elements;

- Full factual records of the site works carried out
- Ground conditions encountered

- In situ testing results
- Geotechnical and environmental laboratory testing results

1.4 Limitations

This report has been prepared in accordance with the requirements of the Welsh Government. It is subject to the report conditions contained in Appendix A.

The information contained in this report is intended for the use of the Welsh Government. WYG can take no responsibility for the use of this information by any third party or for uses other than that described in this report.

2 Site Information

2.1 Location

The site is located between Gwyndy Farm and Penblewin Roundabout. The site stretches in a westerly direction from Gwyndy Farm and proceeds north of Llanddewi Velfrey before re-joining the existing road near Ffynnon Wood. A site location plan is presented as Figure 1.

2.2 Site description

The site generally consists of generally grass covered agricultural land, with irregular field patterns, with adjacent residential areas consisting of farms and cottages and the existing A40 carriageway.

A site layout plan is included as Figure 2.

2.3 Geology

The BGS geology mapping (1:50,000 scale, sheet 228 Haverfordwest) indicates that there is no artificial made ground located within the site area.

There are limited superficial deposits covering the site. These comprise of Glaciofluvial Deposits made up of sands and gravel, Glacial Till and Alluvium comprised of clay, silt, sand and gravel.

The underlying bedrock is comprised of Late Ordovician/ Early Silurian period strata which consists of mudstones and conglomerates:

- Portfield Formation (Mudstone) – Interbedded carbonaceous mudstone with well sorted, fine grained sandstones.
- Portfield Formation and Haverford Mudstone Formation (conglomerate)
- Slade and Redhill Formation (Mudstone)
- Mydrim Shales Formation (Mudstone)

3 Site Investigation

The site investigation was undertaken between the 11th April and 11th May 2016. The first groundwater monitoring visit was undertaken on 19th May. Two further groundwater sampling visits are outstanding and will be reported as an addendum to this report.

Details of the fieldwork methods are given in the notes section at the end of this report.

3.1 Scope

The scope of the site investigation included the following:

- 25 No. Machine excavated trial pits
- 18 No. Rotary percussive cored boreholes
- 9 No. In situ California Bearing Ratio tests
- Collection of disturbed and undisturbed soil samples from exploratory positions.
- Geotechnical and environmental laboratory testing of soil samples
- Installation of landgas and groundwater monitoring wells
- 3 No. Return visits for groundwater sampling and groundwater level monitoring with associated environmental testing.
- A factual report.

TP6 to TP16 and CBR9 and 10 and CBR12 to 14 were not undertaken during the site investigation due to issues with the landowner.

BH13 was cancelled due to issues with access to the position. BH101 and BH102 were added to compensate for the cancellation of trial pits.

Figure 2 shows the layout of the exploratory holes advanced during the site investigation. Exploratory hole logs including photographic plates are presented in Appendix B.

4 Ground Conditions Encountered

4.1 Strata encountered

The sequence of strata encountered beneath the site was;

- Made Ground
- Portfield Formation
- Portfield Formation and Haverford Formation
- Slade and Redhill Formation

A summary of depth of each stratum is provided in Table 1 and descriptions of each stratum are detailed in the subsequent sections. Exploratory hole logs including photographic plates can also be seen in Appendix B.

Table 1 - Summary of strata depths (m bgl) for all exploratory holes

Location	Made Ground	Portfield Formation	Portfield Formation and Haverford Formation	Slade and Redhill Formation
BH01	0.2 – 1.5	ne	ne	1.5 – 8.0[1]
BH02	ne	ne	ne	0.85 – 8.5[1]
BH03	ne	ne	3.5 – 15.0[1]	ne
BH04	ne	ne	ne	0.35 – 18.0[1]
BH05	ne	ne	ne	0.85 – 17.5[1]
BH06	ne	ne	ne	0.3 – 17.4[1]
BH07	ne	ne	ne	0.4 – 10.5[1]
BH08	ne	ne	ne	0.6 – 10.5[1]
BH09	ne	0.35 – 9.5	ne	9.5 – 13.0[1]
BH10	ne	ne	ne	0.35 – 20.0[1]
BH11	ne	ne	ne	0.65 – 11.0[1]
BH12	0 – 4.1	4.1 – 6.9	6.9 – 8.0[1]	ne
BH14	0 – 0.85	0.85 – 14.5[1]	ne	ne
BH15	ne	0.45 – 13.4[1]	ne	
BH16	ne	ne	0.45 – 8.0[1]	ne
BH17	ne	ne	ne	0.4 – 8.0[1]
BH101	ne	ne	ne	0.4 – 8.0[1]

Location	Made Ground	Portfield Formation	Portfield Formation and Haverford Formation	Slade and Redhill Formation
BH102	0.3 – 0.8	ne	ne	0.8 – 8.5[1]
TP01	0 – 0.5	ne	ne	0.5 – 1.9[1]
TP02	ne	ne	ne	0.3 – 1.85[1]
TP03	0 – 3.1	ne	3.1 – 4.1[1]	ne
TP04	ne	ne	ne	0.2 – 2.1[1]
TP05	ne	ne	ne	0.25 – 2.0[1]
TP17	ne	0.25 – 3.65[1]	ne	ne
TP18	ne	0.25 – 3.8[1]	ne	ne
TP19	ne	0.3 – 4.3[1]	ne	ne
TP20	0 – 0.25	0.25 – 4.35[1]	ne	ne
TP21	ne	0.3 – 4.3[1]	ne	ne
TP22	ne	0.35 – 4.3[1]	ne	ne
TP23	ne	0.35 – 4.3[1]	ne	ne
TP24	ne	0.3 – 4.1[1]	ne	ne
TP25	ne	0.0 – 3.1[1]	ne	ne
TP26	ne	0.35 – 4.1[1]	ne	ne
TP27	ne	ne	0.3 – 4.3[1]	ne
TP28	ne	ne	ne	0.3 – 3.2[1]
TP29	ne	ne	ne	0.25 – 3.5[1]
TP30	ne	ne	ne	0.3 – 2.9[1]

[1] Base of stratum not proven
ne denotes not encountered

4.1.1 Made Ground

Limited Made Ground was encountered across the site to generally shallow depths with the exception of BH12 (see Table 1). The Made Ground consisted primarily of reworked ground used as access paths for various fields. The majority was granular comprising brown silty sandy gravel and some areas consisting of gravelly clay with varying boulder content. The gravel consisted of fine to coarse angular to sub-angular mudstone and sandstone. Fill material in BH14 also consisted of metal nails and a clay pipe/ land drain.

4.1.2 Portfield Formation

The Portfield Mudstone Formation was encountered between 0.35m and 14.5m depth and consisted of very stiff to stiff weathered mudstone recovered as brown to grey gravelly clay and sand with mixed lithorelics of mudstone and sandstone. The solid rock contained very closely spaced sub horizontal planar smooth bedding discontinuities with black staining and occasional undulating discontinuities. The base of the stratum was not proven in BH14 and BH15.

4.1.3 Portfield Formation and Haverford Formation

The Portfield Formation and Haverford Formation was encountered in BH3, BH12 and BH16, the base of the stratum was not proven in any of the locations. The Portfield Formation and Haverford Formation was encountered between 0.45m and 15m below ground level and consisted of moderately weak to strong weathered mudstone recovered as grey to brown sandy gravelly Clay/Silt with the gravel comprising fine to coarse sub angular to sub rounded sandstones and mudstones. The solid rock consists of close and wide spaced discontinuities with random fractures.

4.1.4 Slade and Redhill Formation

The Slade and Redhill was encountered at depths and locations as indicated in Table 1. It was typically described as a weak locally moderately strong grey mudstone with very closely spaced discontinuities. Typically near surface deposits of the Slade and Redhill Formation were weathered to a clay with varying amounts of subordinated mudstone lithorelics.

4.2 Groundwater

Groundwater was encountered in the majority of boreholes as well as TP19. The depths are summarised in Table 2.

Table 2 - Summary of groundwater strikes

Location	Depth of groundwater strike (m bgl)	Stratum
BH03	1.0 3.5	Portfield Formation
BH04	1.8	Slade and Redhill Formation
BH10	6.0	Slade and Redhill Formation
BH11	3.0	Slade and Redhill Formation
BH14	4.5	Portfield Formation
BH15	4.5	Portfield Formation
BH16	1.2	Portfield Formation and

Location	Depth of groundwater strike (m bgl)	Stratum
		Haverford Formation
BH17	5.2	Slade and Redhill Formation
BH101	3.2	Slade and Redhill Formation
BH102	1.2	Slade and Redhill Formation
TP19	4.0	Portfield Formation

For groundwater levels measured during the first monitoring visit on 18th April see section 6 and Appendix F.

4.3 In Situ Testing

4.3.1 Standard Penetration Testing

Standard Penetration Tests (SPTs) were undertaken in all boreholes. The results are presented on the exploratory hole logs included in Appendix B.

4.3.2 CBR Testing

CBR values have been determined in-situ at nine locations between 0.5 and 0.9m depth. The results are included in the exploratory hole logs presented in Appendix B and summarised in Table 3 below.

Table 3 - Summary of plate load and CBR testing

Location	Penetration (mm)	CBR (%)
CBR1	2.5	1.69
CBR1	5.0	1.90
CBR2	2.5	4.95
CBR2	5.0	5.70
CBR3	2.5	8.87
CBR3	5.0	8.57
CBR4	2.5	4.19
CBR4	5.0	4.47
CBR5	2.5	3.85
CBR5	5.0	4.19
CBR6	2.5	4.06
CBR6	5.0	4.51
CBR7	2.5	3.44

Location	Penetration (mm)	CBR (%)
CBR7	5.0	3.19
CBR8	2.5	3.23
CBR8	5.0	2.56
CBR11	2.5	15.33
CBR11	5.0	14.95

4.3.3 Visual Evidence of Contamination encountered

No visual or olfactory evidence of contamination was encountered during t the ground investigation.

4.4 Obstructions

No obstructions were encountered in during the investigation.

5 Laboratory Testing

5.1 Geotechnical Testing

Geotechnical testing was scheduled by Mott MacDonald and undertaken by GSTL Ltd, an approved supplier in accordance with the requirements of WYG quality system and are UKAS accredited for a range of geotechnical tests. The test procedures used in each case are given in Table 7.

Table 4 - Summary of Geotechnical Tests

Test	Standard (BS1377:1990)	No.
Moisture content	Part 2, Clause 3.2	43
Atterberg Limits	Part 2, Clause 4.3 and 5.3	33
Particle size distribution by wet sieving	Part 2, Clause 9.2	25
Particle size distribution by pipette	Part 2, Clause 9.5	15
(Gl) BRE SD1 ph, acid and water soluble sulphate and total sulphur		15
BRE Pyritic Suite-Geology		1
Dry Den/MC (4.5kg rammer method 1 litre Mould)	Part 4, Clause 3.5	11
CBR at each compaction point		55
Determination of the uniaxial compressive strength of a single 76mm diameter core	Part 2/3, clause 3.2	1
Slake durability test		6
Los Angeles abrasion test		1
Natural moisture content of rock (UCS) only		1
Point load strength index test	Part 2, Clause 3.2	31

5.2 Environmental Testing

The environmental chemistry was investigated by specialist chemical analysis of selected soil samples carried out by Jones Environmental Forensics Ltd, which is an approved supplier in accordance with the requirements of WYG quality system and is UKAS and MCERTS accredited for a range of chemical analyses. The testing was scheduled by Mott MacDonald and is summarised in Table 8 for soil. The test results for the soil samples are included in Appendix E.

Table 5 - Summary of environmental testing (Soil

Test suite	No.
Total Petroleum Hydrocarbons (TPH)	5
Total Organic Carbon (TOC) or SOM, TOM, Total Carbon	5
CLEA metals	5
ph Value	5
Screening method for Asbestos Containing Material	5

6 Groundwater monitoring

The groundwater levels were monitored during the first three visits on the 19th May, 1st & 7th June 2016. Three further visits will be carried out and reported as an addendum to this document. The monitoring data is presented in Appendix F and summarised in Table 6.

Table 6 - Summary of groundwater levels Visits

Location	Water level max (m bgl)	Water level min (m bgl)	Base of borehole (m bgl)	LNAPL (m bgl)	DNAPL (m bgl)
BH01	2.56	2.70	7.04	ne	ne
BH04	Dry	Dry	17.70	ne	ne
BH08	0.18	0.48	10.52	ne	ne
BH10	Dry	Dry	11.48	ne	ne
BH11	3.60	4.20	9.19	ne	ne
BH12	Dry	Dry	7.82	ne	ne
BH17	4.09	4.43	6.5	ne	ne
BH102	Dry	Dry	8.28	ne	ne

[1] ne denotes not encountered

Notes

1. Standards

All boring operations, sampling of soils*, in situ* testing and geotechnical laboratory testing have been carried out in accordance with the recommendations of the British Standards BS 5930(2015)(1), BS 1377 (1990)(2) and BS10175 (2001)(3).
Soil and rock descriptions follow the recommendations of BS 593. Where descriptions or classifications are based on other documents (e.g. BS 8004 (1986) or CIRIA Project Report 11 (1993)), this is stated in the report text.

2. Site methods

Unless specifically stated otherwise, the following methods are used for exploratory holes.

- Holes described as cable percussive are bored using a light cable percussive rig. Standard penetration tests are carried out where appropriate, as shown in the logs. Disturbed and undisturbed samples are taken from the exploratory holes at the depths on the records.
- Window sampling generally uses the windowless sampling method, using a tracked Geotool.
- Dynamic probes are usually heavy dynamic probes, using the same tracked Geotool used for window sampling.

3. Definitions and abbreviations

The following terms are used in the exploratory hole logs

Samples

U	Undisturbed 102mm dia. sample
TW	Thin Walled undisturbed 102mm dia. sample
B	Bulk sample
D	Small disturbed sample
W	Water sample
CBR	California Bearing Ratio test or CBR value obtained from Mexiprobe test

In situ tests

S	Standard penetration test (SPT)
N	SPT N value (blows/300mm)
HP	Hand penetrometer – shear strength
SV	Hand shear vane – shear strength
VOC	Volatile organic compounds (ppm)
PID	Photo-ionisation detector – used to detect the presence of VOCs.

Core recovery and rock quality

TCR	Total core recovery (%)
SCR	Solid core recovery (%)
RQD	Rock quality designation (%)
FI	Fracture index
NR	No recovery
NI	Not intact

Rotary drilling sizes

	Nominal diameter (mm)	
Index letter	**Borehole**	**Core**
N	75	54
H	99	76
P	120	92
S	146	113

Water strikes

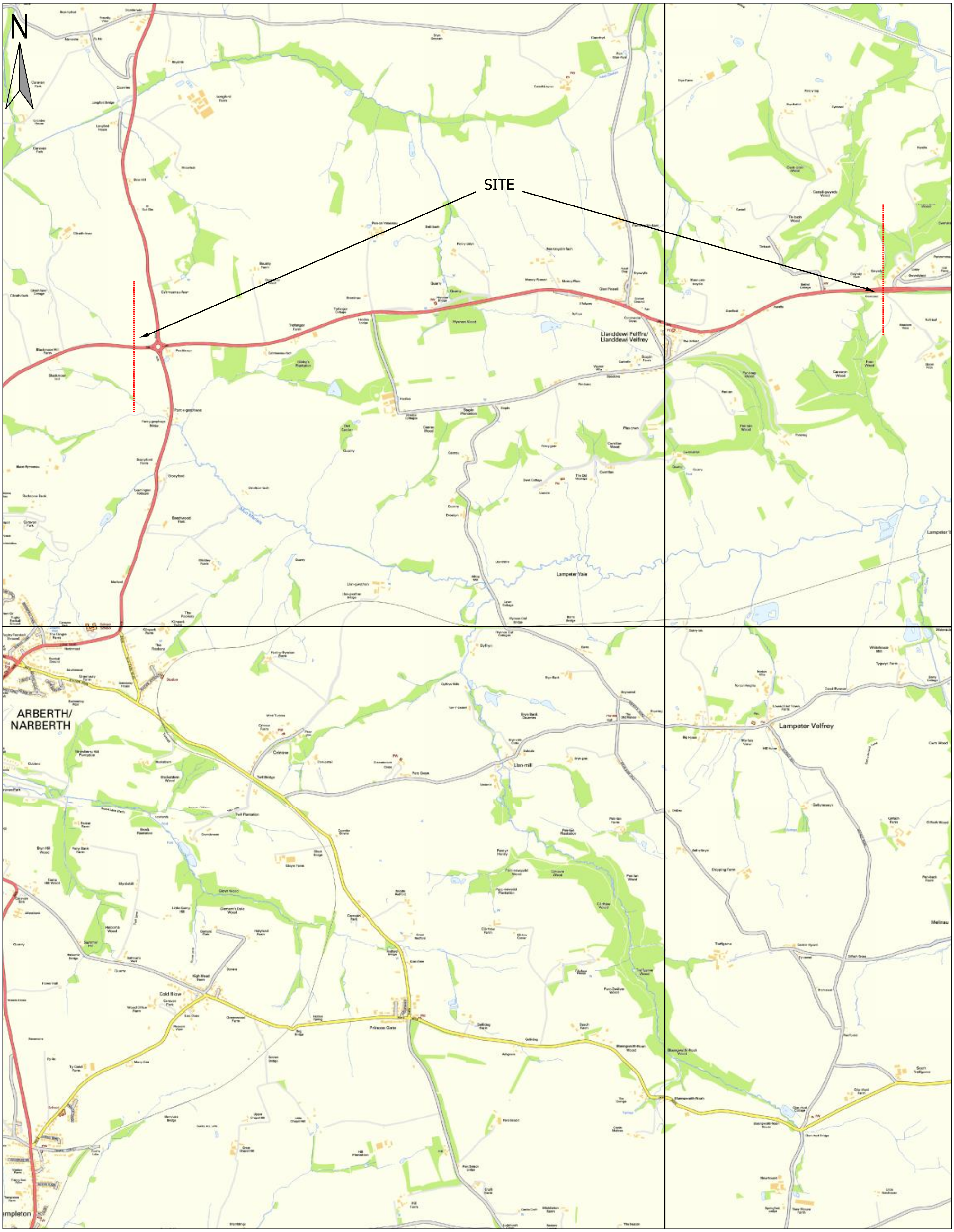
▽	Level of water strike
▼	Water level rose to this level (see Remarks at foot of log for details)

Depth means depth below existing ground level unless otherwise specified. Values specified in soil descriptions given in the exploratory hole logs are depths unless otherwise specified.

Figures

Figure 1 – Site Location Plan

DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND
REPORT ANY OMISSIONS OR ERRORS



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REV	DESCRIPTION	BY	CHK	APP	DATE

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
FAX: +44 (0)29 2045 5321
e-mail: cardiff@wyg.com

Client:
WELSH GOVERNMENT

Project:
A40 LLANDDEWI VELFREY,
PENBLEWIN

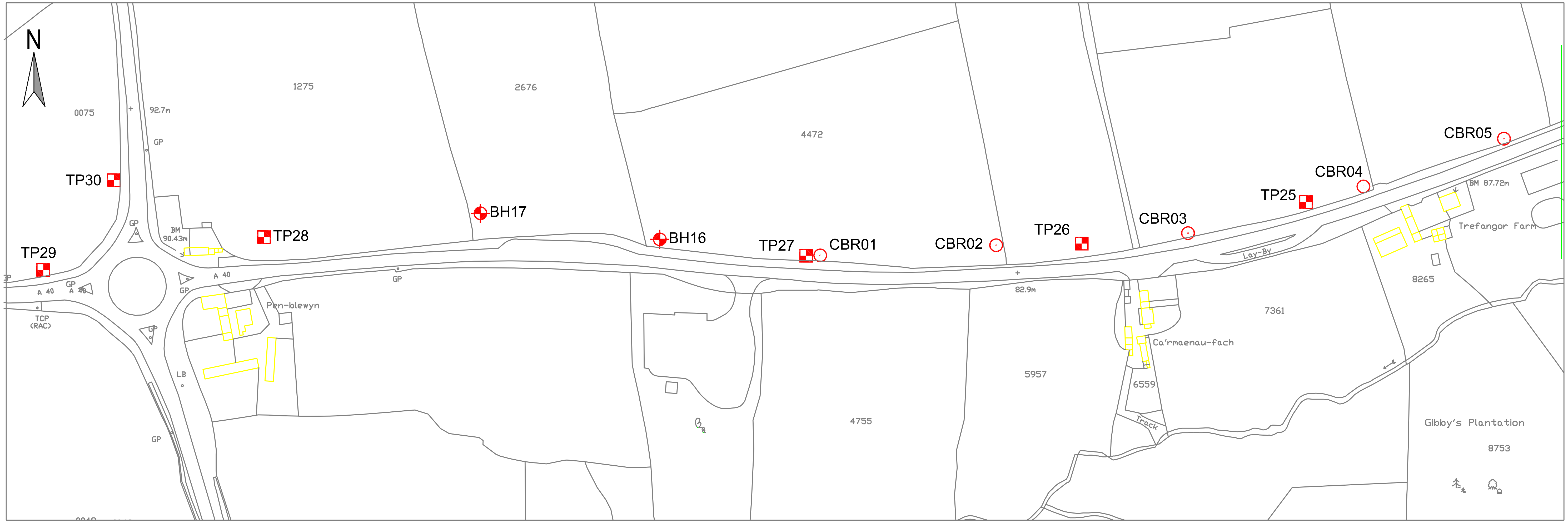
Drawing Title:
SITE LOCATION PLAN

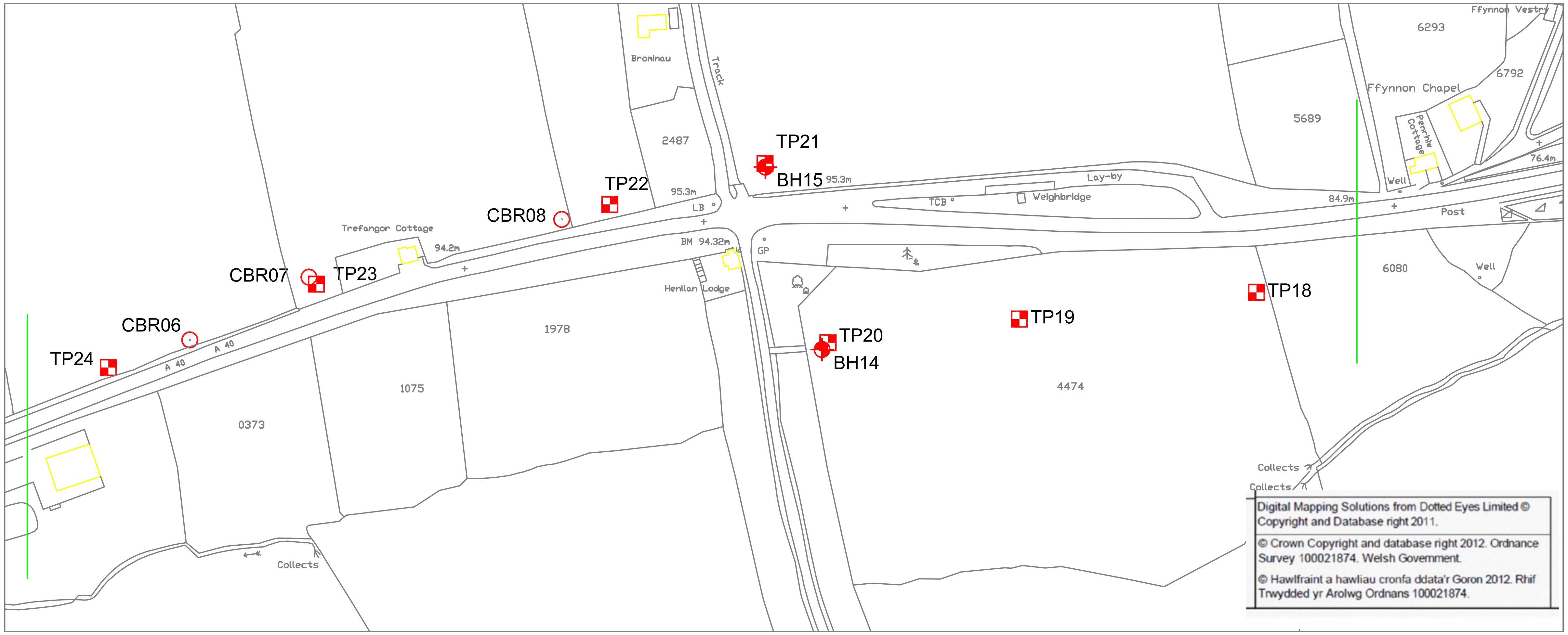
Scale @ A4	Drawn	Date	Checked	Date	Approved	Date
NTS	PP	08.06.16	PV	08.06.16	IV	08.06.16

Project No.	Office	Type	Drawing No.	Revision
A096409	CDF	N	1	00

Figure 2 (Sheets 1-3)– Site Investigation Layout Plan

DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND
REPORT ANY OMISSIONS OR ERRORS





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0 25 50 75 100 125 m

SCALE 1:2500

LEGEND:

- 🟥 TRIAL PIT LOCATIONS
- ⊕ BOREHOLE LOCATIONS
- ○ CBR LOCATIONS

REV	DESCRIPTION	BY	CHK	APP	DATE

Client:

WELSH GOVERNMENT

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
FAX: +44 (0)29 2045 5321
e-mail: cardiff@wyg.com

Project:

A40 LLANDEWI VELFREY, PENBLEWIN

Drawing Title:

SITE INVESTIGATION LAYOUT PLAN
SHEET 1 OF 3

Scale @	Drawn	Date	Checked	Date	Approved	Date
	PP	08.06.16	PV	08.06.16	IV	08.06.16

Project No.	Office	Type	Drawing No.	Revision
A096409	CDF	N	2	00

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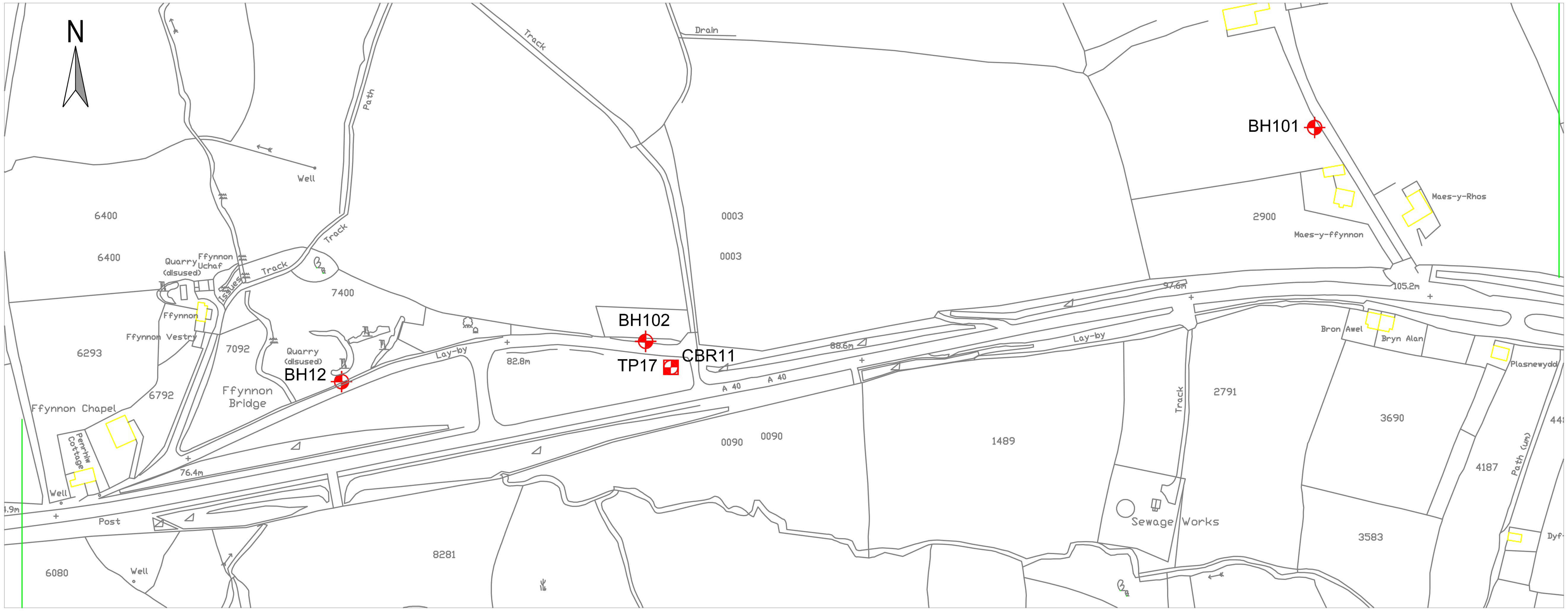

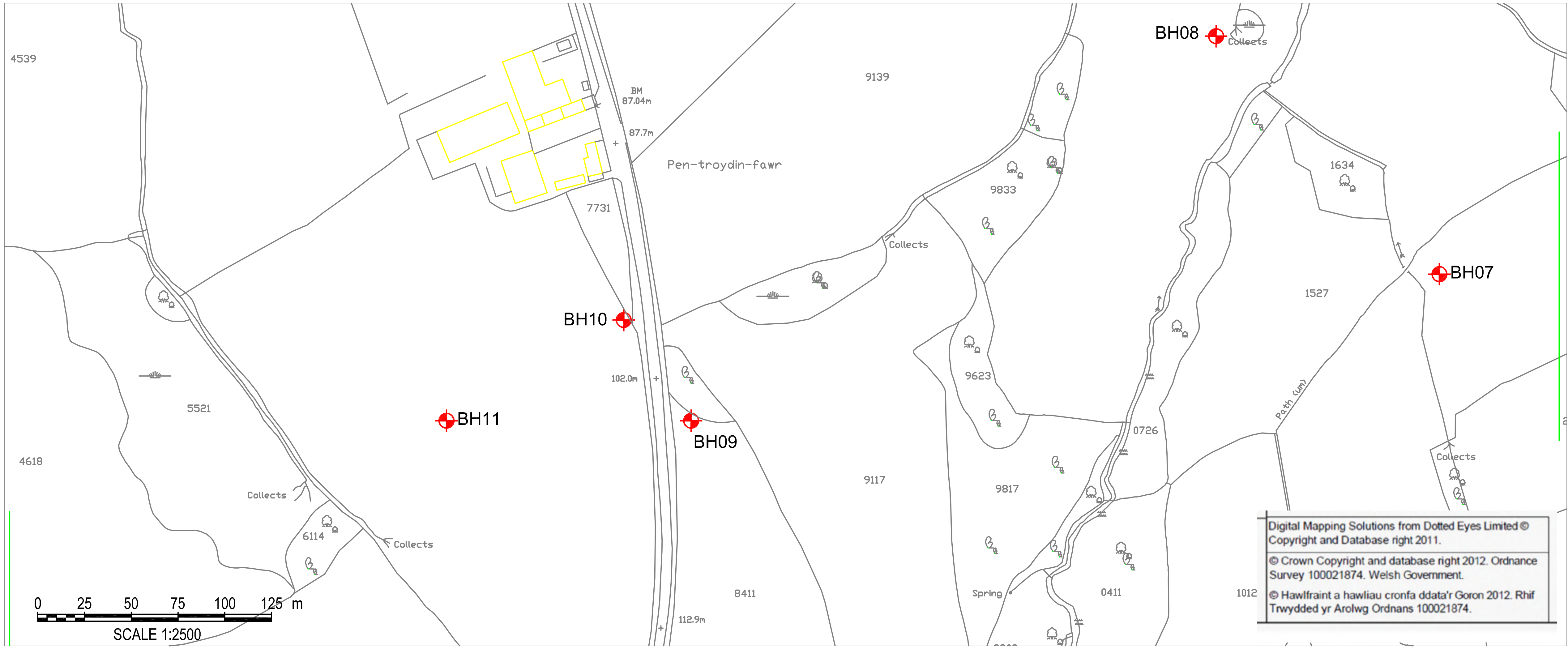

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LEGEND:

- 🟥 TRIAL PIT LOCATIONS
- ⊕ BOREHOLE LOCATIONS
- ○ CBR LOCATIONS

REV	DESCRIPTION	BY	CHK	APP	DATE

Client:
WELSH GOVERNMENT

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LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
FAX: +44 (0)29 2045 5321
e-mail: cardiff@wyg.com

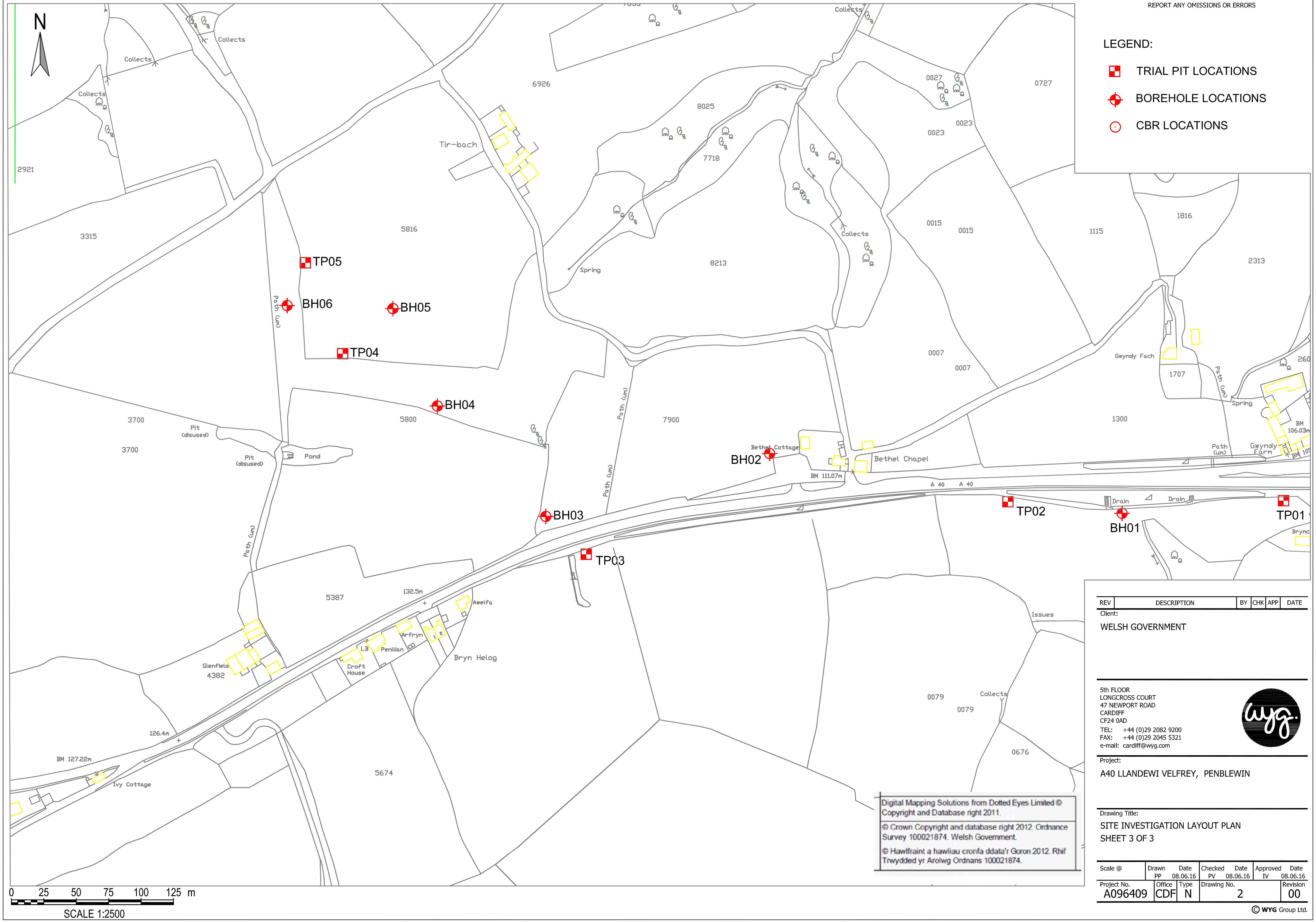
Project:
A40 LLANDEWI VELFREY, PENBLEWIN

Drawing Title:
SITE INVESTIGATION LAYOUT PLAN
SHEET 2 OF 3

Scale @	Drawn	Date	Checked	Date	Approved	Date
	PP	08.06.16	PV	08.06.16	IV	08.06.16

Project No.	Office	Type	Drawing No.	Revision
A096409	CDF	N	2	00

DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND REPORT ANY OMISSIONS OR ERRORS



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LEGEND:

🟥 TRIAL PIT LOCATIONS

⊕ BOREHOLE LOCATIONS

○ CBR LOCATIONS

REV	DESCRIPTION	BY	CHK	APP	DATE

Client:

WELSH GOVERNMENT

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
FAX: +44 (0)29 2045 5321
e-mail: cardiff@wyg.com

Project:

A40 LLANDEWI VELFREY, PENBLEWIN

Drawing Title:

SITE INVESTIGATION LAYOUT PLAN
SHEET 3 OF 3

Scale @	Drawn	Date	Checked	Date	Approved	Date
	PP	08.06.16	PV	08.06.16	IV	08.06.16

Project No.	Office	Type	Drawing No.	Revision
A096409	CDF	N	2	00

Appendices

Appendix A – Report Conditions

APPENDIX A - REPORT CONDITIONS
GROUND INVESTIGATION

This report is produced solely for the benefit of The Welsh Government and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site.

This report is based on a visual site inspection, reference to accessible referenced historical records, information supplied by those parties referenced in the text and preliminary discussions with local and Statutory Authorities. Some of the opinions are based on unconfirmed data and information and are presented as the best that can be obtained without further extensive research. Where ground contamination is suspected but no physical site test results are available to confirm this, the report must be regarded as initial advice only, and further assessment should be undertaken prior to activities related to the site. Where test results undertaken by others have been made available these can only be regarded as a limited sample. The possibility of the presence of contaminants, perhaps in higher concentrations, elsewhere on the site cannot be discounted.

Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, being subject to risk analysis, we are unable to give categoric assurances that they will be accepted by Authorities or Funds etc. without question as such bodies often have unpublished, more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to WYG. In time improved practices or amended legislation may necessitate a re-assessment.

The assessment of ground conditions within this report is based upon the findings of the study undertaken. We have interpreted the ground conditions in between locations on the assumption that conditions do not vary significantly. However, no investigation can inspect each and every part of the site and therefore changes or variances in the physical and chemical site conditions as described in this report cannot be discounted.

The report is limited to those aspects of land contamination specifically reported on and is necessarily restricted and no liability is accepted for any other aspect especially concerning gradual or sudden pollution incidents. The opinions expressed cannot be absolute due to the limitations of time and resources imposed by the agreed brief and the possibility of unrecorded previous use and abuse of the site and adjacent sites. The report concentrates on the site as defined in the report and provides an opinion on surrounding sites. If migrating pollution or contamination (past or present) exists further extensive research will be required before the effects can be better determined.

Appendix B – Exploratory Hole Logs

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH01
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **216132E - 216945N** **Level** : **98.49 m AOD**

Hole Information

From	To	Method	Diameter
0.20m	2.50m	Rotary Cored	143mm
3.00m	3.50m	Dynamic Sampling	143mm
3.50m	8.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **09/05/2016**
Finish Date : **15/04/2016**

Strata Description	Legend	Depth (m) (AOD)
Turf over soft brown SILT with humus and many fine to coarse sub-angular gravels and cobbles of Mudstone (TOPSOIL).		0.20 (98.29)
MADE GROUND: Boulders of MUDSTONE		1.50 (96.99)
Weathered MUDSTONE recovered as grey and brown fine to coarse angular gravel of mudstone.		2.50 (95.99)
Weathered MUDSTONE recovered non intact as a brown clayey very sandy fine to coarse sub-angular gravel.		4.40 (94.09)
Moderately strong grey MUDSTONE with very closely spaced 45° planar smooth brown stained bedding discontinuities and sub vertical stepped discontinuities.		8.00 (90.49)
End of Borehole at 8.00 m		

Depth (m)	Type	Results/Remarks			Casing Diameter	Water Strikes	Backfill / Installation
0.20							
	31	10	10	NA			
1.50 1.50 1.50-1.95	S D01	N=41 (1,3,6,7,11,17)			1.50		
	18	0	0	NA			
					2.50		
				NR			
3.00 3.00-3.45	C D02	N=43 (8,9,10,10,12,11)			3.00		
3.50							
	70	0	0	NI			
4.50 4.50 4.50-4.83	C D03	100 for 235mm (17,8,22,38,25,15)			4.50 4.70 143mm		
	35	7	0	NI			
5.50 5.50 5.50-5.75	C D04	100 for 175mm (25,22,57,21)			5.50		
	80	18	0	NI			
6.50					6.50		
	95	70	0	20			
7.50					7.50		
	90	80	0	18			
					8.00		
	TCR	SCR	RQD	FI			

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-2.0m plain pipe and bentonite, 2.0-8.0m slotted pipe and gravel filter.
3. Move to BH01 from BH12 took 1hr 15mins.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
3.00	3.50	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH02
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215860E - 216992N** **Level** : **115.40 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	1.50m	Dynamic Sampling	143mm
1.50m	8.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **10/05/2016**
Finish Date : **10/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Samples & In Situ Testing Depth (m)	Type	Results/Remarks			Casing Diameter	Water Strikes	Backfill / Installation
Turf over soft brown silty TOPSOIL with humus and roots (TOPSOIL).		0.40 (115.00)								
Weathered MUDSTONE recovered as soft brown silty sandy clay with many fine to coarse sub-angular gravel.		0.85 (114.55)								
Weathered MUDSTONE recovered not intact as grey fine to coarse sub-angular to angular gravel of mudstone with red brown staining.			1.20 1.20-1.65	C D01	N=48 (6,9,8,8,13,19)					
....1.50m to 2.50m not intact			1.50	70	8	0	NI	1.50 143mm		
		2.50 (112.90)	2.50					2.50		
Moderately strong grey MUDSTONE with very closely spaced 30° red brown stained planar smooth bedding discontinuities and widely spaced 70° and sub vertical planar and stepped discontinuities. Clay infill within discontinuities.				100	73	0	>30			
			4.00	100	73	8	>30	4.00		
			5.50	100	67	0	>30	5.50		
			7.00	100	80	0	>50	7.00		
End of Borehole at 8.50 m		8.50 (106.90)						8.50		
				TCR	SCR	RQD	FI			

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	1.50	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH03

Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215688E - 216943N** **Level** : **127.47 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	3.40m	Dynamic Sampling	143mm
3.40m	15.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **03/05/2016**
Finish Date : **04/05/2016**

Strata Description	Depth (m) (AOD)	Depth (m)	Type	Results/Remarks	Casing Diameter	Water Strikes
Turf over soft brown silty TOPSOIL with humus and roots (TOPSOIL).	0.30 (127.17)					
Weathered MUDSTONE recovered as soft brown silty sandy clay with many fine to coarse sub-angular gravel and roots.	1.20 (126.27)					1.00
Weathered MUDSTONE recovered as soft brown and grey brown silt/clay with many fine to medium sub-angular gravels of mixed lithologies.		1.20 1.20-1.65	C D01	N=26 (2,3,5,5,7,9)		
		2.00 2.00-2.45	C D02	N=61 (6,5,5,6,26,24)		
					3.00 143mm	
	3.50 (123.97)	3.40 3.40-3.40	C D03	50 for 0mm (25,50)		3.50
Moderately strong fine grained CONGLOMERATE.	4.50 (122.97)					
Moderately weak to moderately strong grey MUDSTONE with very closely spaced 10-30° red brown stained planar smooth bedding discontinuities, very close random fractures and widely spaced 70° and planar and stepped discontinuities, all with red brown staining and clay infill.						

Depth (m)	TCR	SCR	RQD	FI
3.40				NR
3.50	40	36	24	>20
4.00	70	50	22	12
4.50	97	33	0	32
6.00	90	0	0	45
7.50	100	0	0	>50
9.00	100	33	0	>50

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Track rig from BH04 to BH03 1hr45mins.
4. Groundwater encountered at 1.0m and 3.5m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.00	38%
2.00	3.00	100%
3.00	3.40	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.00m	-	-	
3.50m	-	-	

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH03
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215688E - 216943N** **Level** : **127.47 m AOD**

Hole Information

From	To	Method	Diameter
1.20m 3.40m	3.40m 15.00m	Dynamic Sampling Rotary Cored	143mm 107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **03/05/2016**
Finish Date : **04/05/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
Moderately weak to moderately strong grey MUDSTONE with very closely spaced 10-30° red brown stained planar smooth bedding discontinuities, very close random fractures and widely spaced 70° and planar and stepped discontinuities, all with red brown staining and clay infill.			10.50					10.50		
				97	0	0	NI			
								11.50		
							>50			
			12.00					12.00		
				100	27	0	20			
			13.50					13.50		
				100	53	0	>50			
		15.00 (112.47)						15.00		
End of Borehole at 15.00 m										
				TCR	SCR	RQD	FI			

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Track rig from BH04 to BH03 1hr45mins.
4. Groundwater encountered at 1.0m and 3.5m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.00	38%
2.00	3.00	100%
3.00	3.40	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.00m	-	-	
3.50m	-	-	

WYG ENVIRONMENT
Ground Engineering Services
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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH04
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215604E - 217028N** **Level** : **127.56 m AOD**

Hole Information

From	To	Method	Diameter
0.80m	1.80m	Dynamic Sampling	143mm
1.80m	18.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By :
Start Date : **29/04/2016**
Finish Date : **03/05/2016**

Strata Description	Depth (m) (AOD)	Depth (m)	Type	Results/Remarks			Casing Diameter	Water Strikes
Soft brown sandy SILT with occasional fine sub-angular gravel and humus. (TOPSOIL)	0.35 (127.21)							
Weathered MUDSTONE recovered as light grey brown slightly clayey sand with many fine to medium sub-angular to angular gravel of mudstone.		0.80 0.80-1.25	C D01	N=44 (4,4,8,13,12,11)				
Moderately Weak to moderately strong dark grey MUDSTONE very closely spaced 70° and randomly orientated dark red brown stained planar and undulating smooth discontinuities.	1.80 (125.76)	1.80					2.00 143mm	1.80
		1.80-3.00	100	0	0	>50		
....3.30-3.35m light brown mineralisation infill on discontinuities		3.00-4.50	100	0	0	>50		
....4.80-5.00m orange brown clay infill on discontinuities		4.50-6.00	100	0	0	>50		
		6.00-7.50	100	0	0	>50		
....8.50-8.55m orange brown clay infill on discontinuities		7.50-9.00	100	0	0	>50		
		9.00	100	33	0	NI 9.50 >30		
			TCR	SCR	RQD	FI		

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-3.0m plain pipe and bentonite, 3.0-18.0m slotted pipe and gravel filter.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
0.80	1.80	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.80m	-	-	

WYG ENVIRONMENT

Ground Engineering Services

Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH04

Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215604E - 217028N** **Level** : **127.56 m AOD**

Hole Information

From	To	Method	Diameter
0.80m	1.80m	Dynamic Sampling	143mm
1.80m	18.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By :
Start Date : **29/04/2016**
Finish Date : **03/05/2016**

Strata Description	Legend	Depth (m) (AOD)
Moderately Weak to moderately strong dark grey MUDSTONE very closely spaced 70° and randomly orientated dark red brown stained planar and undulating smooth discontinuities. ....11.25m orange brown staining on discontinuities ....11.30m orange brown staining on discontinuities ....12.20m orange brown staining on discontinuities ....13.65m-13.95m orange brown staining on discontinuities		14.80 (112.76)
Moderately strong dark grey MUDSTONE very closely spaced 10-30° planar smooth bedding discontinuities. ....14.50m-14.80 orange brown staining on discontinuities ....16.00-16.30m irregular bedding ....16.60-16.80m irregular bedding		18.00 (109.56)
End of Borehole at 18.00 m		

Rotary Coring

Depth (m)	TCR	SCR	RQD
10.50	100	17	7
12.00	93	30	0
13.50	97	47	0
15.00	100	90	30
16.50	100	97	0

Casing Diameter (depth)	FI
10.50	NI
11.00	29
12.00	NI
12.75	27
13.50	NI
13.75	30
14.75	25
16.00	11
17.00	25
18.00	

Water Strikes

Backfill / Installation

TCR SCR RQD FI

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-3.0m plain pipe and bentonite, 3.0-18.0m slotted pipe and gravel filter.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
0.80	1.80	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.80m	-	-	

WYG ENVIRONMENT
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Exploratory Hole Number
BH05
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215570E - 217103N** **Level** : **121.23 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	17.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **26/04/2016**
Finish Date : **27/04/2016**

Strata Description	Legend	Depth (m) (AOD)
Turf over soft brown silty TOPSOIL with humus and roots.		0.35 (120.88)
Weathered MUDSTONE recovered as brown silty sandy clay with many fine to coarse sub-angular gravel and lithorelicts of mudstone with root traces.		0.85 (120.38)
Weathered MUDSTONE recovered as brown grey sandy fine to coarse sub-angular to angular gravel of mudstone.		1.40 (119.83)
Moderately weak to moderately strong grey MUDSTONE with very closely spaced 10° bedding discontinuities and random planar smooth, red brown and black stained discontinuities.		7.40 (113.83)
Moderately strong dark grey MUDSTONE with very closely spaced 30° and random planar smooth discontinuities with red brown staining.		

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks			Casing Diameter
1.20	C	50 for 75mm (9,16,41,9)			
1.20	D01				
1.20-1.43					
	100	19	0	NI	
2.00					2.00
	100	0	0	NI	
2.30					2.30
	100	13	0	>50	
3.50					3.50
	90	0	0	>50	
4.50					4.50
	100	50	0	30	
5.50					5.50
	100	0	0	>50	
7.00					7.00
	97	47	9	28	
8.50					8.50
	100	33	20	>30	
					9.50
10.00				>30	
	TCR	SCR	RQD	FI	

Water Strikes

Backfill / Installation

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH05
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215570E - 217103N** **Level** : **121.23 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	17.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**

Logged By : **NP**
Checked By : **PV**
Start Date : **26/04/2016**
Finish Date : **27/04/2016**

Strata Description

Moderately strong dark grey MUDSTONE with very closely spaced 30° and random planar smooth discontinuities with red brown staining.

....12.0-12.2m sub vertical discontinuities 5mm thick with white mineralisation.

....13.5-13.7m sub vertical discontinuities with red mineralisation.

....14.1m sub horizizontal brown stained discontinuities

....15.3-15.35m not intact with white mineralisation.

....15.7-15.8m sub vertical red brown stained discontinuities
....16.0-16.30m not intact brown stained gravel

. . . . 17.3-17.5m sub vertical and 45° red brown stained discontinuities

Depth (m) (AOD): 17.50 (103.73)

End of Borehole at 17.50 m

Rotary Coring

Depth (m)	TCR	SCR	RQD
	100	47	23
11.50	100	80	33
13.00	100	73	15
14.50	100	63	17
16.00	100	87	63

Depth (m)	FI
10.50	22
11.50	16
12.50	20
13.50	22
14.50	>30
15.50	16
16.50	8
17.50	

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services

Longcross Court, 47 Newport Road, Cardiff,CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH06
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215488E - 217106N** **Level** : **123.19 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	2.20m	Dynamic Sampling	143mm
2.20m	17.70m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **27/04/2016**
Finish Date : **28/04/2016**

Strata Description	Depth (m)	(AOD)
Turf over soft brown silt with humus and roots (TOPSOIL).	0.30	(122.89)
Weathered MUDSTONE recovered as brown slightly clayey very sandy fine to coarse sub-angular to angular gravel of mudstone.	2.20	(120.99)
Weathered MUDSTONE recovered as a grey fine to coarse angular gravel of mudstone with red brown and black staining.	2.40	(120.79)
Weak to moderately weak grey brown MUDSTONE with very closely spaced irregular bedding discontinuities, planar and undulating with red brown and black staining.	4.70	(118.49)
Moderately weak to moderately strong dark grey MUDSTONE with very closely spaced 10-20° bedding discontinuities and very close 45-60° discontinuities - all planar smooth with red brown staining.		

Depth (m)	Type	Results/Remarks				Casing Diameter
1.20 1.20-1.65	C D01	N=35 (6,8,7,6,12,10)				
2.20 2.20 2.20-2.35	C D02	50 for 75mm (21,4,43,7,0)				2.20 143mm
	TCR	SCR	RQD	FI		
2.20	100	28	15	25		
3.20	33	0	0	NI		3.20
4.70 4.70 4.70-4.85	C D03	50 for 75mm (47,3,50)				4.70
4.70	60	0	0	NI		
5.20	60	0	0	NI		5.20
5.70	60	0	0	NI		5.70
6.20	100	14	7	>50		6.20
7.70	43	0	0	NI		7.70
9.20	50	0	0	NI		9.20

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.20	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH06
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215488E - 217106N** **Level** : **123.19 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	2.20m	Dynamic Sampling	143mm
2.20m	17.70m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **27/04/2016**
Finish Date : **28/04/2016**

Strata Description	Depth (m) (AOD)
Moderately weak to moderately strong dark grey MUDSTONE with very closely spaced 10-20° bedding discontinuities and very close 45-60° discontinuities - all planar smooth with red brown staining.	10.30 (112.89)
Moderately strong dark grey and light grey interbedded MUDSTONE with very closely spaced 10-20° bedding discontinuities planar smooth. . . . . 13.7m 70° red brown stained planar smooth discontinuities ....14.60m red brown staining on discontinuities . . . . 14.70m 10mm light grey bed 20°	17.70 (105.49)
End of Borehole at 17.70 m	

Rotary Coring

Depth (m)	TCR	SCR	RQD	FI
10.20	1	35	0	>50
11.20	90	8	0	>50
12.20	100	80	31	19
				30
13.70	100	67	27	18
15.20	100	40	14	
16.70	100	5	0	>50

Casing Diameter: 10.20, 11.20, 12.20, 13.20, 14.20, 15.20, 16.20, 17.70

Water Strikes | Backfill / Installation

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.20	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH07
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215214E - 217289N** **Level** : **79.28 m AOD**

Hole Information

From	To	Method	Diameter
0.00m	1.50m	ODEX	143mm
1.50m	10.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **20/04/2016**
Finish Date : **20/04/2016**

Strata Description	Depth (m) (AOD)
Weathered MUDSTONE recovered as dark brown clayey sandy fine to coarse sub-angular to angular gravel of mudstone.	0.40 (78.88)
MUDSTONE recovered as grey fine to coarse angular gravel and cobbles of mudstone with red brown staining on surface.	4.40 (74.88)
Grey moderately strong MUDSTONE with very closely spaced planar smooth sub horizontal to 45° bedding discontinuities and sub vertical discontinuities. . . . . 8.05-8.15m soft grey sandy clay	

Samples & In Situ Testing

Depth (m)	Type / TCR	Results/Remarks SCR	RQD	FI	Casing Diameter
1.50	C				1.50 143mm
1.50		0 for 0mm 25/30mm - Abandoned			
1.50-1.61	D01				
	90	3	0	NI	
2.50	94	25	0	NI	2.50
3.30	91	0	0	NI	3.30
4.40	100	62	10	30	4.40
5.40	91	52	18	18	5.40
6.50	100	87	0	22	6.50
				25	7.50
8.00	100	80	24		
				17	8.50
9.50	100	75	13	15	9.50
	TCR	SCR	RQD	FI	

Water Strikes

Backfill / Installation

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr 30mins tracking to BH7 with trackmats.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH07
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215214E - 217289N** **Level** : **79.28 m AOD**

Hole Information

From	To	Method	Diameter
0.00m	1.50m	ODEX	143mm
1.50m	10.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**

Logged By : **NP**
Checked By : **PV**
Start Date : **20/04/2016**
Finish Date : **20/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
Grey moderately strong MUDSTONE with very closely spaced planar smooth sub horizontal to 45° bedding discontinuities and sub vertical discontinuities.		10.50 (68.78)						10.50		■
End of Borehole at 10.50 m										

TCR SCR RQD FI

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr 30mins tracking to BH7 with trackmats.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH08
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215095E - 217416N** **Level** : **66.35 m AOD**

Hole Information

From	To	Method	Diameter
0.00m	4.20m	Dynamic Sample/ODEX	143mm
4.50m	10.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **21/04/2016**
Finish Date : **21/04/2016**

Strata Description	Depth (m)	(AOD)
Turf over soft brown SILT with humus, rootlets and fine subangular gravel of mudstone (TOPSOIL).	0.60	(65.75)
Weathered MUDSTONE recovered as soft to firm brown mottled blue-grey silty clay with rare fine to medium sub-angular gravel of Mudstone.	1.05	(65.30)
Weathered MUDSTONE recovered as grey brown silty very clayey fine sub-angular gravel of Mudstone.	1.40	(64.95)
Weathered MUDSTONE recovered as stiff grey slightly sandy clay with many fine to medium lithorelicts of Mudstone.	2.10	(64.25)
Weathered MUDSTONE recovered as stiff dark grey slightly sandy friable clay with relic Mudstone texture.	3.60	(62.75)
Weathered MUDSTONE recovered as dark grey slightly sandy slightly clayey fine to medium sub-angular gravel and lithorelicts of Mudstone.	4.50	(61.85)
Weathered MUDSTONE recovered as slightly clayey fine to coarse sub-angular gravel of weak to strong Mudstone.		

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks
1.20 1.20-1.65	S D01	N=22 (4,4,6,4,5,7)
2.70 2.70-3.15	S D02	N=47 (8,12,10,12,12,13)
3.15 3.15-3.45	C D03	100 for 225mm (20,5,31,49,20)
5.50 5.50 5.50-5.80	~~C~~ D04	100 for 225mm (25,22,34,44)

Depth (m)	TCR	SCR	RQD	FI
4.50	60	3	0	NI
5.50	55	20	0	NI
6.50	50	15	10	NI
7.50	35	0	0	NI
8.50	50	0	0	NI
9.50	60	0	0	NI

Casing Diameter: 4.50 143mm; 5.50; 6.50; 7.50; 8.50; 9.50

Water Strikes

Backfill / Installation

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-1.50m plain pipe and bentonite, 1.50-10.5m slotted pipe and gravel filter.
4. Tracking to BH8 (partially with trackmats) 1hr.
5. Groundwater was not encountered.
6. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	3.40	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH08
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **215095E - 217416N** **Level** : **66.35 m AOD**

Hole Information

From	To	Method	Diameter
0.00m	4.20m	Dynamic Sample/ODEX	143mm
4.50m	10.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **21/04/2016**
Finish Date : **21/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring					Casing Diameter	Water Strikes	Backfill / Installation
			Depth (m)	TCR	SCR	RQD	FI			
Weathered MUDSTONE recovered as slightly clayey fine to coarse sub-angular gravel of weak to strong Mudstone.	▤	10.50 (55.85)						10.50		▨
End of Borehole at 10.50 m										
				TCR	SCR	RQD	FI			

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-1.50m plain pipe and bentonite, 1.50-10.5m slotted pipe and gravel filter.
4. Tracking to BH8 (partially with trackmats) 1hr.
5. Groundwater was not encountered.
6. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	3.40	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH09
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **214814E - 217211N** **Level** : **105.17 m AOD**

Hole Information

From	To	Method	Diameter
1.00m	3.50m	Dynamic Sampling	143mm
3.50m	13.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **22/04/2016**
Finish Date : **25/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Samples & In Situ Testing Depth (m)	Type	Results/Remarks			Casing Diameter	Water Strikes	Backfill / Installation
Turf over soft brown SILT with humus, rootlets (TOPSOIL).		0.35 (104.82)								
Weathered CONGLOMERATE recovered as brown occasionally grey slightly clayey fine to coarse sand with occasional fine to coarse rounded to sub-angular gravel of mixed lithologies and rare cobbles of sandstone.			1.00 1.00-1.45	S D01	N=32 (6,8,8,7,9,8)					
			2.50 2.50-2.95	S D02	N=50 (2,4,5,10,25,10)					
		3.50 (101.67)	3.50					3.00 143mm		
Very weak brown fine grained CONGLOMERATE with very closely spaced 45° bedding and very closely spaced 45° to 80° planar rough discontinuities with red brown staining.				100	35	0	20			
			4.50 4.50 4.50-4.67	C D03	80 for 100mm (25,36,44)			4.50	4.50	
				100	25	16	18			
			5.50					5.50		
				70	16	0	>30			
			6.50					6.50		
				85	12	10	NI			
			7.50					7.50		
				87	25	10	20			
			8.50					8.50		
		9.50		60	14	0	>30			
Weathered MUDSTONE recovered as dark grey very sandy clay.		(95.67)	9.50 9.50 9.50-9.80	C D04	100 for 135mm (13,12,37,63)			9.50		
				35 TCR	0 SCR	0 RQD	NI FI			

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr 30mins tracking to BH9.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.00	2.50	100%
3.00	3.50	90%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
4.50m	-	-	

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH09
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **214814E - 217211N** **Level** : **105.17 m AOD**

Hole Information

From	To	Method	Diameter
1.00m	3.50m	Dynamic Sampling	143mm
3.50m	13.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **22/04/2016**
Finish Date : **25/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
Weathered MUDSTONE recovered as dark grey very sandy clay. ....10.50m to 13.00m no recovery, borehole collapsed			10.50					10.50		
				0	0	0	NR			
			11.50					11.50		
				12	0	0	NR			
			12.50					12.50		
		13.00 (92.17)		0	0	0	NR	13.00		
End of Borehole at 13.00 m										

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr 30mins tracking to BH9.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.00	2.50	100%
3.00	3.50	90%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
4.50m	-	-	

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Exploratory Hole Number

BH10

Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Dynamic Sampling/Rotary Cored**
Co-ordinates : **214778E - 217264N** **Level** : **99.44 m AOD**

Scale 1:50 **Sheet 1 of 2**

Logged By : **NP**
Checked By : **PV**
Start Date : **13/04/2016**
Finish Date : **15/04/2016**

Hole Information

From	To	Method	Diameter
0.00m	3.90m	Dynamic Sampling	143mm
4.50m	13.50m	Rotary Cored	143mm
13.50m	20.00m	Rotary Open Hole	107mm

Strata Description

Strata Description	Depth (m) (AOD)
Turf over soft brown silt with humus and rootlets. (TOPSOIL)	0.35 (99.09)
Weathered MUDSTONE recovered as soft red brown mottled grey sandy clay with many fine to coarse, sub-angular to angular gravel of grey mudstone.	0.60 (98.84)
Weathered MUDSTONE recovered as dense brown slightly clayey sandy fine to coarse, sub-angular to angular gravel of Mudstone.	2.30 (97.14)
Weathered MUDSTONE recovered as brown grey occasionally mottled orange brown sandy friable clay with many fine to coarse, angular lithorelicts of dark grey Mudstone.	4.50 (94.94)
Weathered MUDSTONE recovered as dark grey very sandy gravelly clay. Gravel is angular fine to coarse of mudstone.	

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks			
0.40	ES4				
1.20 1.20-2.20	S B4	N=32 (2,8,7,7,10,8)			
2.70 2.90-3.90	S B4	N=35 (7,8,9,9,9,8)			
4.50 4.50	C	50 for 105mm (17,8,24,26)			
	50	0	0	NA	
6.00 6.00	C	92 for 285mm (10,15,23,22,25,22)			
	30	0	0	NA	
7.50 7.50	C	N=80 (12,13,23,16,21,20)			
	13	0	0	NA	
9.00					
9.30 9.30-10.80	C B4	100 for 200mm (15,10,25,36,39)			
	36	0	0	NA	
	TCR	SCR	RQD	FI	

Casing Diameter: 5.00 143mm; 6.00; 7.50; 9.00

Water Strikes: ▽ 6.00

Backfill / Installation

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-3.0m plain pipe and bentonite, 3.0-12.0m slotted pipe and gravel filter, 12.0-20.0m. bentonite.
3. Trackmats mobilised to access position 1hr 55mins.
4. Waiting for installation instructions 1hr.
5. Casing jammed at 12.0m, open hole to 20.0m.
6. * - Based on Driller's description.
7. Groundwater was not encountered.

Dynamic Sampling

From	To	Recovery
1.00	2.00	100%
1.20	2.70	100%
2.70	3.90	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
6.00m	-	-	

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Exploratory Hole Number
BH10
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Dynamic Sampling/Rotary Cored**
Co-ordinates : **214778E - 217264N** **Level** : **99.44 m AOD**

Hole Information

From	To	Method	Diameter
0.00m	3.90m	Dynamic Sampling	143mm
4.50m	13.50m	Rotary Cored	143mm
13.50m	20.00m	Rotary Open Hole	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **13/04/2016**
Finish Date : **15/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	Rotary Coring TCR	Rotary Coring SCR	Rotary Coring RQD	Rotary Coring FI	Casing Diameter	Water Strikes	Backfill / Installation
Weathered MUDSTONE recovered as dark grey very sandy gravelly clay. Gravel is angular fine to coarse of mudstone.			10.80 10.80	C	115 for 244mm (17,8,21,26,34,34)			10.80		
				60	0	0	NA			
		12.00 (87.44)								
Weathered MUDSTONE recovered not intact as moderately weak to moderately strong dark grey mudstone.			12.30 12.30	C	100 for 100mm (25,56,44)			12.30		
				53	0	0	NI			
. . . . 80° fractures at 13.20-13.40m . . . . 80° fractures at 13.20-13.40m.								13.50		
		13.80 (85.64)								
Weathered MUDSTONE* No recovery: casing jammed and hole collapsed. Open hole to 20.0m, driller recorded mudstone with penetration consistent with rock.			13.80 13.80 13.80-13.90	C D5	100 for 80mm (25,87,13)					
				0	0	0				
								15.00 143mm		
		17.60 (81.84)								
MUDSTONE*.										
		20.00 (79.44)								
End of Borehole at 20.00 m				TCR	SCR	RQD	FI			

Remarks / Observations:

8. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.00	2.00	100%
1.20	2.70	100%
2.70	3.90	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
6.00m	-	-	

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
BH11
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **214683E - 217211N** **Level** : **97.00 m AOD**

Hole Information

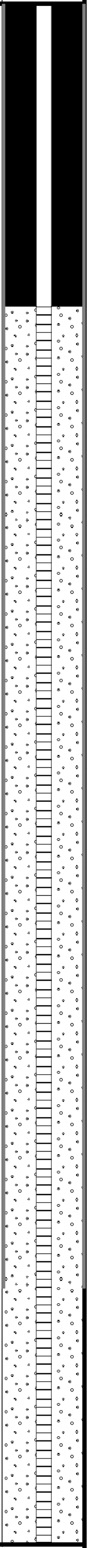
From	To	Method	Diameter
1.20m	2.70m	Dynamic Sampling	143mm
3.00m	11.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **15/04/2016**
Finish Date : **19/04/2016**

Strata Description	Legend	Depth (m) (AOD)
Turf over soft brown SILT with humus, rootlets with humus and fine sub-angular gravel of mudstone. (TOPSOIL)	▨	0.65
Weathered MUDSTONE recovered as medium dense brown and grey mottled very clayey sandy fine to coarse sub-angular to angular gravel of Mudstone.	▤	(96.35) 1.80
Weathered MUDSTONE recovered as grey occasionally brown sandy very clayey fine to coarse sub-angular to angular gravel and lithorelicts of mudstone with occasional cobbles.	▤	(95.20) 2.70
Weathered MUDSTONE recovered as grey occasionally brown sandy very clayey fine to coarse sub-angular to angular gravel and Lithorelicts of mudstone with occasional cobbles.	▤	(94.30) 3.00 3.20
Weathered MUDSTONE recovered as grey occasionally brown sandy very clayey fine to coarse sub-angular to angular gravel and Lithorelicts of Mudstone with occasional cobbles.	▤	(94.00) (93.80)
Weathered MUDSTONE recovered as grey occasionally brown sandy very clayey fine to coarse sub-angular to angular gravel and Lithorelicts of mudstone with occasional cobbles.	▤	6.00
Weathered MUDSTONE recovered as grey occasionally dark grey sandy clay and occasional fine to coarse sub-angular gravels and cobbles of Mudstone.	▤	(91.00) 8.50
Weathered MUDSTONE recovered as dark grey slightly clayey slightly sandy fine to coarse sub-angular to angular gravel, lithorelicts and cobbles of Mudstone.	▤	(88.50)

Samples & In Situ Testing Depth (m)	Type	Results/Remarks			Casing Diameter	Water Strikes
0.40	ES4					
1.20 1.20-2.20	S B4	N=16 (2,2,3,4,4,5)				
2.70	S	50 for 150mm (15,10,21,24,5)				
3.00						3.00
	66	0	0	NI		
4.50 4.50	C	100 for 110mm (21,4,46,54)			4.50	
	30	0	0	NI		
6.00 6.00	C	100 for 100mm (25,58,42)			6.00	
	30	0	0	NI		
7.50 7.50	C	N=50 (10,12,11,11,11,17)			7.50	
	45	0	0	NI		
8.50 8.50	C	100 for 200mm (16,9,22,31,47)			8.50 8.50 143mm	
	30	0	0	NI		
10.00 10.00	C TCR	100 for 165mm (20,5,36,48,16) SCR	RQD	FI	10.00	

Backfill / Installation



Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-2.0m plain pipe and bentonite, 2.0-11.0m slotted pipe and gravel filter, 12.0-20.0m bentonite.
3. Trackmats mobilised to access position 1hr.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
3.00m	-	-	

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Exploratory Hole Number
BH11
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **214683E - 217211N** **Level** : **97.00 m AOD**

Hole Information

From	To	Method	Diameter
1.20m 3.00m	2.70m 11.00m	Dynamic Sampling Rotary Cored	143mm 107mm

Scale 1:50 **Sheet 2 of 2**

Logged By : **NP**
Checked By : **PV**
Start Date : **15/04/2016**
Finish Date : **19/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring					Casing Diameter	Water Strikes	Backfill / Installation
			Depth (m)	TCR	SCR	RQD	FI			
Weathered MUDSTONE recovered as dark grey slightly clayey slightly sandy fine to coarse sub-angular to angular gravel, lithorelicts and cobbles of Mudstone.		11.00 (86.00)		50	0	0	NI	11.00		
End of Borehole at 11.00 m										

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-2.0m plain pipe and bentonite, 2.0-11.0m slotted pipe and gravel filter, 12.0-20.0m bentonite.
3. Trackmats mobilised to access position 1hr.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
3.00m	-	-	

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Exploratory Hole Number
BH12
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213771E - 216926N** **Level** : **75.71 m AOD**

Hole Information

From	To	Method	Diameter
1.50m	4.50m	Dynamic Sampling	143mm
4.50m	8.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **03/05/2016**
Finish Date : **03/05/2016**

Strata Description	Legend	Depth (m) (AOD)	Depth (m)	Type	Results/Remarks	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
MADE GROUND: Hardcore with dark grey clay			0.50	ES4								
		0.80 (74.91)										
PROBABLE MADE GROUND: Brown clayey sandy fine to coarse sub-angular to angular GRAVEL of Mudstone and Sandstone.			1.50 1.50-3.00	C B4	N=14 (5,5,5,3,3,3)							
			2.50	ES4								
			3.00 3.00-3.45	S D5	N=11 (3,4,3,3,2,3)							
		4.10 (71.61)										
Weathered MUDSTONE recovered as stiff brown slightly sandy clay/silt with lithorelicts of Mudstone.			4.35	ES4								
		4.50 (71.21)								4.50 143mm		
Weathered MUDSTONE recovered as fine to coarse sub-angular to angular gravel of moderately weak grey mudstone with red brown staining.			4.50 4.50 4.50-4.76	S D5	50 for 105mm (7,9,22,28)							
						20	0	0	NI			
			5.50 5.50-6.50	B4						5.50		
						80	0	0	NI			
			6.50							6.50		
						27	0	0	NI			
		6.90 (68.81)										
Strong dark grey medium grained SANDSTONE.			7.00			50	0	0	NI	7.00		
			7.10			20	9	0	NI	7.10		
		8.00 (67.71)								8.00		

End of Borehole at 8.00 m

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-2.0m plain pipe and bentonite, 2.0-8.0m slotted pipe and gravel filter.
3. Rig move to BH12 from BH14 - 2hrs.
4. Groundwater was not encountered.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.50	3.00	67%
3.00	4.50	67%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH14
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213321E - 216778N** **Level** : **92.96 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	5.50m	Dynamic Sampling	143mm
5.50m	14.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **28/04/2016**
Finish Date : **29/04/2016**

Strata Description	Legend	Depth (m)	(AOD)
MADE GROUND: Grass over dark grey brown sandy clayey GRAVEL.		0.25	(92.71)
MADE GROUND: Soft to firm brown silty slightly gravelly CLAY. ....0.70m metal nail 40mm. ....0.80m clay pipe/land drain.		0.85	(92.11)
Weathered MUDSTONE recovered as stiff orange brown slightly clayey sandy silt with occasional fine to medium sub-rounded to sub-angular gravel of mixed lithologies. ....3.00m decayed root.		4.70	(88.26)
Weathered MUDSTONE recovered as orange brown fine sandy silt. .		5.40	(87.56)
Weathered MUDSTONE recovered as stiff orange brown slightly clayey slightly sandy silt with many medium sub-rounded to sub-angular gravel of mixed lithologies.		5.50	(87.46)
Weathered SANDSTONE recovered as brown silty sandy fine to coarse sub-angular gravel and cobbles of mixed lithologies.		6.50	(86.46)
Weathered MUDSTONE recovered as brown very clayey sandy silt with cobbles of sandstone.		7.50	(85.46)
Weathered SANDSTONE recovered as very stiff dark brown grey clay with many fine to medium sub-rounded to sub-angular gravel of mixed lithologies.		8.50	(84.46)
Weathered MUDSTONE recovered as very stiff grey very sandy clay with many fine to coarse sub-rounded to sub-angular gravel of mixed lithologies and occasional cobbles and boulders of sandstone. .			

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks	Casing Diameter	Water Strikes	Backfill / Installation
0.40	ES4				
1.20 1.20-1.65	S D5	N=9 (1,2,2,3,2,2)			
2.20-3.20	B4				
2.70 2.70-3.15	S D5	N=7 (2,2,1,2,2,2)			
3.70 3.70-4.30	S B4	N=26 (4,5,5,7,7,7)			
4.50 4.50-4.95	C D5	N=37 (5,10,10,9,8,10)	4.50 143mm	▽ 4.50	
5.50					
6.50 6.50 6.50-6.90	C D6	100 for 285mm (12,13,21,26,28,25)	6.50		
7.50 7.50 7.50-7.95	C D7	N=56 (11,12,12,14,13,17)	7.50		
8.50 8.50 8.50-8.83	C D8	90 for 240mm (18,7,14,29,33,14)	8.50		
9.50 9.50 9.50-9.68	C D9	100 for 160mm (25,40,51,9)	9.50		

TCR	SCR	RQD	FI
5	0	0	NA
60	0	0	NA
15	0	0	NI
30	8	0	NI
25	0	0	NI

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr to move rig across highway safely. Groundwater encountered at 4.5m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	3.70	100%
3.70	4.30	100%
4.50	5.50	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
4.50m	-	-	

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Exploratory Hole Number
BH14
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213321E - 216778N** **Level** : **92.96 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	5.50m	Dynamic Sampling	143mm
5.50m	14.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **28/04/2016**
Finish Date : **29/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
Weathered MUDSTONE recovered as very stiff grey very sandy clay with many fine to coarse sub-rounded to sub-angular gravel of mixed lithologies and occasional cobbles and boulders of sandstone. .			10.50 10.50 10.50-10.95	C D10	N=60 (10,10,12,13,15,20)			10.50		
				15	0	0	NI			
			11.50 11.50 11.50-11.95	C D11	N=68 (18,7,12,16,20,20)			11.50		
				10	0	0	NI			
			12.50 12.50 12.50-12.83	C D12	75 for 245mm (16,9,14,14,24,23)			12.50		
				15	0	0	NI			
			13.50 13.50 13.50-14.50	C B4	N=79 (20,5,21,18,20,20)			13.50		
				30	0	0	NI			
		14.50 (78.46)						14.50		
End of Borehole at 14.50 m										

TCR SCR RQD FI

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. 1hr to move rig across highway safely. Groundwater encountered at 4.5m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	3.70	100%
3.70	4.30	100%
4.50	5.50	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
4.50m	-	-	

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Exploratory Hole Number
BH15
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213292E - 216870N** **Level** : **96.20 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	5.20m	Dynamic Sampling	143mm
5.20m	15.10m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **27/04/2016**
Finish Date : **28/04/2016**

Strata Description	Depth (m) (AOD)
Turf over soft brown sandy SILT with humus and rootlets. TOPSOIL	0.45 (95.75)
Weathered SILTSTONE recovered as brown clayey sandy silt with fine to coarse sub-angular gravels and cobbles of grey siltstone.	5.20 (91.00)
Weathered SILTSTONE recovered as brown sandy clay with sub-angular cobbles of siltstone.	6.20 (90.00)
Moderately strong grey SILTSTONE with very closely spaced sub horizontal planar smooth bedding discontinuities with sub vertical stepped rough black stained discontinuities.	7.00 (89.20)
Strong grey SILTSTONE with very closely spaced sub horizontal-20° planar smooth bedding discontinuities with red brown and black staining and occasionally undulating bedding. Sub vertical planar smooth black stained discontinuities.	

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks	Casing Diameter
0.40	ES4		
1.20 1.20-1.65	S D5	N=14 (2,3,3,4,3,4)	
2.00-2.70	B4		
2.70 2.70-4.20	S B4	N=15 (2,2,3,4,4,4)	
4.50 4.50-5.20	S B4	N=19 (4,4,5,4,6,4)	4.50 143mm
6.20 6.20	C	100 for 115mm (25,0,67,33)	
7.70-8.01	C4		
8.01-8.22	C4		
8.30-8.66	C4		

Depth (m)	TCR	SCR	RQD	FI
5.20-6.20	45	0	0	NA
6.20-7.30	100	45	25	23
7.30-8.30	100	75	36	17
8.30-9.80	100	73	53	25

Remarks / Observations: Continued next sheet

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	4.20	100%
4.50	5.20	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH15
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213292E - 216870N** **Level** : **96.20 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	5.20m	Dynamic Sampling	143mm
5.20m	15.10m	Rotary Cored	107mm

Scale 1:50 **Sheet 2 of 2**
Logged By : **NP**
Checked By : **PV**
Start Date : **27/04/2016**
Finish Date : **28/04/2016**

Strata Description	Legend	Depth (m) (AOD)	Rotary Coring Depth (m)	TCR	SCR	RQD	FI	Casing Diameter	Water Strikes	Backfill / Installation
Strong grey SILTSTONE with very closely spaced sub horizontal-20° planar smooth bedding discontinuities with red brown and black staining and occasionally undulating bedding. Sub vertical planar smooth black stained discontinuities.				75	5	0	NI			
			10.60	97	83	32	25	10.60		
			12.10	50	25	12	25+	12.10		
			13.40	29	0	0	NI	13.40		
			14.10	50	0	0	NI	14.10		
		14.50 (81.70)						14.50		
End of Borehole at 14.50 m				TCR	SCR	RQD	FI			

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.70	100%
2.70	4.20	100%
4.50	5.20	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks

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Exploratory Hole Number
BH16
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **212350E - 216673N** **Level** : **77.44 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	7.00m	Dynamic Sampling	143mm
7.00m	8.00m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **05/05/2016**
Finish Date : **05/05/2016**

Strata Description	Legend	Depth (m) (AOD)	Samples & In Situ Testing Depth (m)	Type	Results/Remarks				Casing Diameter	Water Strikes	Backfill / Installation
Turf over soft brown SILT with humus and roots (TOPSOIL).		0.45 (76.99)									
Weathered CONGLOMERATE recovered as firm orange brown very sandy silt/clay with many fine to coarse sub-angular to sub-rounded gravel of sandstone and mudstone.		3.20 (74.24)	1.20 1.20-1.65	S D5	N=8 (2,2,1,2,2,3)					1.20	
			2.20 2.20-3.20	S B5	N=11 (2,1,3,2,3,3)						
Weathered CONGLOMERATE recovered as Firm to stiff dark grey brown silt/clay with many fine to coarse sub-angular Gravel of Sandstone and Mudstone.		8.00 (69.44)	5.50 5.50-7.00	C B5	N=29 (4,5,6,7,8,8)				5.50 143mm		
			7.00 7.00 7.00-7.45	S D6	N=46 (9,6,6,7,11,22)						
				10	0	0	NA				
End of Borehole at 8.00 m									8.00		
				TCR	SCR	RQD	FI				

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Move to BH16 from BH01 1hr45mins.
4. Groundwater encountered at 1.2m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.20	100%
2.20	3.20	100%
5.50	7.00	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.20m	-	-	

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Exploratory Hole Number
BH17
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **212237E - 216690N** **Level** : **80.08 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	7.80m	Dynamic Sampling	143mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **06/05/2016**
Finish Date : **06/05/2016**

Strata Description	Depth (m) (AOD)	Samples & In Situ Testing Depth (m)	Type	Results/Remarks	Casing Diameter	Water Strikes
Turf over soft brown SILT with humus and roots (TOPSOIL).	0.40 (79.68)					
Weathered MUDSTONE, Firm orange brown very sandy silt/clay with many fine to coarse sub-angular to sub-rounded gravel of sandstone and mudstone.		1.20 1.20-2.20	S B4	N=9 (1,2,2,3,2,2)		
		2.20 2.20-2.65	S D5	N=19 (1,3,4,5,5,5)		
	3.30 (76.78)	3.20 3.20-4.20	S B4	N=16 (3,4,4,3,4,5)		
Weathered MUDSTONE, Firm to stiff dark grey brown silt/clay with many fine to coarse sub-angular gravel of sandstone and mudstone.	4.30 (75.78)	4.20 4.20-4.65	S D5	N=22 (2,4,5,5,6,6)		
Weathered MUDSTONE, Very stiff orange brown very sandy silt/clay with many fine to coarse sub-angular to sub-rounded gravel of sandstone and mudstone.		5.20 5.20-6.70	S B4	N=28 (5,7,6,7,7,8)		▽ 5.20
		6.70 6.70-7.15	S D5	N=29 (4,8,7,6,8,8)		
	7.80 (72.28)				7.80 143mm	
End of Borehole at 7.80 m						

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-1.8m plain pipe and bentonite, 1.8-8.0m slotted pipe and gravel filter.
3. Groundwater was not encountered.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.20	100%
2.20	3.20	100%
3.20	4.20	100%
4.20	5.20	100%
5.20	6.70	100%
6.70	7.80	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
5.20m	-	-	

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Exploratory Hole Number
BH101
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **214314E - 217067N** **Level** : **103.44 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	2.00m	Dynamic Sampling	107mm
2.00m	8.00m	Rotary Cored	

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **05/05/2016**
Finish Date : **05/05/2016**

Strata Description	Legend	Depth (m) (AOD)
Turf over brown sandy SILT with humus and roots (TOPSOIL).		0.40 (103.04)
Weathered MUDSTONE recovered as brown and grey clayey sand with fine to coarse sub-angular gravel and cobbles of mudstone.		0.80 (102.64)
Weathered MUDSTONE recovered as grey and brown very sandy fine to medium angular gravel of mudstone.		1.80 (101.64)
Moderately strong grey MUDSTONE with very closely spaced 45° planar smooth bedding discontinuities with red brown and black staining.		3.90 (99.54)
Strong grey coarse grained SANDSTONE with very closely spaced 45&70° planar rough black stained discontinuities.		6.50 (96.94)
Strong brown fine grained CONGLOMERATE with very closely spaced 45° bedding disc & 70° planar rough black stained discontinuities. ....7.5-7.9m becoming grey.		8.00 (95.44)
End of Borehole at 8.00 m		

Samples & In Situ Testing

Depth (m)	Type TCR	Results/Remarks SCR	RQD	FI	Casing Diameter	Water Strikes
0.00-1.20	B4					
0.60	ES4					
1.20 1.20-1.80	C B4	N=50 (9,11,10,11,13,16)				
2.00 2.00 2.00-2.18	C D5	110 for 150mm (25,28,82)				
	100	0	0	>50		
3.00					3.00	
						3.20
	70	0	0	>50		
4.00					4.00	
	70	0	0	NI		
5.00					5.00	
	100	0	0	NI		
5.50					5.50	
	80	0	0	NI		
6.00					6.00	
	100	16	0	42		
6.50						
	100	50	0			
7.00					7.00	
	30	0	0	NI		
7.50					7.50	
	80	16	0	30		
					8.00	

Backfill / Installation

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. Hole backfilled with bentonite.
3. Groundwater encountered at 3.2m.
5. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.00	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
3.20m	-	-	

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Exploratory Hole Number
BH102
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**

Project Number : **A096409**
Client : **Welsh Government**
Method : **Rotary cored**
Co-ordinates : **213941E - 216948N** **Level** : **85.40 m AOD**

Hole Information

From	To	Method	Diameter
1.20m	3.20m	Dynamic Sampling	143mm
3.20m	8.50m	Rotary Cored	107mm

Scale 1:50 **Sheet 1 of 1**
Logged By : **NP**
Checked By : **PV**
Start Date : **05/05/2016**
Finish Date : **06/05/2016**

Strata Description	Legend	Depth (m)	(AOD)
Grass over brown silty TOPSOIL with roots and humus (TOPSOIL).		0.30	(85.10)
MADE GROUND: Soft brown slightly sandy CLAY with many fine to coarse sub-angular gravel of Mudstone.		0.80	(84.60)
Weathered MUDSTONE recovered as soft to firm brown grey clay with many fine to coarse sub-angular gravel of mudstone.		1.50	(83.90)
Weathered MUDSTONE recovered as grey very clayey sandy fine sub-angular gravel of mudstone.		3.00	(82.40)
Very weak grey and red brown stained MUDSTONE.		3.20	(82.20)
Very weak grey and red brown stained MUDSTONE.		4.00	(81.40)
Moderately strong dark grey MUDSTONE with very closely spaced 45° planar smooth bedding discontinuities and sub vertical planar smooth discontinuities. ....4.4-5.0m sub-vertical planar smooth fracture.		8.50	(76.90)
End of Borehole at 8.50 m			

Samples & In Situ Testing

Depth (m)	Type	Results/Remarks
0.00-1.20	B4	
0.50	ES4	
1.20	C	
1.20-1.65	D5	N=10 (2,1,2,2,2,4)
2.20	C	
2.20-2.65	D6	N=17 (3,2,3,4,4,6)
3.20	C	58 for 145mm (17,8,8,50)
3.20		
3.20-3.43	D7	
4.00	C	50 for 9mm (25,50)
4.00		
4.00-4.05	D8	

Depth (m)	TCR	SCR	RQD	FI
3.20-4.00	50	0	0	NI
4.00-5.50	93	68	0	NI (4.00-4.50) >50 (4.50-5.50)
5.50-7.00	66	7	0	NI
7.00-8.50	100	5	0	NI

Casing Diameter	Water Strikes
4.00 143mm	1.20

Remarks / Observations:

1. Hand dug inspection pit to 1.2m.
2. 50mm standpipe installed: 0.0-2.5m plain pipe and bentonite, 2.5-8.0m slotted pipe and gravel filter.
3. Groundwater encountered at 1.2m.
4. No visual or olfactory evidence of contamination observed.

Dynamic Sampling

From	To	Recovery
1.20	2.20	100%
2.20	3.20	100%

Groundwater

Depth Struck	Rising To	Time (mins)	Remarks
1.20m	-	-	

Plate 1 BH01

Plate 2 BH01

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5th Floor, Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
Environmental Consultancy
Ground Technologies & Investigation

Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 3 BH02

Plate 4 BH02

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47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
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Plate 5 BH02

Plate 6 BH03

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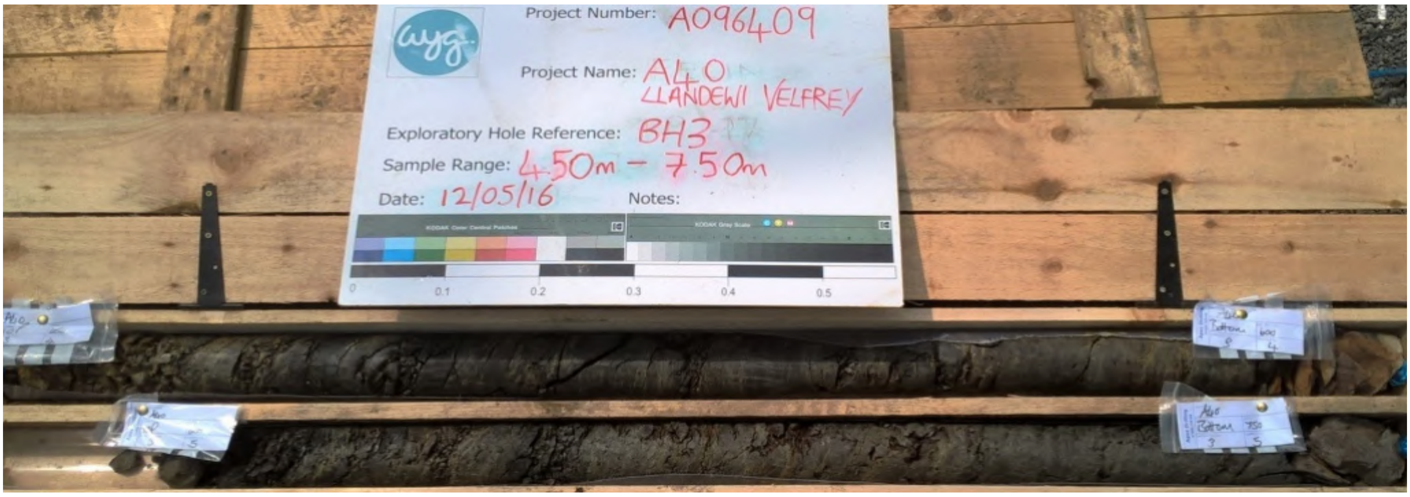

Plate 7 BH03

Plate 8 BH03

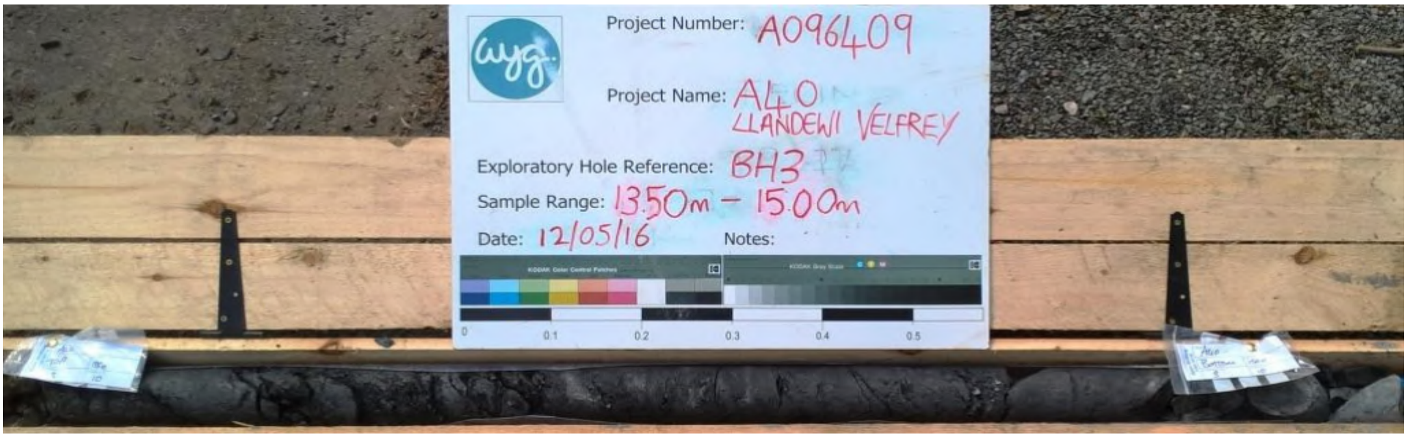

Plate 9 BH03

Plate 10 BH04

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47 Newport Road
Cardiff
CF24 0AD

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Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

Plate 11 BH04

Plate 12 BH04

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Fax: 029 20 455321
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 13 BH04

Plate 14 BH04

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47 Newport Road
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Fax: 029 20 455321
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Project Number: A096409

Project Name: A40 LLANDEWI VELFREY

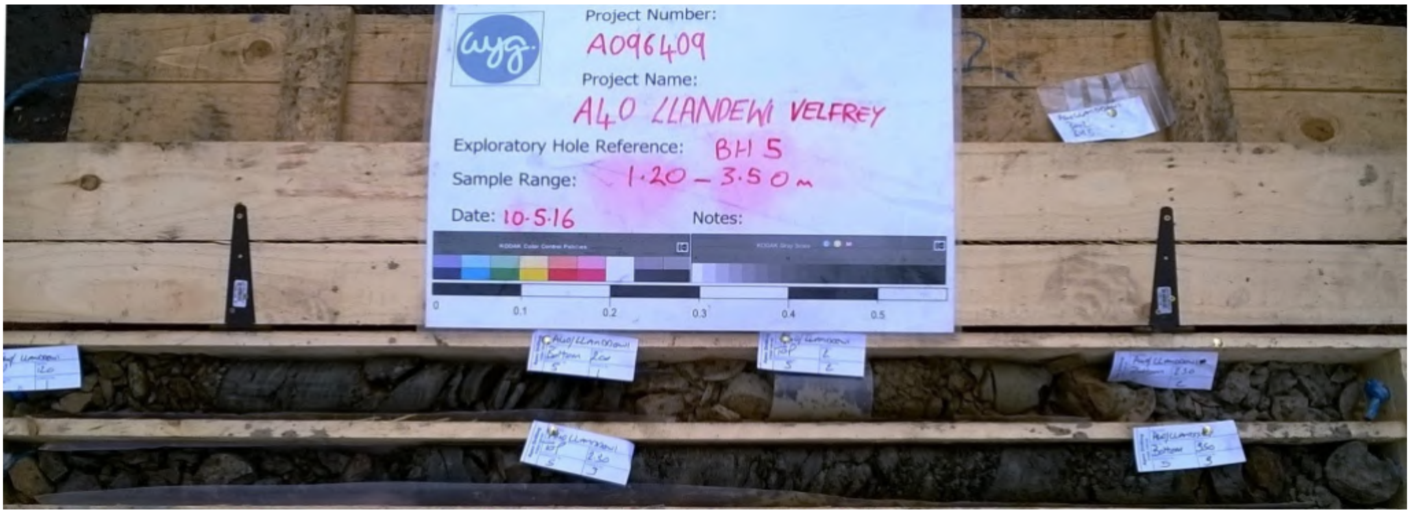
Exploratory Hole Reference: BH 4

Sample Range: 15.00 – 18.00 m

Date: 10.5.16

Notes:

Plate 15 BH04



Project Number: A096409

Project Name: A40 LLANDEWI VELFREY

Exploratory Hole Reference: BH 5

Sample Range: 1.20 – 3.50 m

Date: 10.5.16

Notes:

Plate 16 BH05

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Fax: 029 20 455321
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Project No.: A096409	Date : 10.06.2016

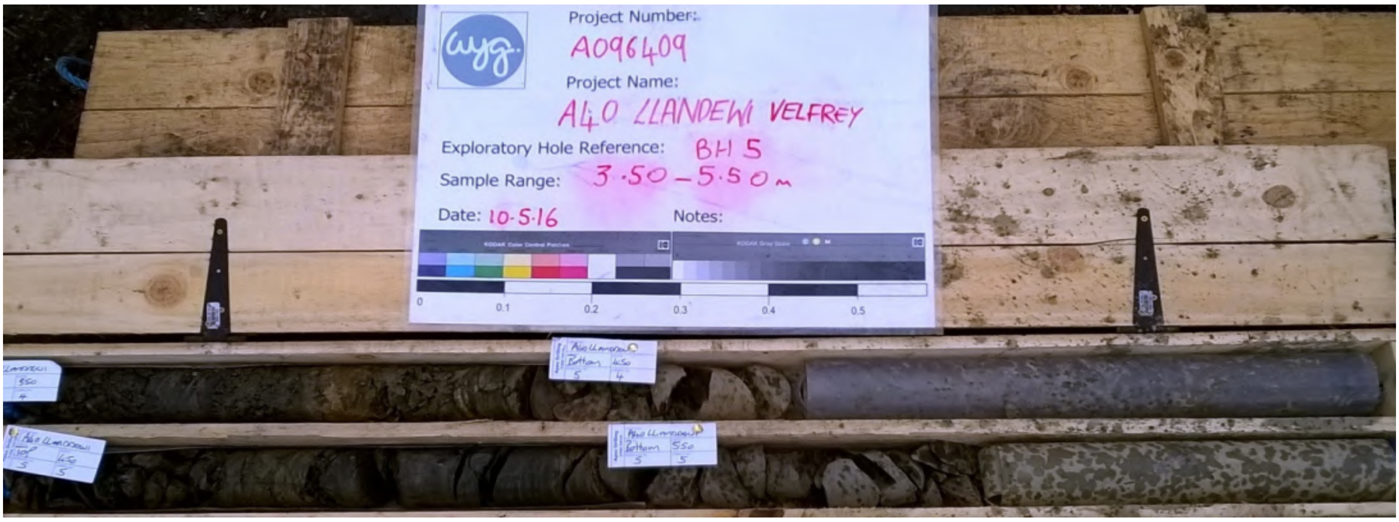

Plate 17 BH05

Plate 18 BH05

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Plate 19 BH05

Plate 20 BH05

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Project No.: A096409

Date : 10.06.2016

Plate 21 BH05

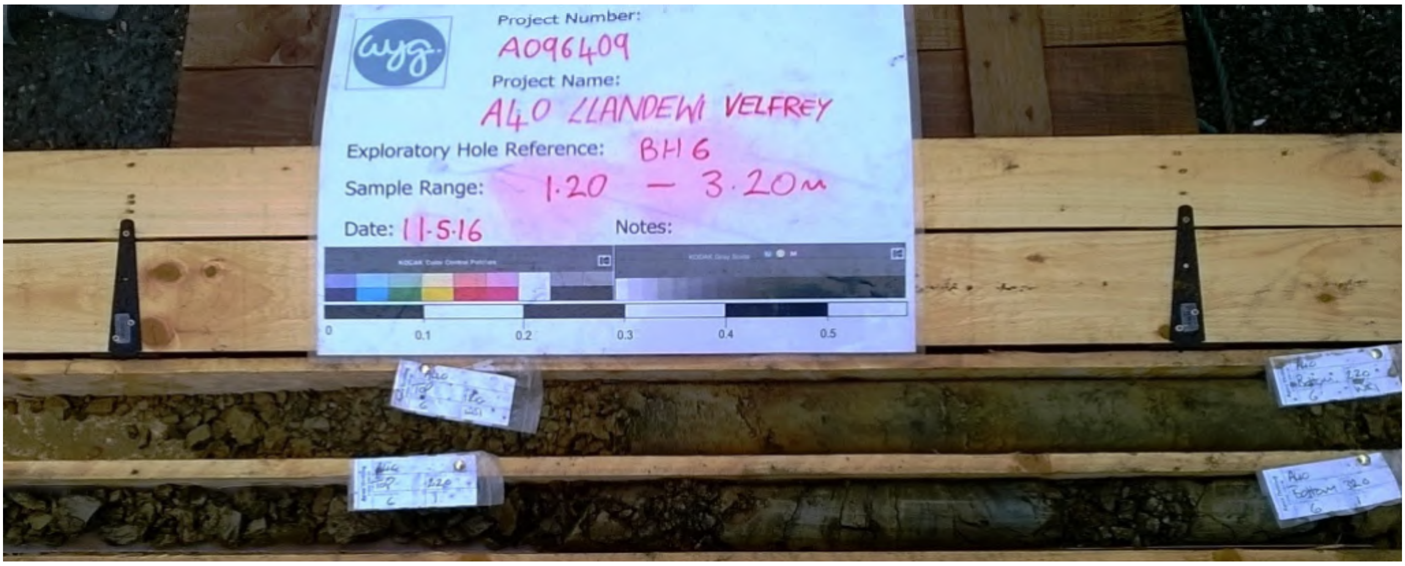

Plate 22 BH06

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Fax: 029 20 455321
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Plate 23 BH06

Plate 24 BH06

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Plate 25 BH06

Plate 26 BH06

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	Project No.: A096409 — Date : 10.06.2016

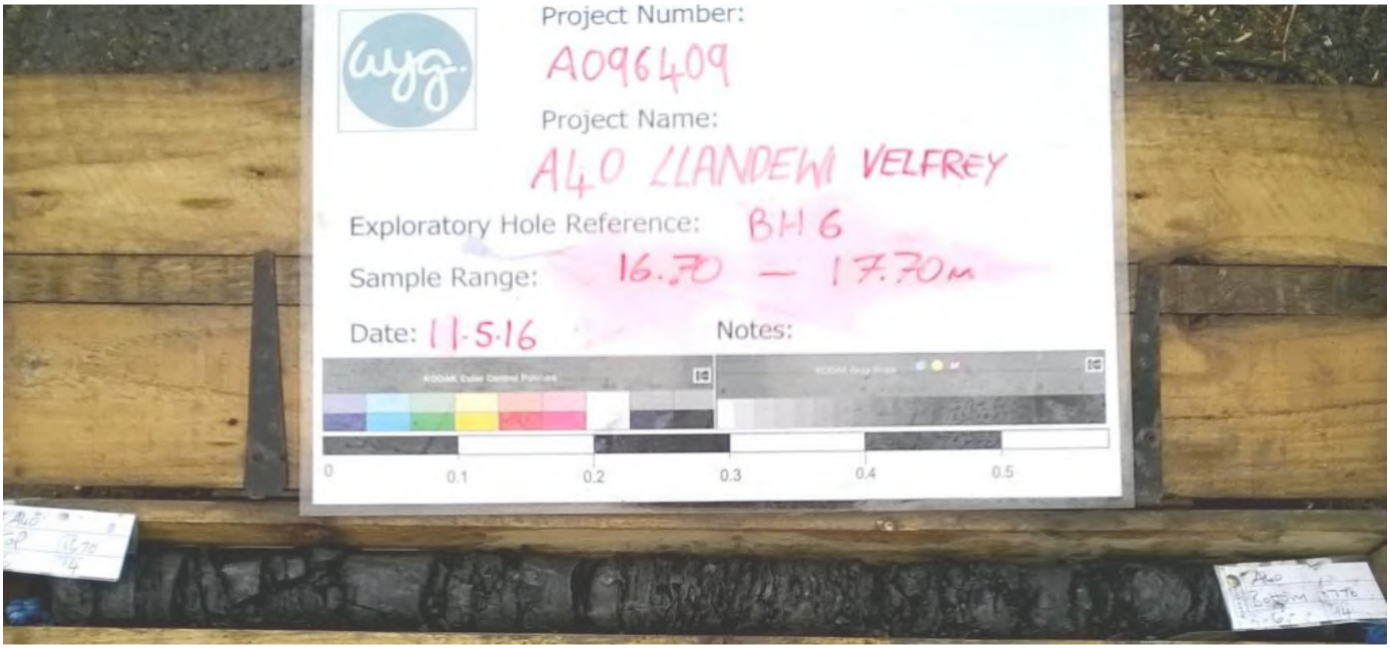

Plate 27 BH06

Plate 28 BH07

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E-mail enviro.cardiff@wyg.com
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 29 BH07

Plate 30 BH07

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	Client: Welsh Government	
	Project No.: A096409	Date : 10.06.2016

Plate 31 BH08

Plate 32 BH07

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Fax: 029 20 455321
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 33 BH08

Plate 34 BH09

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Plate 35 BH09

Plate 36 BH09

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Fax: 029 20 455321
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Project No.: A096409

Date : 10.06.2016

Plate 37 BH10

Plate 38 BH10

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A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016


Project Number: A096409
Project Name: A40 LLANDEWI VELREY
Exploratory Hole Reference: BH10
Sample Range: 10.80m - 13.80m
Date: 13/04/16 - 15/04/16 Notes:

Plate 39 BH10


Project Number: A096409
Project Name: A40 LLANDEWI VELREY
Exploratory Hole Reference: BH11
Sample Range: 1.20m - 7.50m
Date: 18/04/16-19/04/16 Notes:

Plate 40 BH11

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Cardiff
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Fax: 029 20 455321
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Project :-
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Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

Plate 41 BH11

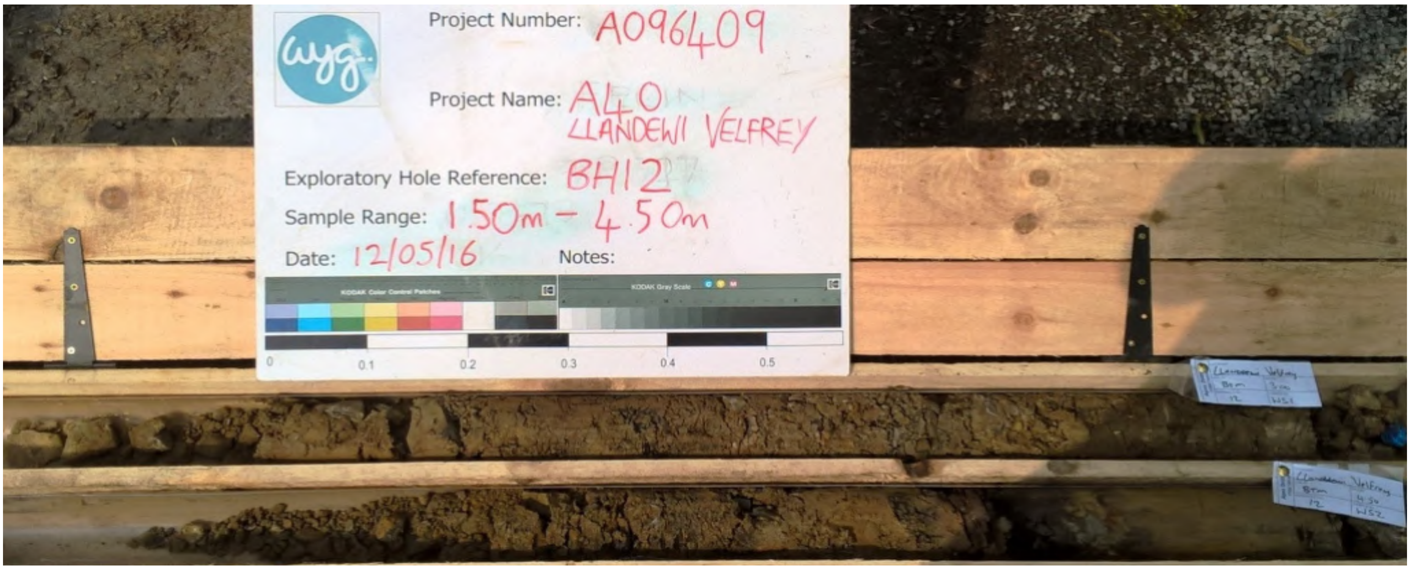

Plate 42 BH12

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Cardiff
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Fax: 029 20 455321
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 43 BH12

Plate 44 BH14

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47 Newport Road
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Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

Plate 45 BH14

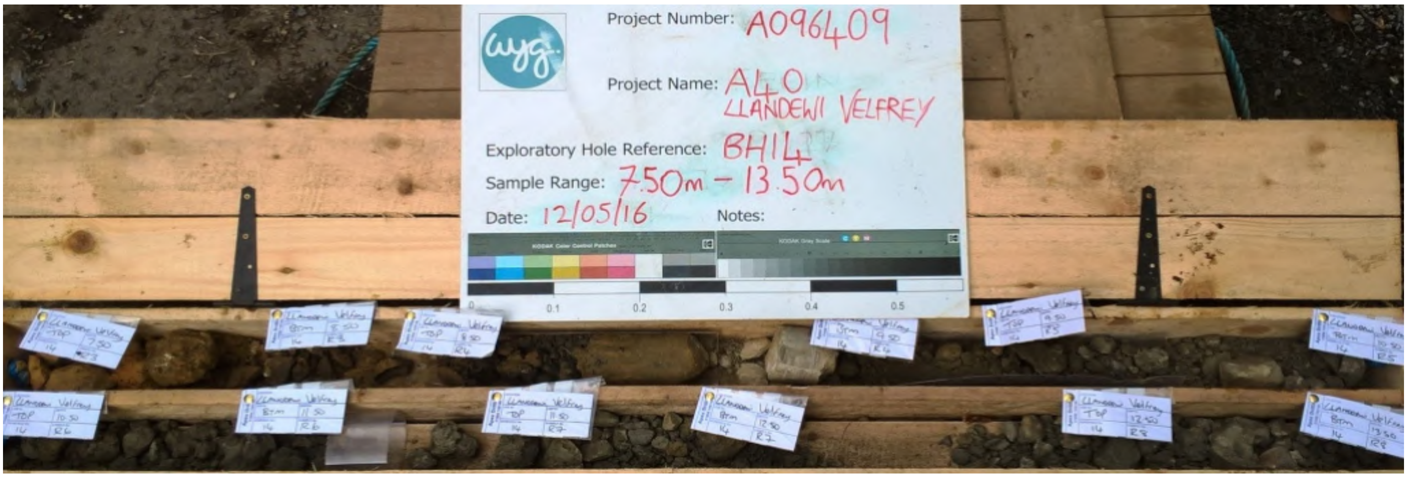

Plate 46 BH14

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Cardiff
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Tel: 029 20 829200
Fax: 029 20 455321
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 47 BH14

Plate 48 BH15

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5th Floor, Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

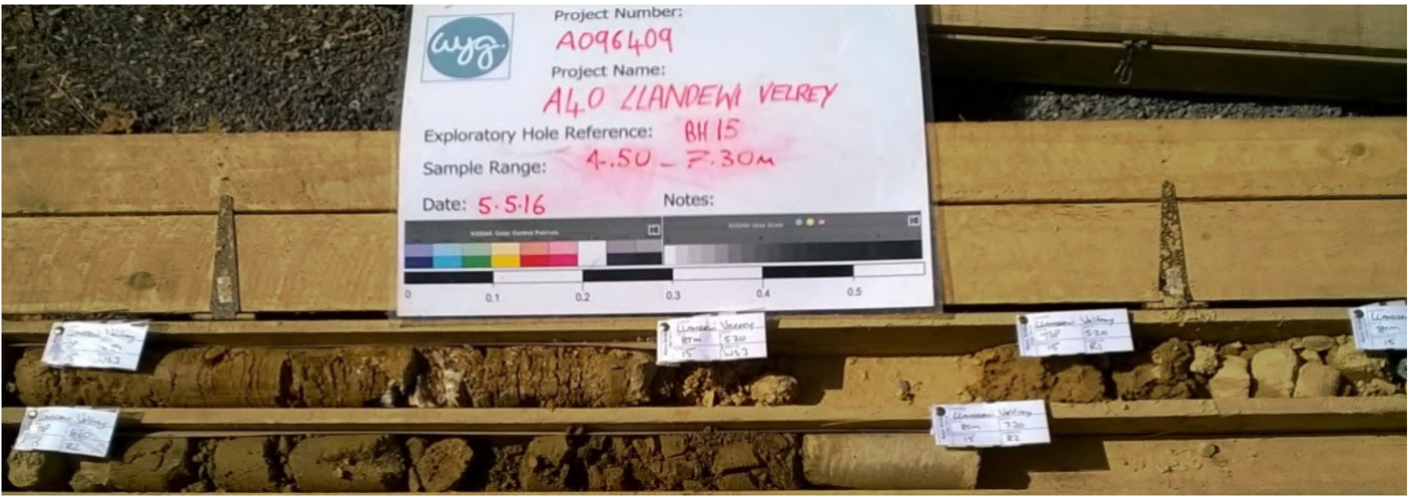

Plate 49 BH15

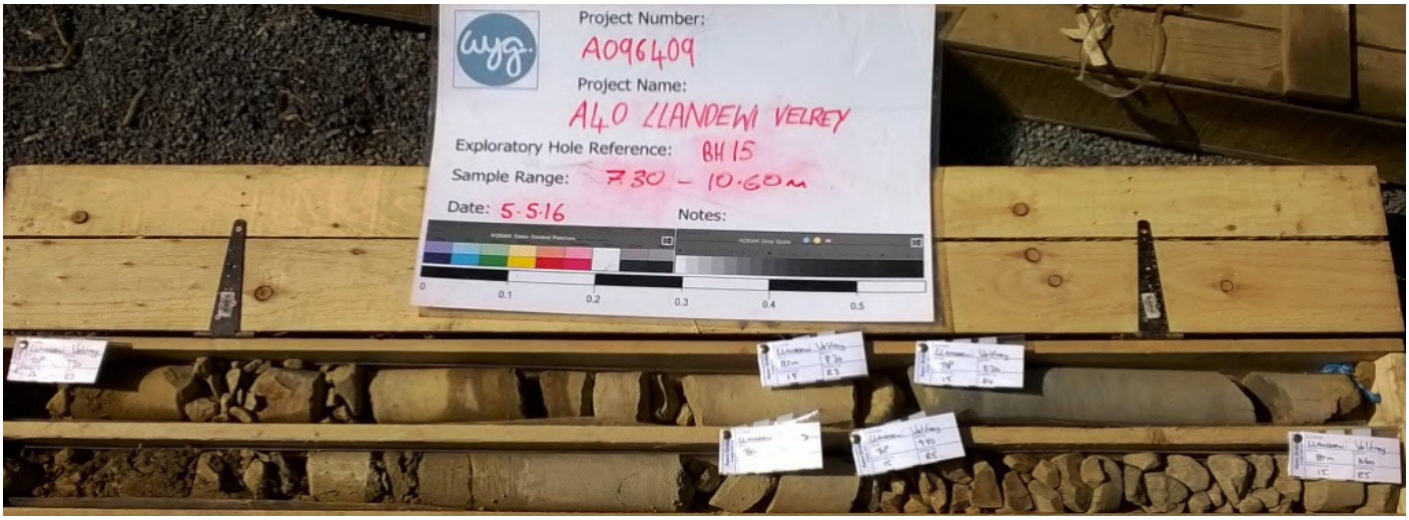

Plate 50 BH15

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Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 51 BH15

Plate 52 BH16

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Tel: 029 20 829200
Fax: 029 20 455321
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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 53 BH16

Plate 54 BH17

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Fax: 029 20 455321
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Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

Plate 55 BH17

Plate 56 BH17

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Project :-
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 57 BH101

Plate 58 BH101

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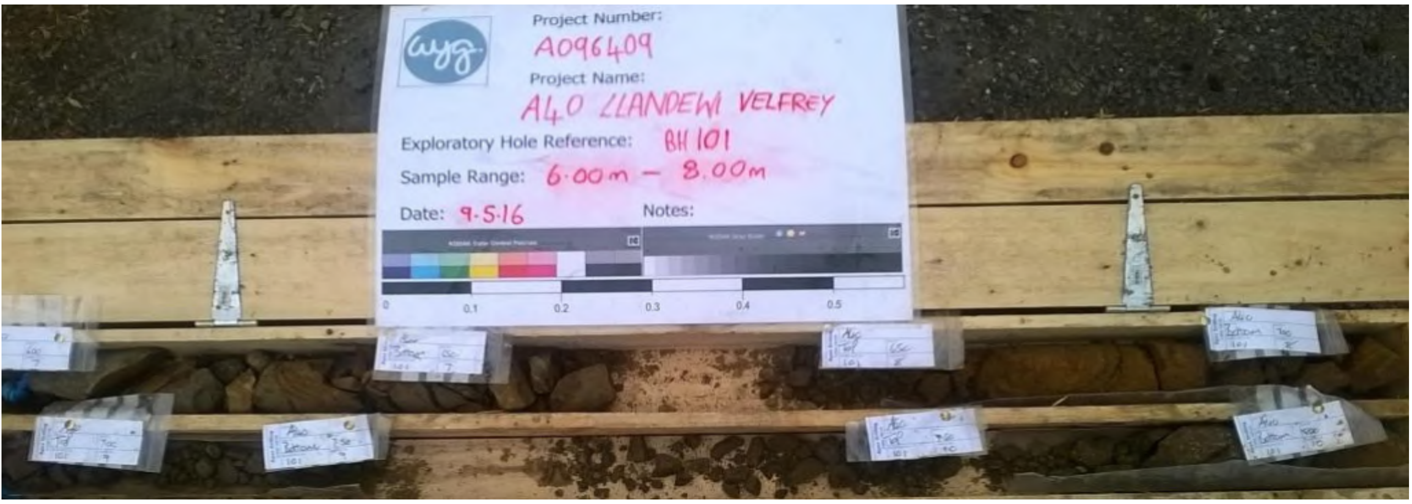
Client: Welsh Government

Project No.: A096409

Date : 10.06.2016



Project Number: A096409
Project Name: A40 LLANDEWI VELFREY
Exploratory Hole Reference: BH 101
Sample Range: 6.00m – 8.00m
Date: 9.5.16
Notes:

Plate 59 BH101

Project Number: A096409
Project Name: A40 LLANDEWI VELFREY
Exploratory Hole Reference: BH 102
Sample Range: 1.20m – 3.20m
Date: 9.5.16
Notes:

Plate 60 BH102

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	Client: Welsh Government
	Project No.: A096409 — Date : 10.06.2016

Plate 61 BH102

Plate 62 BH102

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Project :-
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP01
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **216256E - 216955N**
Level : **105.04 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **09/05/16**
Finish Date : **09/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
MADE GROUND: Dark grey slightly sandy, slightly clayey angular to sub-angular fine to coarse mudstone GRAVEL with some cobbles and boulders.		104.54	**0.50**			0.20-0.50 0.30	B1 ES1	
Weathered MUDSTONE, Grey medium to coarse angular mudstone GRAVEL.		103.14	**1.90**			0.55 0.70-1.10	ES2 B2	
End of Trial Pit at 1.90 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.95m
Width : 0.60m
Orientation : 0 degrees
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number

TP02

Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **216044E - 216954N**
Level : **104.18 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **09/05/16**
Finish Date : **09/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	103.88	**0.30**		▨	0.25	ES1	
Weathered MUDSTONE,Soft light browny grey gravelly CLAY. Gravel is fine to medium angular to sub-angular mudstone.	☰	103.68	**0.50**		▨	0.30-0.50	B1	
Weathered MUDSTONE, Grey medium to coarse angular mudstone GRAVEL.	☰	102.33	**1.85**		▨	0.90-1.40	B2	

End of Trial Pit at 1.85 m bgl.

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number
TP03
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **215719E - 216914N**
Level : **128.42 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **09/05/16**
Finish Date : **09/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
MADE GROUND: Soft drown sandy gravelly CLAY. Gravel is fine to coarse angular to sub-angular brick (including partial brick wall), metal, plastic, tile and concrete. Numerous cobble and boulder sized pieces		125.32	**3.10**			0.15 0.50 1.50 2.50	ES1 ES2 ES2 ES4	
Orange brown slightly clayey sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded mudstone and sandstone. Some cobbles of sandstone and mudstone present.		125.12	**3.30**			3.10-3.30	B1	
Browny grey slightly clayey sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded mudstone and sandstone.		124.57	**3.85**			3.40-3.70 3.50	B2 ES5	
Brown grey slightly gravelly SAND. Gravel is fine to coarse sub-angular to sub-rounded sandstone.		124.32	**4.10**			3.90-4.10	B3	

End of Trial Pit at 4.10 m bgl.

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.20m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Moderatley unstable through made ground

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number
TP04
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **215531E - 217068N**
Level : **127.89 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **11/05/16**
Finish Date : **11/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).		127.69	**0.20**					
Orange brown slightly clayey GRAVEL. Gravel is fine to coarse angular and elongate friable mudstone.		127.49	**0.40**			0.20-0.40	B1	
Grey medium to coarse angular mudstone GRAVEL.		125.79	**2.10**			0.40 0.80-1.20 1.80-2.10	ES1 B2 B3	
End of Trial Pit at 2.10 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff, CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP05
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **215502E - 217139N**
Level : **117.90 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **11/05/16**
Finish Date : **11/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	117.65	**0.25**		▨			
Orange brown slightly clayey GRAVEL. Gravel is fine to coarse angular and elongate friable mudstone.	▤	117.35	**0.55**		▨	0.30-0.50	B1	
Grey medium to coarse angular mudstone GRAVEL.	▤	115.90	**2.00**		▨	1.60-2.00	B2	

End of Trial Pit at 2.00 m bgl.

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number
TP17
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213955E - 216934N**
Level : **84.81 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **11/05/16**
Finish Date : **01/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).		84.56	**0.25**					
Light grey brown stiff CLAY.		84.16	**0.65**			0.30 0.30 0.30	1 2 3	HV = 50kPa HV = 54kPa HV = 54kPa
Orange brown slightly sandy gravelly CLAY. Gravel is fine to coarse angular to sub-rounded mudstone.		83.16	**1.65**					
Orange brown clayey slightly sandy GRAVEL. Gravel is fine to coarse angular to sub-rounded mudstone.		81.41	**3.40**					
Grey mudstone fine to medium, angular, flat and friable GRAVEL.		81.16	**3.65**					
End of Trial Pit at 3.65 m bgl.								

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : Not required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number
TP18
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213542E - 216807N**
Level : **88.06 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **06/05/16**
Finish Date : **06/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).		87.81	**0.25**					
Firm to stiff light brown mottled grey sandy slightly gravelly stiff CLAY. Gravel is fine to coarse rounded to sub-angular.		87.11	**0.95**			0.60 0.60 0.60	1 2 3	HV = 70kPa HV = 72kPa HV = 72kPa
Grey brown clayey GRAVEL. Gravel is fine to coarse angular to subangular mudstone. Cobbles and boulders of mudstone present.		85.96	**2.10**					
Firm to stiff grey brown gravelly CLAY/SILT. Gravel is fine to coarse angular to subangular mudstone. Cobbles and boulders of mudstone present. ....becoming slightly gravelly CLAY/SILT with depth.		84.26	**3.80**					

End of Trial Pit at 3.80 m bgl.

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : Not required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP19
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213421E - 216793N**
Level : **92.02 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **06/05/16**
Finish Date : **06/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	91.72	**0.30**		▨	0.20	ES1	
Soft light brown orange slightly sandy gravelly SILT. Gravel is fine to medium rounded to angular mudstone and sandstone.	▤	90.62	**1.40**		▨	0.40-0.80	B1	
Stiff orange slightly gravelly CLAY. Gravel is fine to coarse angular to sub-angular mudstone.	▤	89.32	**2.70**		▨	1.70-2.10	B2	
Light grey brown slightly clayey sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded and is composed of sandstone, mudstone, quartz and some igneous rock.	▤	87.72	**4.30**		▨	3.00-3.40	B3	
End of Trial Pit at 4.30 m bgl.								

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.30m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Generally stable - partial instability within GRAVEL after water seepage

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Ground Engineering Services
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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP20
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213324E - 216781N**
Level : **93.07 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **06/05/16**
Finish Date : **06/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
MADE GROUND: Brown clayey GRAVEL. Gravel is fine to medium angular to subangular mudstone, sandstone, tile, brick and metal wire		92.82	**0.25**			0.15	ES1	
Soft brown slightly sandy gravelly CLAY.		92.67	**0.40**			0.30	ES2	
Firm light brown orange slightly sandy gravelly SILT. Gravel is fine to medium rounded to angular mudstone and sandstone.		91.57	**1.50**			0.50-1.00 0.60-0.63 0.61-2.00	B1 ES3 B2	
Firm to stiff orange slightly gravelly CLAY. Gravel is fine to coarse angular to sub-angular mudstone.		90.47	**2.60**					
Firm to stiff brown to grey slightly gravelly CLAY. Gravel is fine to medium sub-angular to rounded mudstone.		89.67	**3.40**			2.90-3.30	B3	
Light brown to grey gravelly CLAY. Gravel is fine to medium sub-angular to rounded mudstone. Some angular to elongated cobbles towards base.		88.72	**4.35**			3.60-4.00	B4	

End of Trial Pit at 4.35 m bgl.

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.25m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP21
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213292E - 216872N**
Level : **96.37 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **06/05/16**
Finish Date : **06/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).		96.07	**0.30**			0.20	ES1	
Soft orange brown sandy gravelly CLAY with irregular bands of white to grey sand. Gravel is fine to coarse angular to sub-rounded siltstone and sandstone. Some cobbles also present.		94.77	**1.60**			0.60-1.10	B1	
Light brown slightly clayey sandy GRAVEL. Gravel is fine to coarse angular to rounded sandstone and mudstone. Lots of cobbles and boulders also present.		93.57	**2.80**			1.80-2.30	B2	
Firm to stiff browny orange slightly sandy gravelly CLAY. Gravel is fine to coarse rounded to sub-angular mudstone.		92.07	**4.30**			3.00-3.40 4.00-4.30	B3 B4	
End of Trial Pit at 4.30 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.20m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP22
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213213E - 216851N**
Level : **95.58 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **05/05/16**
Finish Date : **05/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	95.23	**0.35**		▨	0.30	ES1	
Firm to stiff orange brown slightly sandy gravelly CLAY with irregular bands of white to grey sand. Gravel is fine to coarse angular to sub-rounded siltstone and sandstone. Some cobbles also present.	▤	93.88	**1.70**		▨	0.80-1.20	B1	
Light brown clayey slightly sandy GRAVEL. Gravel is fine to coarse angular to rounded sandstone and mudstone. Cobbles and boulders also present.	▤	93.13	**2.45**		▨	1.90-2.30	B2	
Stiff browny orange slightly sandy gravelly CLAY. Gravel is fine to coarse rounded to sub-angular mudstone.	▤	91.28	**4.30**		▨	2.70-3.10	B3	
End of Trial Pit at 4.30 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.20m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

Exploratory Hole Number

TP23

Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **213063E - 216811N**
Level : **94.14 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **05/05/16**
Finish Date : **05/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	93.79	**0.35**		▨	0.30	ES1	
Firm orange brown slightly sandy gravelly CLAY. Gravel is fine to coarse angular to sub-rounded siltstone and sandstone. Some cobbles also present.	▤	92.79	**1.35**		▨	0.50-0.90 0.82-3.30	B1 B3	
Light brown slightly clayey sandy GRAVEL. Gravel is fine to coarse angular to rounded sandstone, mudstone. Cobbles and boulders also present.	▤	91.69	**2.45**		▨	1.50-1.80	B2	
Firm to stiff brown orange slightly sandy gravelly CLAY. Gravel is fine to coarse rounded to sub-angular mudstone. Angular to sub-angular cobbles and boulders.	▤	89.84	**4.30**		▨	3.90-4.30	B4	

End of Trial Pit at 4.30 m bgl.

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.20m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP24
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **212958E - 216768N**
Level : **91.72 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **05/05/16**
Finish Date : **05/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	91.42	**0.30**		▨	0.25	ES1	
Firm orange brown sandy gravelly CLAY. Gravel is fine to coarse angular to sub-rounded siltstone and sandstone. Some cobbles also present.	▤	90.22	**1.50**		▨	0.60-1.00	B1	
Light brown slightly clayey sandy GRAVEL. Gravel is fine to coarse angular to rounded sandstone, mudstone and some quartz. Cobbles and boulders also present.	▤	89.42	**2.30**		▨	1.80-2.20	B2	
Firm to stiff browny orange slightly sandy gravelly CLAY. Gravel is fine to coarse rounded to sub-angular mudstone.	▤	87.62	**4.10**		▨	2.50-2.80 3.40-3.90	B3 B4	

End of Trial Pit at 4.10 m bgl.

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.00m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Exploratory Hole Number
TP25
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **212756E - 216697N**
Level : **87.59 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **04/05/16**
Finish Date : **04/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Sandy CLAY (TOPSOIL).						0.30	ES1	
		87.19	**0.40**					
Light brown clayey sandy GRAVEL. Gravel is fine to coarse sub-rounded to sub-angular (some elongate and angular). Some cobbles present - the number of which increasing with depth.						0.60-0.90	B1	
		85.89	**1.70**					
Angular to sub-angular sandstone COBBLES with a sandy clayey matrix. Boulders of sandstone also present.						1.90-2.30	B2	
						2.80-3.10	B3	
		84.44	**3.15**					
End of Trial Pit at 3.15 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.95m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
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Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP26
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **212615E - 216671N**
Level : **84.25 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **04/05/16**
Finish Date : **04/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown slightly gravelly sandy CLAY with rootlets and grass covering (TOPSOIL).	▨	83.90	**0.35**		▨	0.30	ES1	
Orange brown clayey sandy GRAVEL. Gravel is fine to coarse sub-rounded to sub-angular sandstone and mudstone with some cobbles. Some pockets yellow brown clay with fine to medium rounded gravel.	▤	82.80	**1.45**		▨	0.50-0.80	B1	
Firm orange brown sandy slightly gravelly CLAY. Gravel is fine to coarse sub-angular to rounded mudstone and sandstone.	▤	82.25	**2.00**		▨	1.50-1.90	B2	
Light brown yellow slightly clayey sandy GRAVEL. Gravel is fine to medium sub-rounded to sub-angular mudstone and sandstone. Pockets of gravelly (fine to medium rounded to sub-rounded mudstone and sandstone) sandy clay. ....with pockets of gravelly (fine to medium rounded to sub-rounded mudstone and sandstone) sandy clay.	▤	80.15	**4.10**		▨	2.10-2.40 3.00-3.50	B3 B4	
End of Trial Pit at 4.10 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information
Length : 1.95m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff, CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP27
Final

Project : A40 Penblewin-Llandewi Velfrey GI
Project Number : A096409
Client : Welsh Government
Method : JCB 3CX
Co-ordinates : 212442E - 216663N
Level : 79.32 mAOD

Scale 1:25 **Sheet 1 of 1**
Logged By : CW
Checked By : PV
Start Date : 04/05/16
Finish Date : 04/05/16

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown sandy slightly gravelly CLAY with rootlets and grass covering (TOPSOIL).	▨	79.02	**0.30**		▨	0.25	ES1	
Orange brown slightly clayey gravelly SAND. Gravel is sub-rounded to subangular sandstone and mudstone. Some cobbles are present.	▤	78.12	**1.20**		▨	0.40-0.90 0.60	B1 ES2	
Orange brown sandy GRAVEL. Gravel is medium to coarse subrounded to subangular sandstone and mudstone. Some cobbles are also present.	▤	77.62	**1.70**		▨	1.30-1.60	B2	
Orange brown slightly gravelly SAND. Gravel is sub-rounded to subangular sandstone and mudstone. Few cobbles are present.	▤	75.02	**4.30**		▨	1.80-2.30 3.00-3.30 4.10-4.30	B3 B4 B5	
End of Trial Pit at 4.30 m bgl.								

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.95m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff, CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP28
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **212101E - 216675N**
Level : **88.07 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **03/05/16**
Finish Date : **03/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown sandy slightly gravelly CLAY with rootlets and grass covering (TOPSOIL).		87.77	**0.30**			0.25	ES1	
Orange brown slightly clayey gravelly SAND. Gravel is sub-rounded to subangular sandstone and mudstone. Some cobbles are present. Localised pockets of brown clay are present.		86.47	**1.60**			0.40-0.70 0.60	B1 ES2	
Orange brown slightly clayey sandy GRAVEL. Gravel is fine to coarse sub-rounded to subangular sandstone and mudstone. Some cobbles are present. Localised pockets of brown clay are present.		85.77	**2.30**			1.60-2.00	B2	
Light brown to grey gravelly CLAY. Gravel is fine to coarse sub-angular to angular weathered and fractured mudstone with some cobbles.		85.37	**2.70**			2.30-2.50	B3	
Grey medium to coarse angular mudstone GRAVEL.		84.87	**3.20**			2.70-3.00	B4	

End of Trial Pit at 3.20 m bgl.

Observations / Remarks

1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.85m
Width : 0.60m
Orientation : -
Shoring : None required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

WYG ENVIRONMENT
Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff, CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP29
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **211963E - 216654N**
Level : **93.57 mAOD**

Scale 1:25 **Sheet 1 of 1**

Logged By : **CW**
Checked By : **PV**
Start Date : **03/05/16**
Finish Date : **03/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test		Notes / Remarks
						Depth	Type	
Brown sandy slightly gravelly CLAY with rootlets and grass covering (TOPSOIL).	▨	93.32	**0.25**		▨			
Orange brown clayey slightly sandy GRAVEL. Gravel is fine to coarse angular to sub-angular mudstone.	▤	92.67	**0.90**		▨	0.30-0.80 0.30	B1 ES1	
Grey fine to coarse, angular, flat and friable mudstone gravel. Some mudstone cobbles are present.	▤	91.07	**2.50**		▨	1.00-1.50 1.90-2.30	B2 B3	
End of Trial Pit at 2.50 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 1.90m
Width : 0.60m
Orientation : -
Shoring : Not required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

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Ground Engineering Services
Longcross Court, 47 Newport Road, Cardiff, CF24 0AD.
Tel: 02920 829 200. Email: admin.cardiff@wyg.com

Exploratory Hole Number
TP30
Final

Project : **A40 Penblewin-Llandewi Velfrey GI**
Project Number : **A096409**
Client : **Welsh Government**
Method : **JCB 3CX**
Co-ordinates : **212007E - 216710N**
Level : **93.17 mAOD**

Scale 1:25 **Sheet 1 of 1**
Logged By : **CW**
Checked By : **PV**
Start Date : **03/05/16**
Finish Date : **03/05/16**

Strata Description	Legend	Reduced Level (mOD)	Depth (m)	Water Strike (m)	Installation/ Backfill	Sample Test Depth	Sample Test Type	Notes / Remarks
Brown sandy slightly gravelly CLAY with rootlets and grass covering (TOPSOIL).		92.87	**0.30**					
Orange brown clayey gravelly SAND. Gravel is fine to medium angular to subangular mudstone.		91.57	**1.60**			0.40-0.70 0.40 1.00-1.30	B1 ES1 B2	
Firm to stiff orange brown mottled grey slightly sandy slightly gravelly CLAY. Gravel is fine coarse sub-rounded to sub-angular mudstone and sandstone.		91.07	**2.10**			1.60-1.80	B3	
Grey fine to coarse, angular, flat and friable mudstone GRAVEL. Some mudstone cobbles are present.		90.27	**2.90**			2.20-2.60	B4	
End of Trial Pit at 2.90 m bgl.								

Observations / Remarks
1. No groundwater was encountered during excavation.
2. No visual or olfactory evidence of contamination encountered.
3. Upon completion trial pit backfilled with arsisings.

Excavation Information

Length : 2.00m
Width : 0.60m
Orientation : -
Shoring : Not required
Stability : Stable

Groundwater

Struck	Rising to	Time (mins)	Remarks

Plate 1 TP01

Plate 2 TP01

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5th Floor, Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
Environmental Consultancy
Ground Technologies & Investigation

Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 3 TP02

Plate 4 TP02

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5th Floor, Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 5 TP03

Plate 6 TP03

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47 Newport Road
Cardiff
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Tel: 029 20 829200
Fax: 029 20 455321
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Project :-
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 7 TP04

Plate 8 TP04

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47 Newport Road
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Tel: 029 20 829200
Fax: 029 20 455321
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Ground Technologies & Investigation

Project :-
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Client: Welsh Government

Project No.: A096409	Date : 10.06.2016

Plate 9 TP05

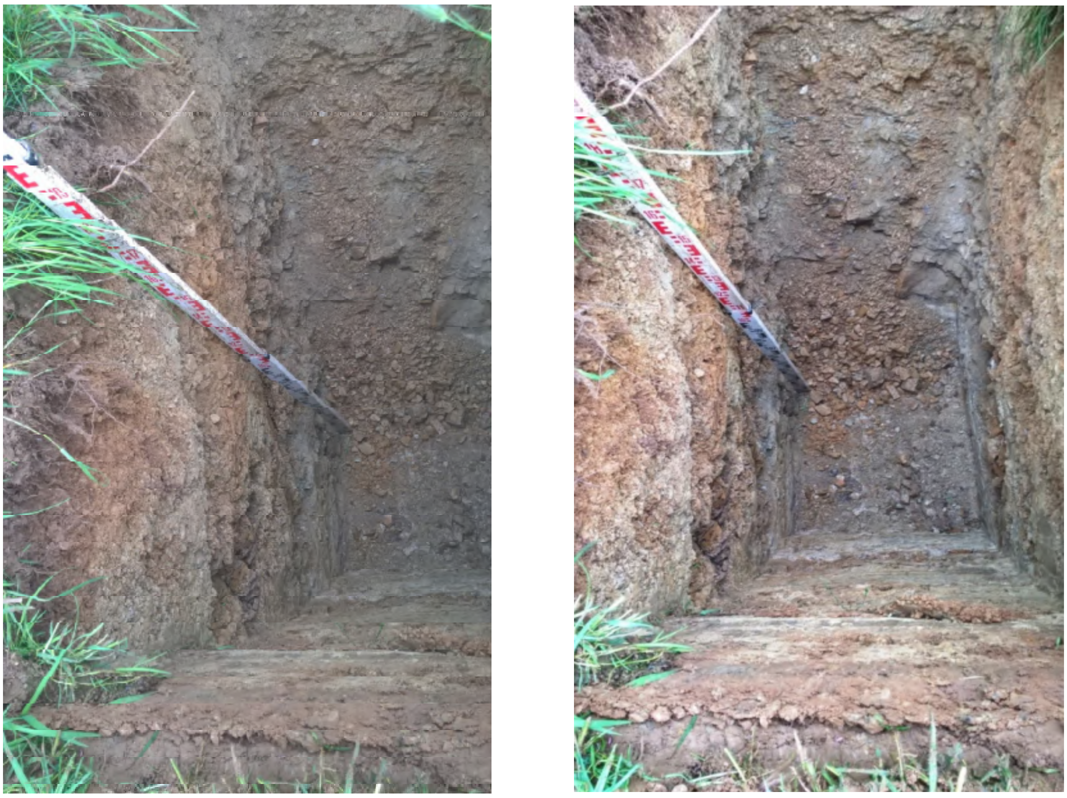

Plate 10 TP05

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Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 11 TP17

Plate 12 TP17

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47 Newport Road
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Client: Welsh Government

Project No.: A096409

Date : 10.06.2016

Plate 13 TP18

Plate 14 TP18

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Project No.: A096409	Date : 10.06.2016

Plate 15 TP19

Plate 16 TP19

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Plate 17 TP20

Plate 18 TP20

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47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
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Plate 19 TP21

Plate 20 TP21

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47 Newport Road
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CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Client: Welsh Government

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Plate 21 TP22

Plate 22 TP22

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47 Newport Road
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Fax: 029 20 455321
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Plate 23 TP23

Plate 24 TP23

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47 Newport Road
Cardiff
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Fax: 029 20 455321
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Project No.: A096409	Date : 10.06.2016

WYG - ENVIRONMENT
Client: WAG
Project: A40 LLANDEWI VELFREY
Position No: TP24
Depth: 4.1m
Date: 05/05/16

Plate 25 TP24

Plate 26 TP24

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Fax: 029 20 455321
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A40 Landewi Velfrey - Penblewin

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Project No.: A096409

Date : 10.06.2016

Plate 27 TP25

Plate 28 TP25

Plate 29 TP26

Plate 30 TP26

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Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Plate 31 TP27

Plate 32 TP27

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Fax: 029 20 455321
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Plate 33 TP28

Plate 34 TP28

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Fax: 029 20 455321
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Date : 10.06.2016

Plate 35 TP29

Plate 36 TP29

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47 Newport Road
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Fax: 029 20 455321
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Plate 37 TP30

Plate 38 TP30

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47 Newport Road
Cardiff
CF24 0AD

Tel: 029 20 829200
Fax: 029 20 455321
E-mail enviro.cardiff@wyg.com
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Ground Technologies & Investigation

Project :-
A40 Landewi Velfrey - Penblewin

Client: Welsh Government

Project No.: A096409

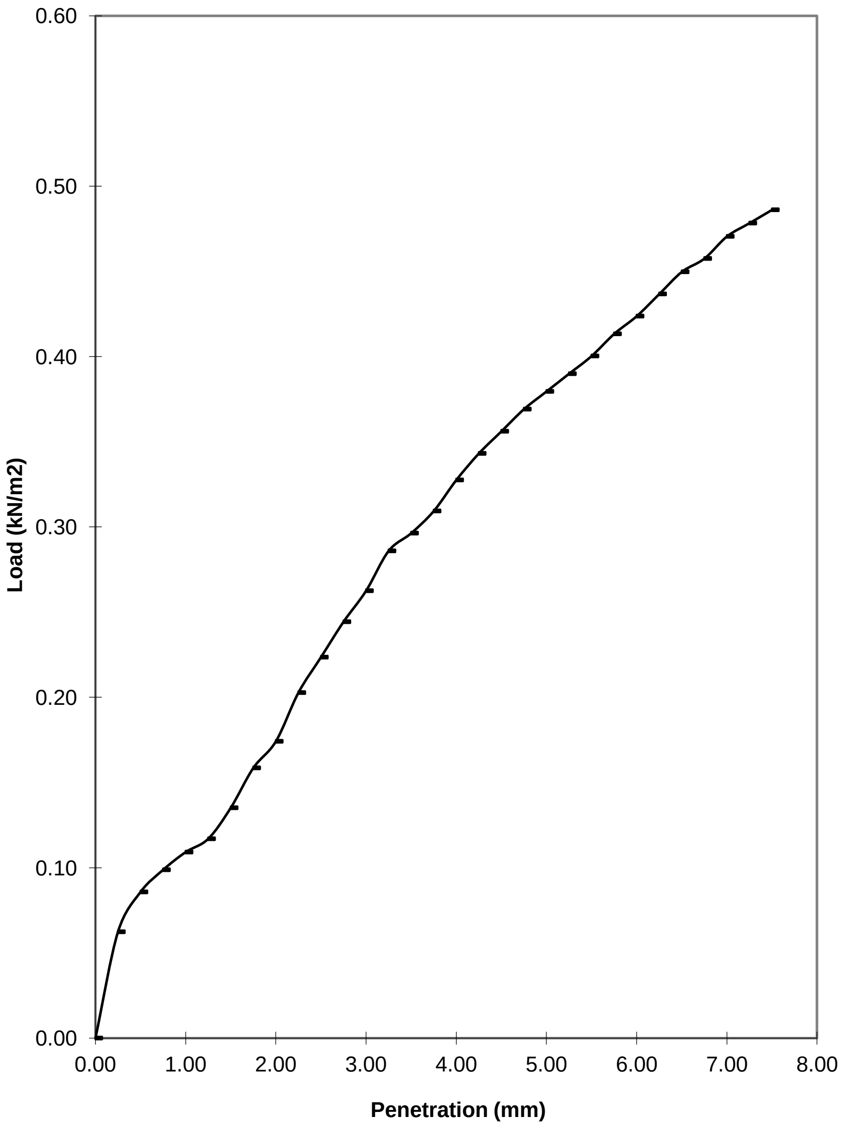
Date : 10.06.2016

Appendix C – In Situ CBR Testing Results

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	24	0.06
0.50	33	0.09
0.75	38	0.10
1.00	42	0.11
1.25	45	0.12
1.50	52	0.14
1.75	61	0.16
2.00	67	0.17
2.25	78	0.20
2.50	86	0.22
2.75	94	0.24
3.00	101	0.26
3.25	110	0.29
3.50	114	0.30
3.75	119	0.31
4.00	126	0.33
4.25	132	0.34
4.50	137	0.36
4.75	142	0.37
5.00	146	0.38
5.25	150	0.39
5.50	154	0.40
5.75	159	0.41
6.00	163	0.42
6.25	168	0.44
6.50	173	0.45
6.75	176	0.46
7.00	181	0.47
7.25	184	0.48
7.50	187	0.49

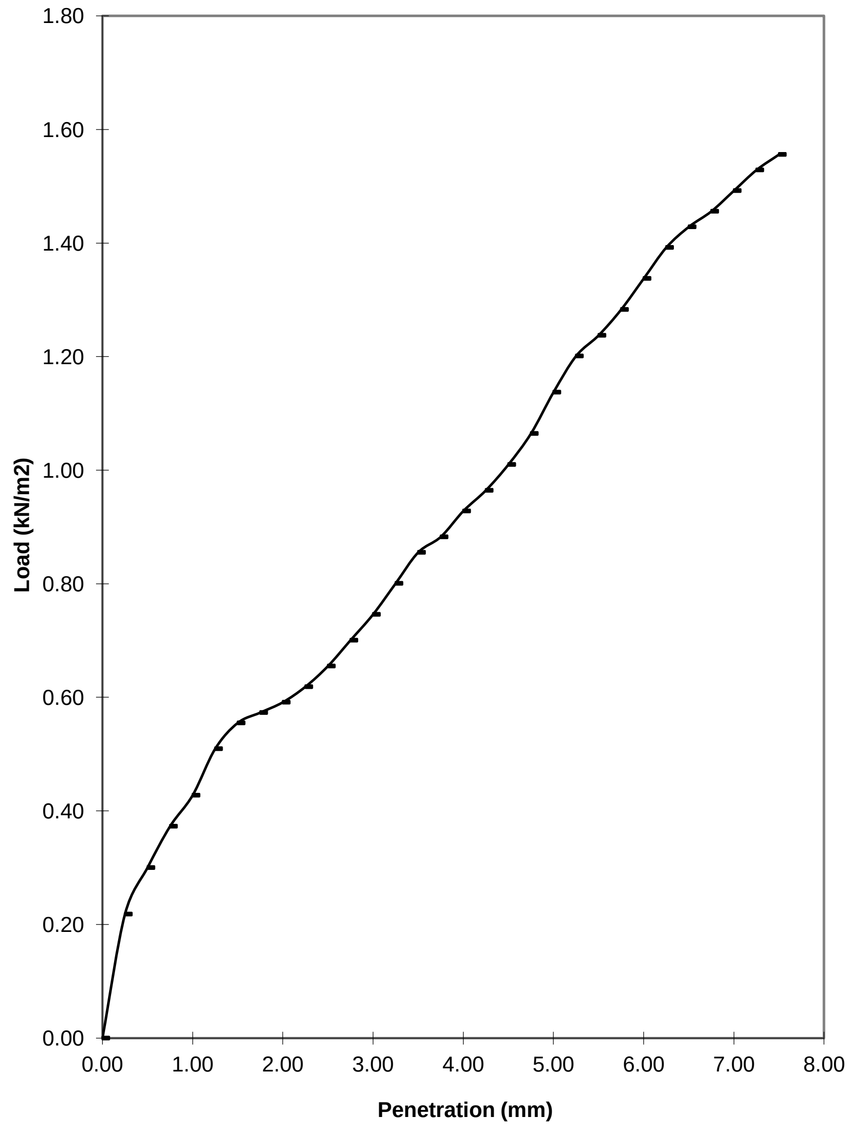


Test Depth: 0.50m.	Soil Description: Firm light brown sandy gravelly CLAY	CBR at 2.50mm 1.69 %
Mass of Split Rings: 5kg		CBR at 5.00mm 1.90 %
PR Factor: 2.6 N/Div		**CBR Value: 1.9** %
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 35.7%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 1		
CONTRACT: Llanddewi Velrfey		SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	24	0.22
0.50	33	0.30
0.75	41	0.37
1.00	47	0.43
1.25	56	0.51
1.50	61	0.56
1.75	63	0.57
2.00	65	0.59
2.25	68	0.62
2.50	72	0.66
2.75	77	0.70
3.00	82	0.75
3.25	88	0.80
3.50	94	0.86
3.75	97	0.88
4.00	102	0.93
4.25	106	0.96
4.50	111	1.01
4.75	117	1.06
5.00	125	1.14
5.25	132	1.20
5.50	136	1.24
5.75	141	1.28
6.00	147	1.34
6.25	153	1.39
6.50	157	1.43
6.75	160	1.46
7.00	164	1.49
7.25	168	1.53
7.50	171	1.56



Test Depth: 0.60m.	Soil Description: Light brown very clayey sandy fine to coarse GRAVEL	CBR at 2.50mm 4.95 %
Mass of Split Rings: 5kg		CBR at 5.00mm 5.70 %
PR Factor: 9.1 N/Div		**CBR Value: 5.7 %**
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 11.43%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 2		

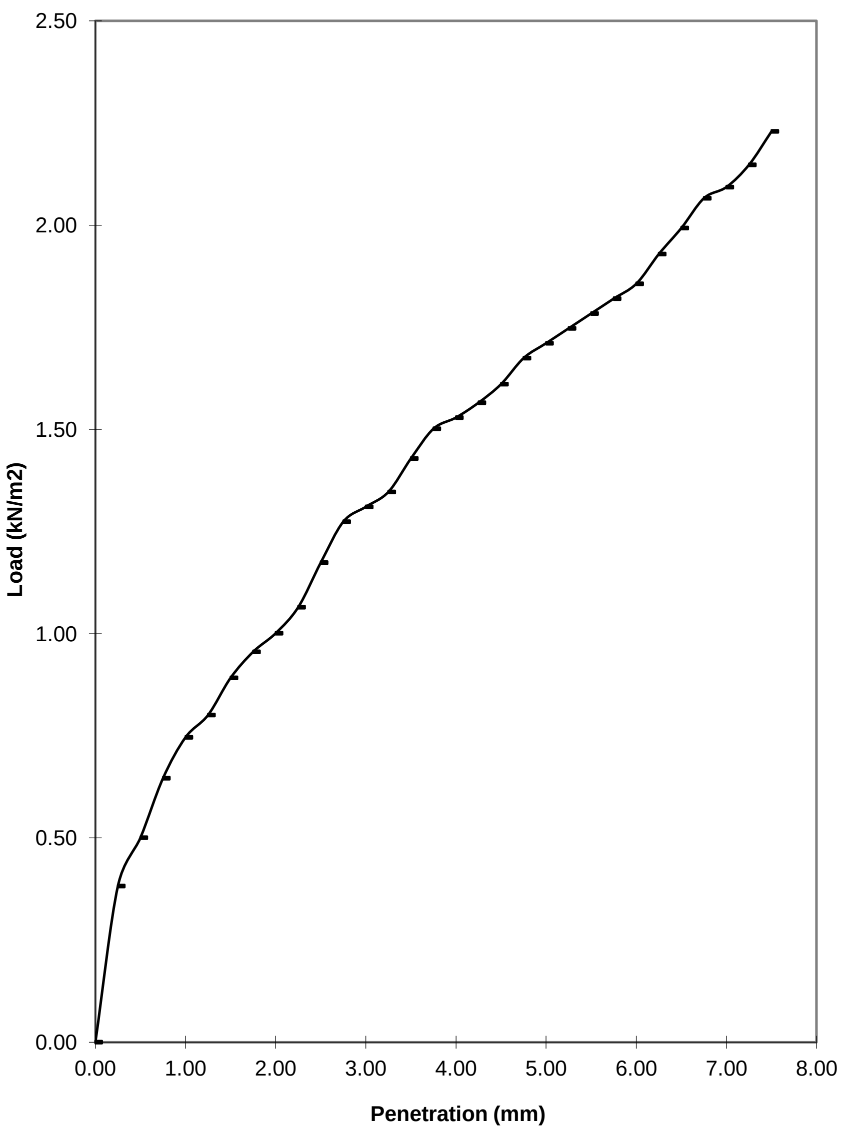
CONTRACT:
Llanddewi Velrfey

SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	42	0.38
0.50	55	0.50
0.75	71	0.65
1.00	82	0.75
1.25	88	0.80
1.50	98	0.89
1.75	105	0.96
2.00	110	1.00
2.25	117	1.06
2.50	129	1.17
2.75	140	1.27
3.00	144	1.31
3.25	148	1.35
3.50	157	1.43
3.75	165	1.50
4.00	168	1.53
4.25	172	1.57
4.50	177	1.61
4.75	184	1.67
5.00	188	1.71
5.25	192	1.75
5.50	196	1.78
5.75	200	1.82
6.00	204	1.86
6.25	212	1.93
6.50	219	1.99
6.75	227	2.07
7.00	230	2.09
7.25	236	2.15
7.50	245	2.23

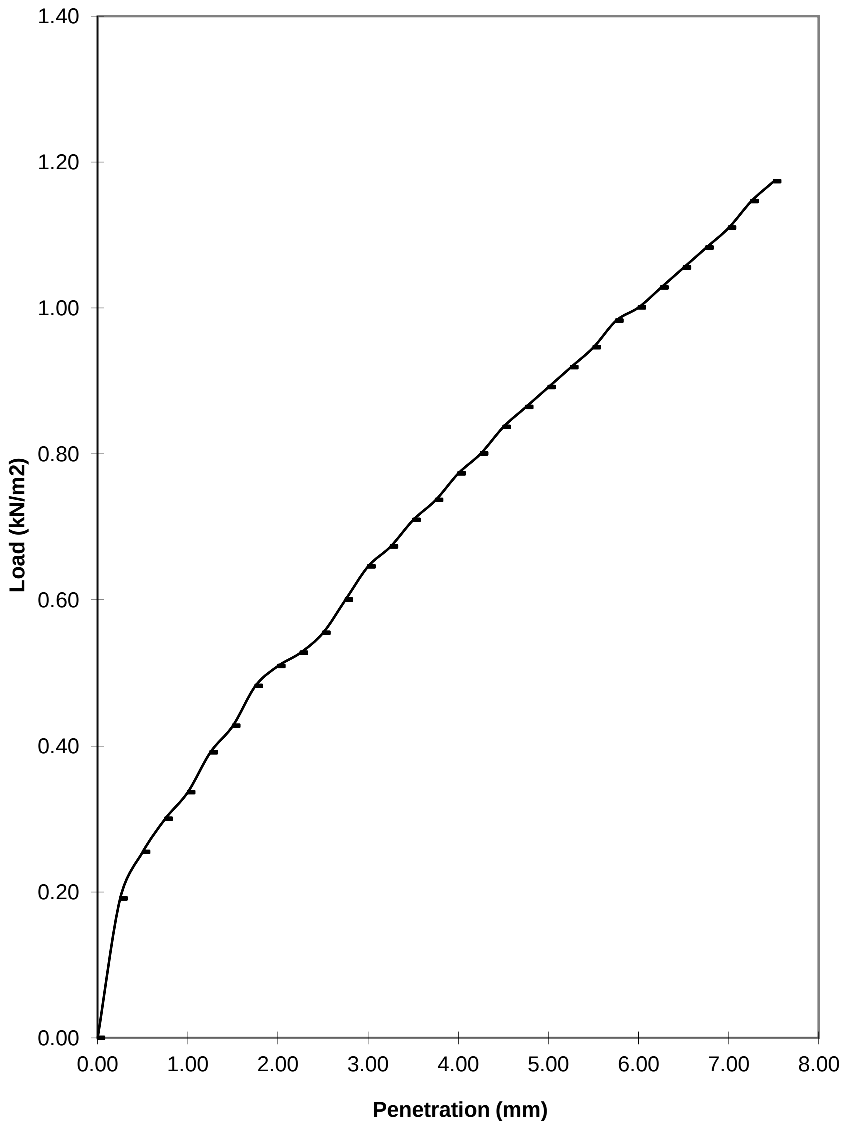


Test Depth: 0.65m.	Soil Description: Light brown slightly clayey sandy fine to coarse GRAVEL	CBR at 2.50mm 8.87 %
Mass of Split Rings: 5kg		CBR at 5.00mm 8.57 %
PR Factor: 9.1 N/Div		**CBR Value: 8.9** %
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 16.61%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 3		
CONTRACT: Llanddewi Velrfey		

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	21	0.19
0.50	28	0.25
0.75	33	0.30
1.00	37	0.34
1.25	43	0.39
1.50	47	0.43
1.75	53	0.48
2.00	56	0.51
2.25	58	0.53
2.50	61	0.56
2.75	66	0.60
3.00	71	0.65
3.25	74	0.67
3.50	78	0.71
3.75	81	0.74
4.00	85	0.77
4.25	88	0.80
4.50	92	0.84
4.75	95	0.86
5.00	98	0.89
5.25	101	0.92
5.50	104	0.95
5.75	108	0.98
6.00	110	1.00
6.25	113	1.03
6.50	116	1.06
6.75	119	1.08
7.00	122	1.11
7.25	126	1.15
7.50	129	1.17

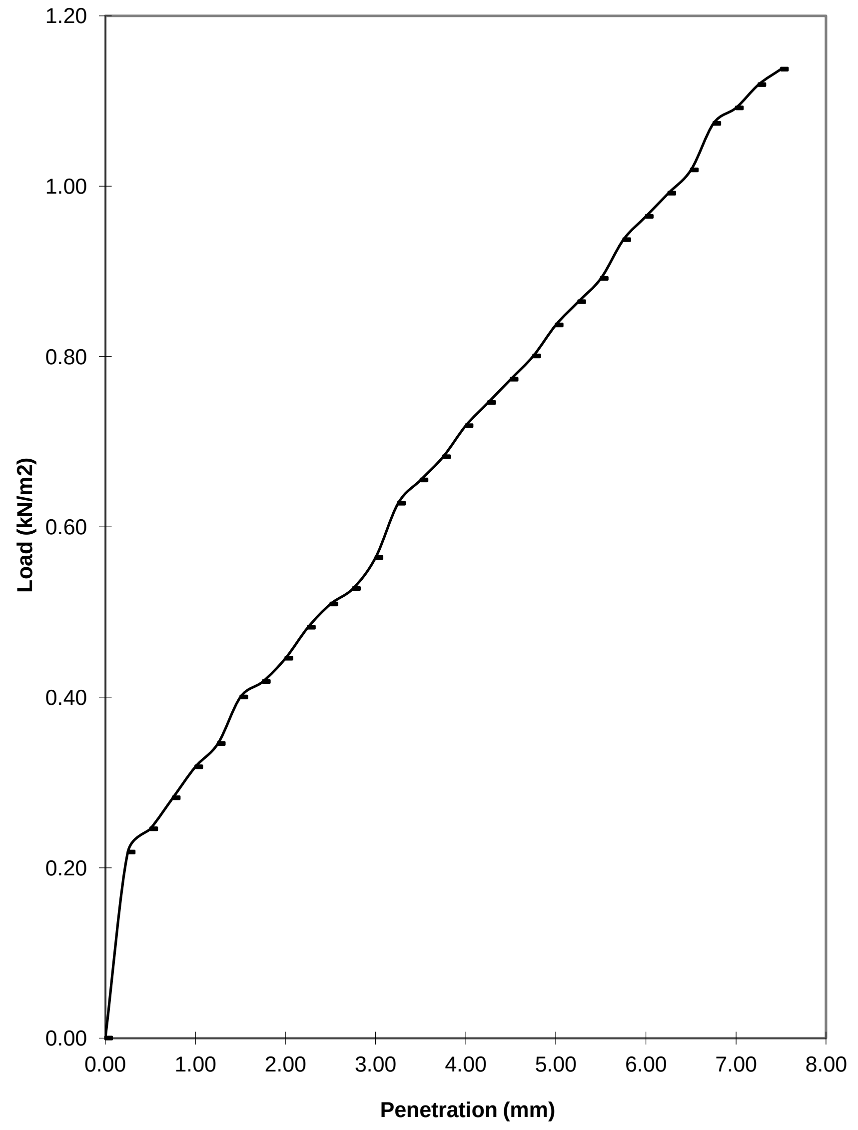


Test Depth: 0.65m.	Soil Description: Light brown very clayey sandy fine to coarse GRAVEL	CBR at 2.50mm 4.19 %
Mass of Split Rings: 5kg		CBR at 5.00mm 4.47 %
PR Factor: 9.1 N/Div		**CBR Value: 4.5 %**
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 17.79%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 4		
CONTRACT: Llanddewi Velrfey		SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	24	0.22
0.50	27	0.25
0.75	31	0.28
1.00	35	0.32
1.25	38	0.35
1.50	44	0.40
1.75	46	0.42
2.00	49	0.45
2.25	53	0.48
2.50	56	0.51
2.75	58	0.53
3.00	62	0.56
3.25	69	0.63
3.50	72	0.66
3.75	75	0.68
4.00	79	0.72
4.25	82	0.75
4.50	85	0.77
4.75	88	0.80
5.00	92	0.84
5.25	95	0.86
5.50	98	0.89
5.75	103	0.94
6.00	106	0.96
6.25	109	0.99
6.50	112	1.02
6.75	118	1.07
7.00	120	1.09
7.25	123	1.12
7.50	125	1.14

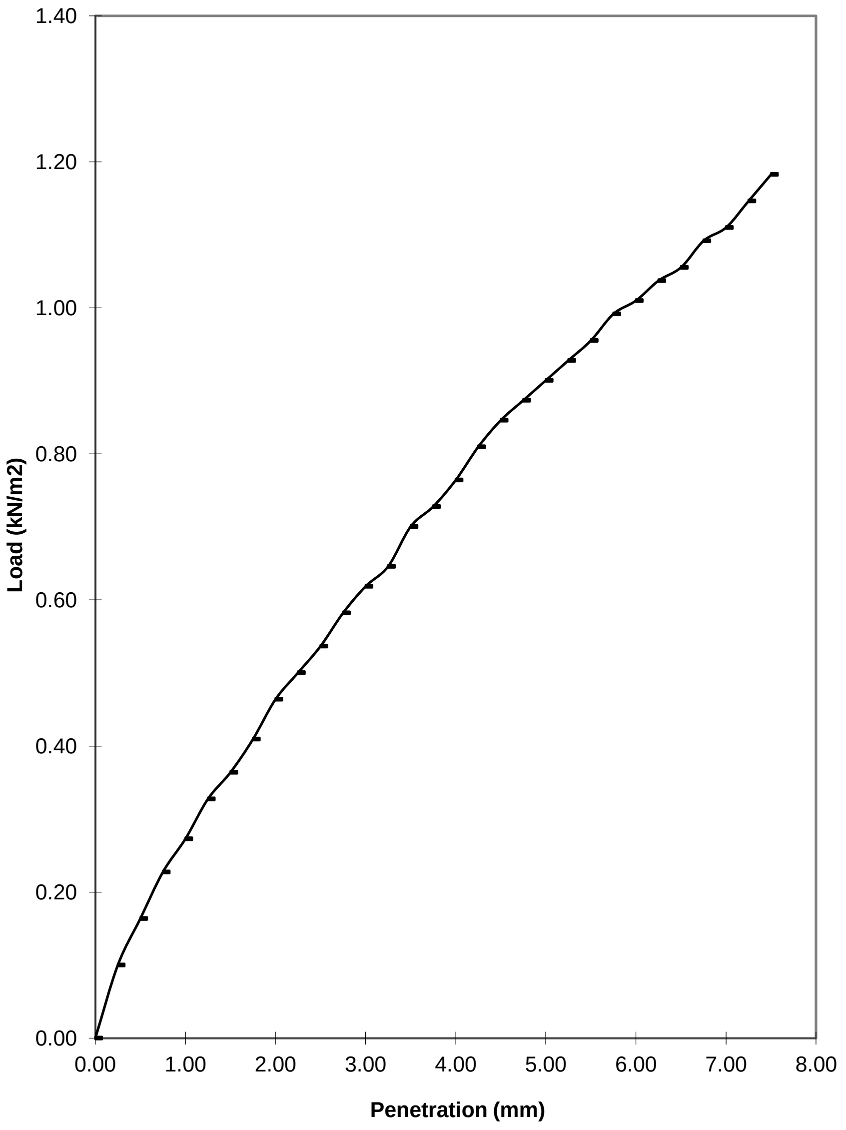


Test Depth: 0.80m.	Soil Description: Firm light brown sandy gravelly CLAY	CBR at 2.50mm 3.85 %
Mass of Split Rings: 5kg		CBR at 5.00mm 4.19 %
PR Factor: 9.1 N/Div		**CBR Value: 4.2** %
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 22.22%	Checked By: D.M.
DATE: 10.05.16	Remarks:	SOUTHERN GROUND TESTING
TEST REFERENCE: CBR 5		
CONTRACT: Llanddewi Velrfey		

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	11	0.10
0.50	18	0.16
0.75	25	0.23
1.00	30	0.27
1.25	36	0.33
1.50	40	0.36
1.75	45	0.41
2.00	51	0.46
2.25	55	0.50
2.50	59	0.54
2.75	64	0.58
3.00	68	0.62
3.25	71	0.65
3.50	77	0.70
3.75	80	0.73
4.00	84	0.76
4.25	89	0.81
4.50	93	0.85
4.75	96	0.87
5.00	99	0.90
5.25	102	0.93
5.50	105	0.96
5.75	109	0.99
6.00	111	1.01
6.25	114	1.04
6.50	116	1.06
6.75	120	1.09
7.00	122	1.11
7.25	126	1.15
7.50	130	1.18



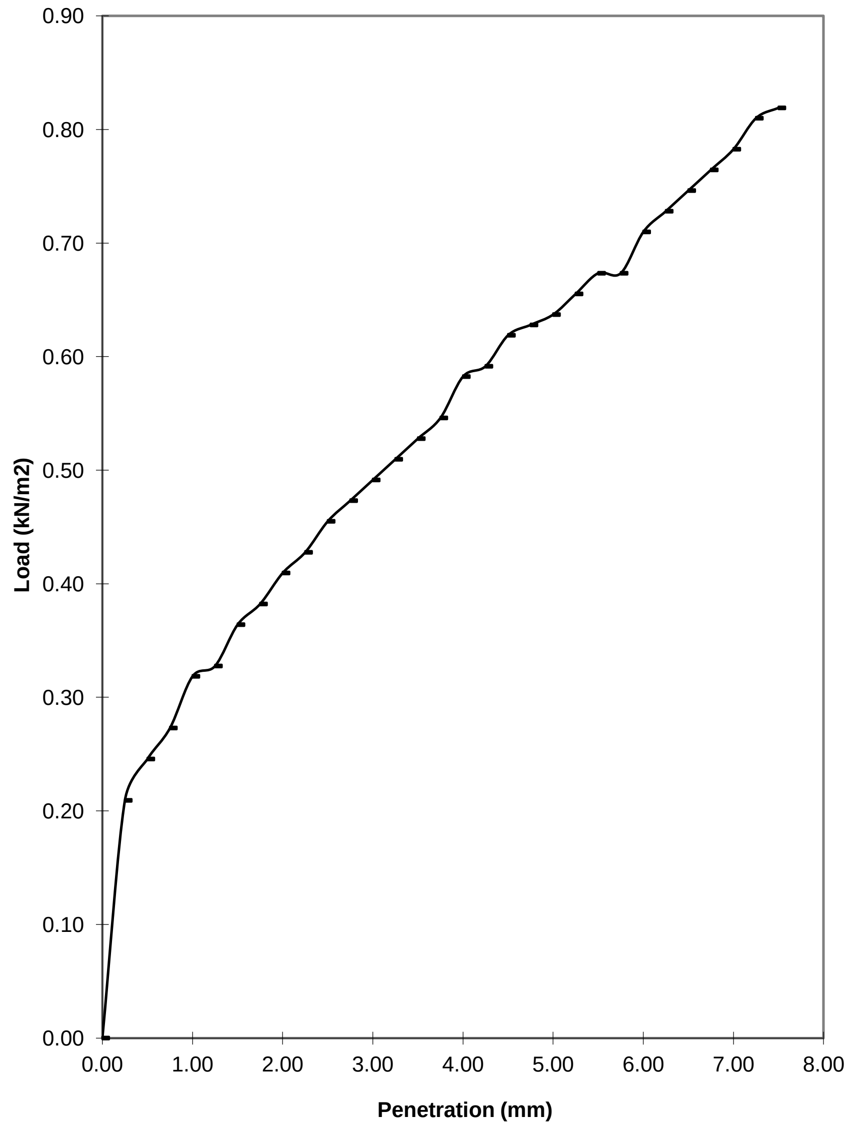
Test Depth: 0.60m.	Soil Description: Firm light brown slightly sandy slightly gravelly CLAY	CBR at 2.50mm 4.06 %
Mass of Split Rings: 5kg		CBR at 5.00mm 4.51 %
PR Factor: 9.1 N/Div		**CBR Value: 4.5** %
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 19.53%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 6		
CONTRACT: Llanddewi Velrfey		

SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	23	0.21
0.50	27	0.25
0.75	30	0.27
1.00	35	0.32
1.25	36	0.33
1.50	40	0.36
1.75	42	0.38
2.00	45	0.41
2.25	47	0.43
2.50	50	0.46
2.75	52	0.47
3.00	54	0.49
3.25	56	0.51
3.50	58	0.53
3.75	60	0.55
4.00	64	0.58
4.25	65	0.59
4.50	68	0.62
4.75	69	0.63
5.00	70	0.64
5.25	72	0.66
5.50	74	0.67
5.75	74	0.67
6.00	78	0.71
6.25	80	0.73
6.50	82	0.75
6.75	84	0.76
7.00	86	0.78
7.25	89	0.81
7.50	90	0.82



Test Depth: 0.70m.

Mass of Split Rings: 5kg

PR Factor: 9.1 N/Div

Soil Description:
Firm light brown slightly sandy slighlty gravelly CLAY

CBR at 2.50mm 3.44 %

CBR at 5.00mm 3.19 %

CBR Value: 3.4 %

Carried out in accordance
with BS1377: Part 9: 1990, Test 4.3

Moisture Ciontent: 14.72%

Checked By: D.M.

DATE: 10.05.16

TEST REFERENCE: CBR 7

Remarks:

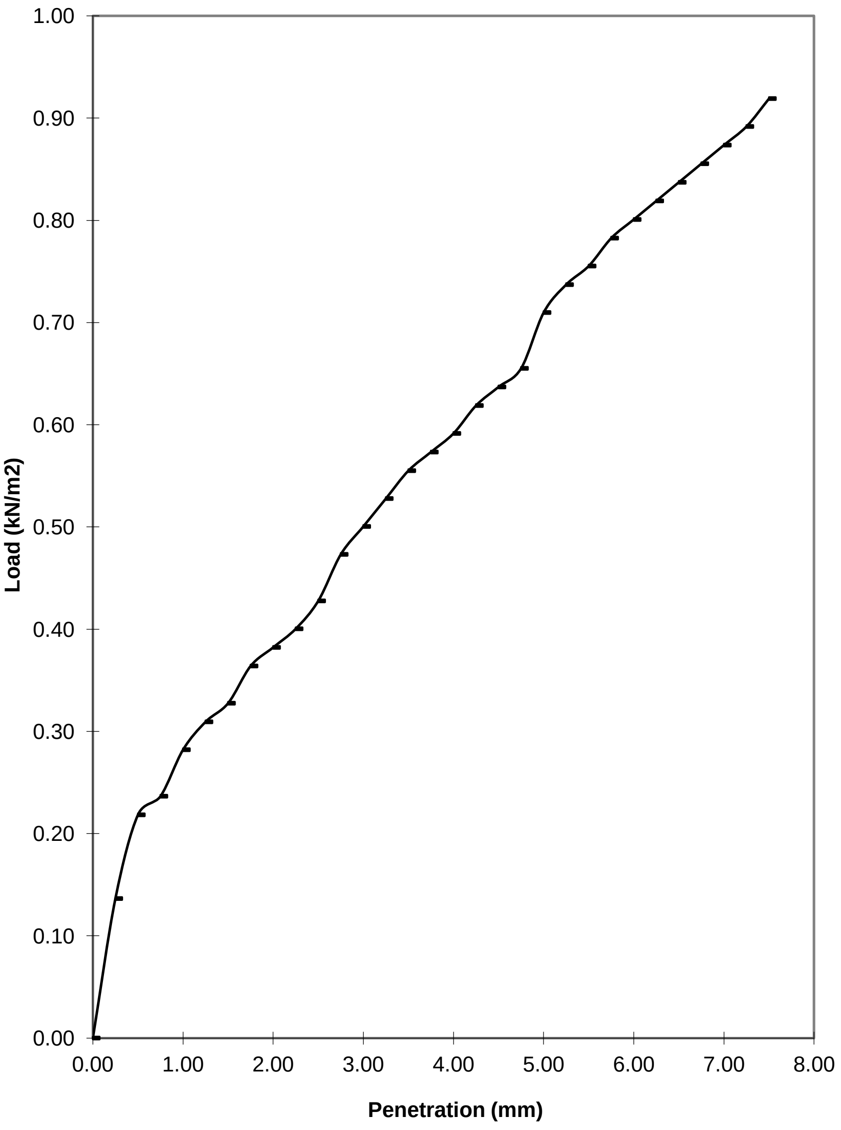
CONTRACT:
Llanddewi Velrfey

SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	15	0.14
0.50	24	0.22
0.75	26	0.24
1.00	31	0.28
1.25	34	0.31
1.50	36	0.33
1.75	40	0.36
2.00	42	0.38
2.25	44	0.40
2.50	47	0.43
2.75	52	0.47
3.00	55	0.50
3.25	58	0.53
3.50	61	0.56
3.75	63	0.57
4.00	65	0.59
4.25	68	0.62
4.50	70	0.64
4.75	72	0.66
5.00	78	0.71
5.25	81	0.74
5.50	83	0.76
5.75	86	0.78
6.00	88	0.80
6.25	90	0.82
6.50	92	0.84
6.75	94	0.86
7.00	96	0.87
7.25	98	0.89
7.50	101	0.92

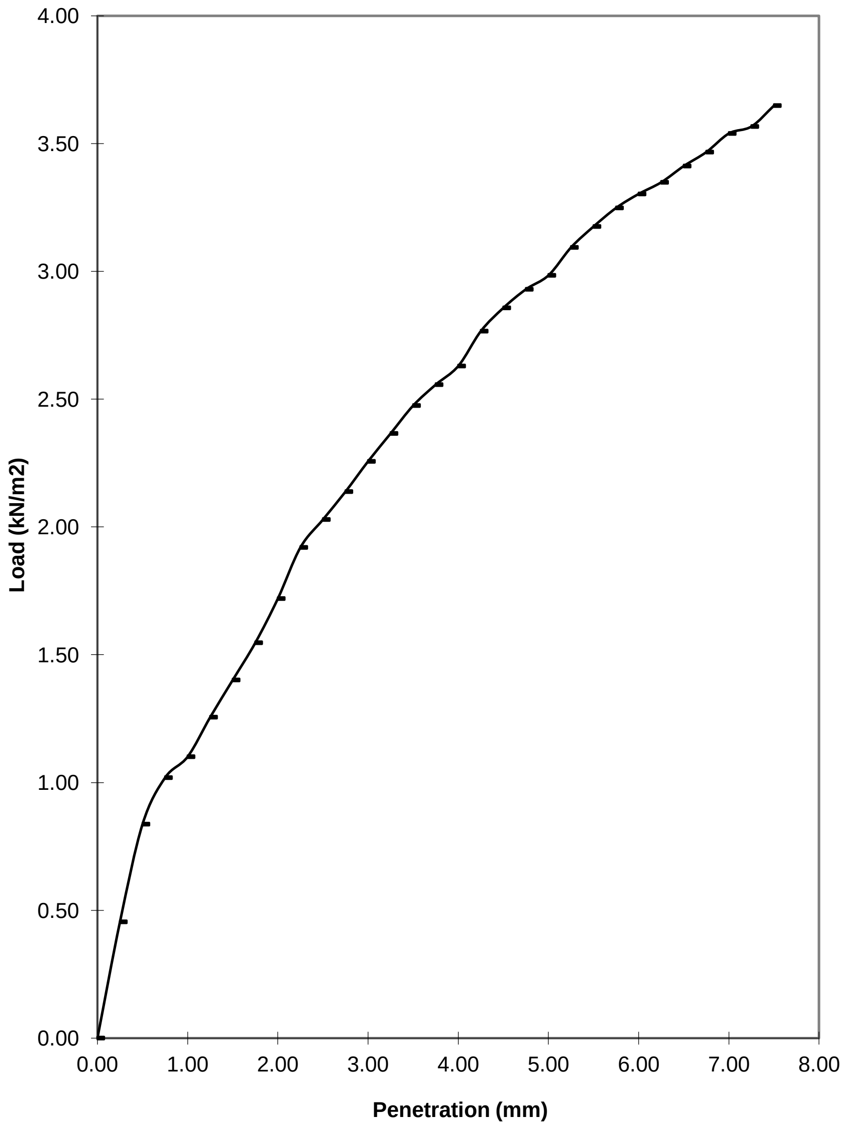


Test Depth: 0.60m.	Soil Description: Firm light brown slightly sandy slighlty gravelly CLAY	CBR at 2.50mm 3.23 %
Mass of Split Rings: 10kg		CBR at 5.00mm 3.56 %
PR Factor: 9.1 N/Div		**CBR Value: 3.6 %**
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 14.65%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 8		
CONTRACT: Llanddewi Velrfey		SOUTHERN GROUND TESTING

SOUTHERN GROUND TESTING

IN SITU CBR TEST

PENETRATION (mm)	PR READING (divs)	LOAD (KN)
0.00	0	0.00
0.25	50	0.46
0.50	92	0.84
0.75	112	1.02
1.00	121	1.10
1.25	138	1.26
1.50	154	1.40
1.75	170	1.55
2.00	189	1.72
2.25	211	1.92
2.50	223	2.03
2.75	235	2.14
3.00	248	2.26
3.25	260	2.37
3.50	272	2.48
3.75	281	2.56
4.00	289	2.63
4.25	304	2.77
4.50	314	2.86
4.75	322	2.93
5.00	328	2.98
5.25	340	3.09
5.50	349	3.18
5.75	357	3.25
6.00	363	3.30
6.25	368	3.35
6.50	375	3.41
6.75	381	3.47
7.00	389	3.54
7.25	392	3.57
7.50	401	3.65



Test Depth: 0.90m	Soil Description: Red brown highly weathered SHALE	CBR at 2.50mm 15.33 %
Mass of Split Rings: 10kg		CBR at 5.00mm 14.95 %
PR Factor: 9.1 N/Div		**CBR Value: 15.3 %**
Carried out in accordance with BS1377: Part 9: 1990, Test 4.3	Moisture Content: 21.30%	Checked By: D.M.
DATE: 10.05.16	Remarks:	
TEST REFERENCE: CBR 11		
CONTRACT: Llanddewi Velrfey		SOUTHERN GROUND TESTING

Appendix D – Geotechnical Laboratory Testing Results

Test Report: **Method of the Determination of the plastic limit and plasticity index**
BS 1377 : Part 2 : 1990 Method 5

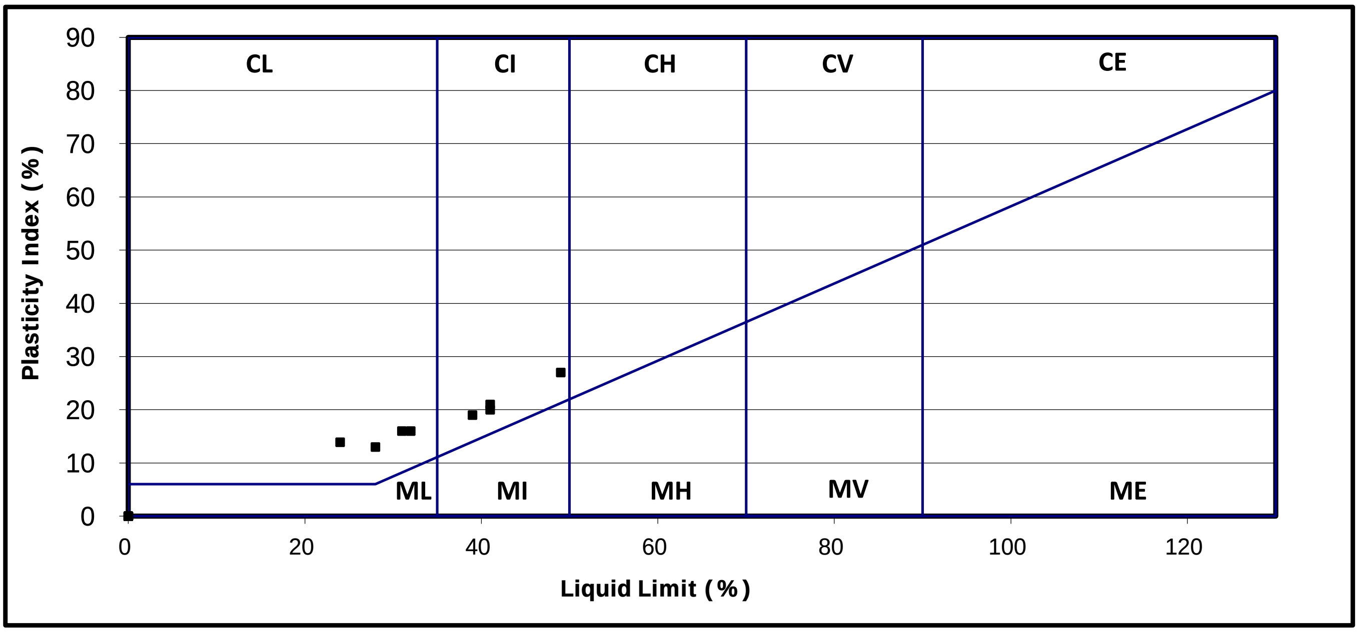
Client ref: **A096409**
Location: **A40, Llanddewi**
Contract Number: **30894-200516**

Hole / Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3 / 4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
BH7	B	3.30 - 4.46	2.5		NP		2	
BH8	B	1.70 - 2.70	7.3	24	10	14	80	CL Low Plasticity
BH9	B	1.20 - 1.80	18	41	20	21	90	CI Intermediate Plasticity
BH10	B	1.20 - 2.20	21	49	22	27	93	CI Intermediate Plasticity
BH10	B	2.90 - 3.90	15	39	20	19	91	CI Intermediate Plasticity
BH11	B	1.20 - 2.20	8.4	32	16	16	70	CL Low Plasticity
BH16	B	5.50 - 7.00	10	28	15	13	90	CL Low Plasticity
BH17	B	5.20 - 6.70	9.3	31	15	16	90	CL Low Plasticity
BH102	B	0.00 - 2.20	20	41	21	20	85	CI Intermediate Plasticity

Symbols: **NP : Non Plastic** **# : Liquid Limit and Plastic Limit Wet Sieved**

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

BS 5930:1999+A2:2010



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)
Date: 10.6.16

UKAS TESTING 2788

Test Report: **Method of the Determination of the plastic limit and plasticity index**
BS 1377 : Part 2 : 1990 Method 5

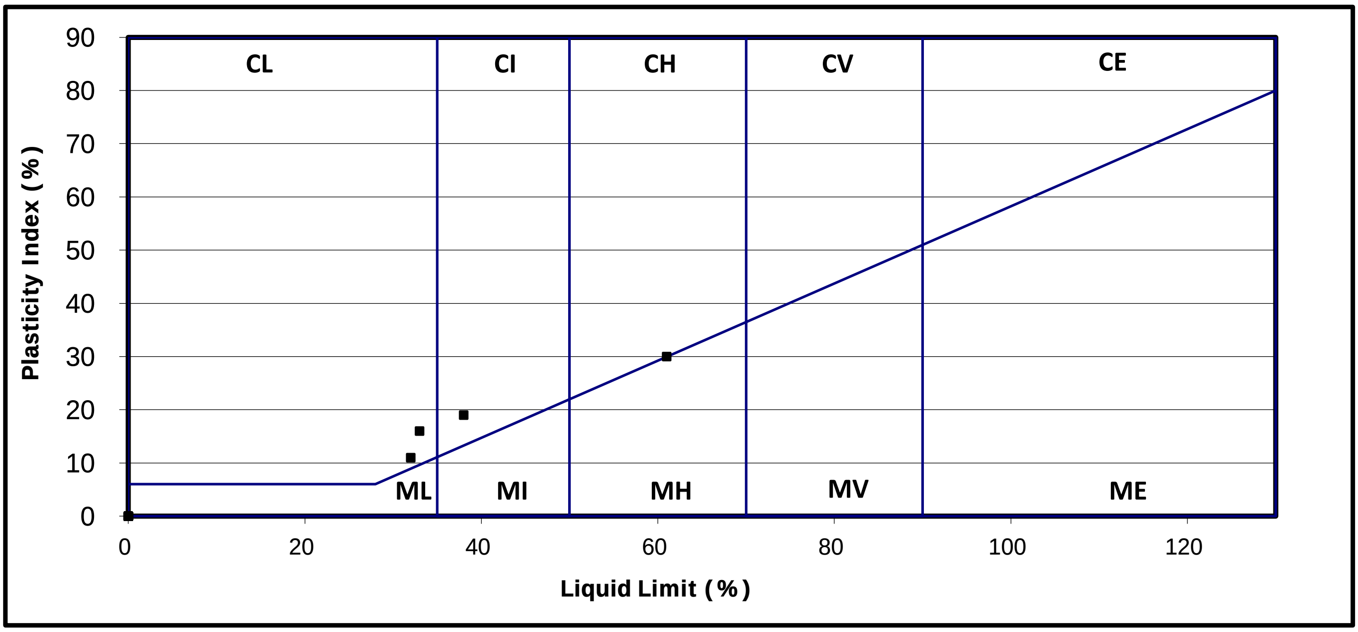
Client ref: **A096409**
Location: **A40, Llanddewi**
Contract Number: **30894-200516**

Hole / Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3/4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
TP17/1	B	0.30 - 0.60	14	32	21	11	94	CL Low Plasticity
TP17/2	B	0.80 - 1.10	9.0	61	31	30	100	CH High Plasticity
TP17/3	B	1.70 - 2.00	15					
TP18/2	B	1.20 - 1.50	13					
TP18/3	B	2.10 - 2.40	16	38	19	19	90	CI Intermediate Plasticity
TP18/4	B	3.10 - 3.40	19	33	17	16	91	CL Low Plasticity

Symbols: **NP : Non Plastic** **# : Liquid Limit and Plastic Limit Wet Sieved**

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

BS 5930:1999+A2:2010



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)
Date: 10.6.16

2788

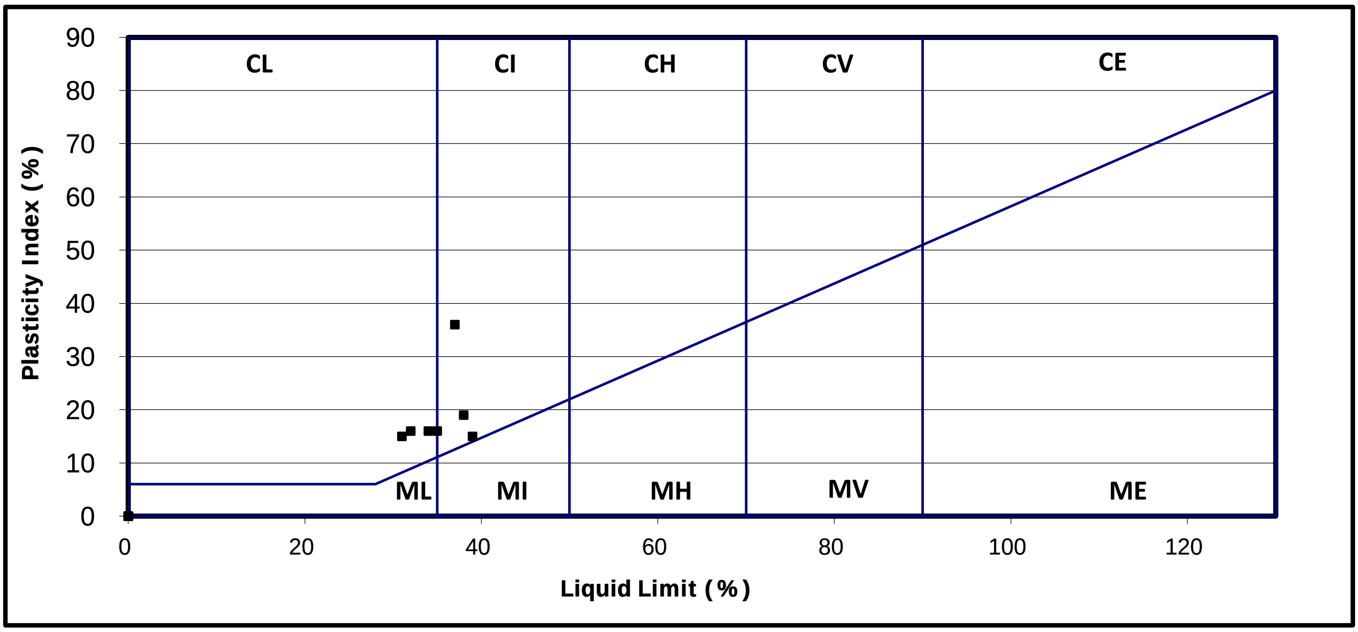
Test Report: **Method of the Determination of the plastic limit and plasticity index**
BS 1377 : Part 2 : 1990 Method 5

Client ref: **A096409**
Location: **A40, Llanddewi**
Contract Number: **30894-200516**

Hole / Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3 / 4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
TP24 / 1	B	0.60 - 1.00	15	31	16	15	90	CL Low Plasticity
TP24 / 3	B	2.50 - 2.80	17	35	19	16	90	CL / I Low / Inter. Plasticity
TP24 / 4	B	3.40 - 3.90	16	32	16	16	90	CL Low Plasticity
TP25 / 2	B	1.9 - 2.30	21	39	24	15	85	CI Intermediate Plasticity
TP26 / 2	B	1.50 - 1.90	17	34	18	16	91	CL Low Plasticity
TP27 / 2	B	1.30 - 1.60	10					
TP28 / 2	B	1.60 - 2.00	15					
TP28 / 3	B	2.30 - 2.50	23	38	19	19	91	CI Intermediate Plasticity
TP29 / 3	B	1.00 - 1.50	9.5					
TP30 / 2	B	1.00 - 1.30	19					
TP30 / 3	B	1.60 - 1.80	17	37	1.0	36	90	CI Intermediate Plasticity

Symbols: **NP : Non Plastic** **# : Liquid Limit and Plastic Limit Wet Sieved**

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.
BS 5930:1999+A2:2010



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)
Date: 10.6.16

UKAS TESTING 2788

Test Report: **Method of the Determination of the plastic limit and plasticity index**
BS 1377 : Part 2 : 1990 Method 5

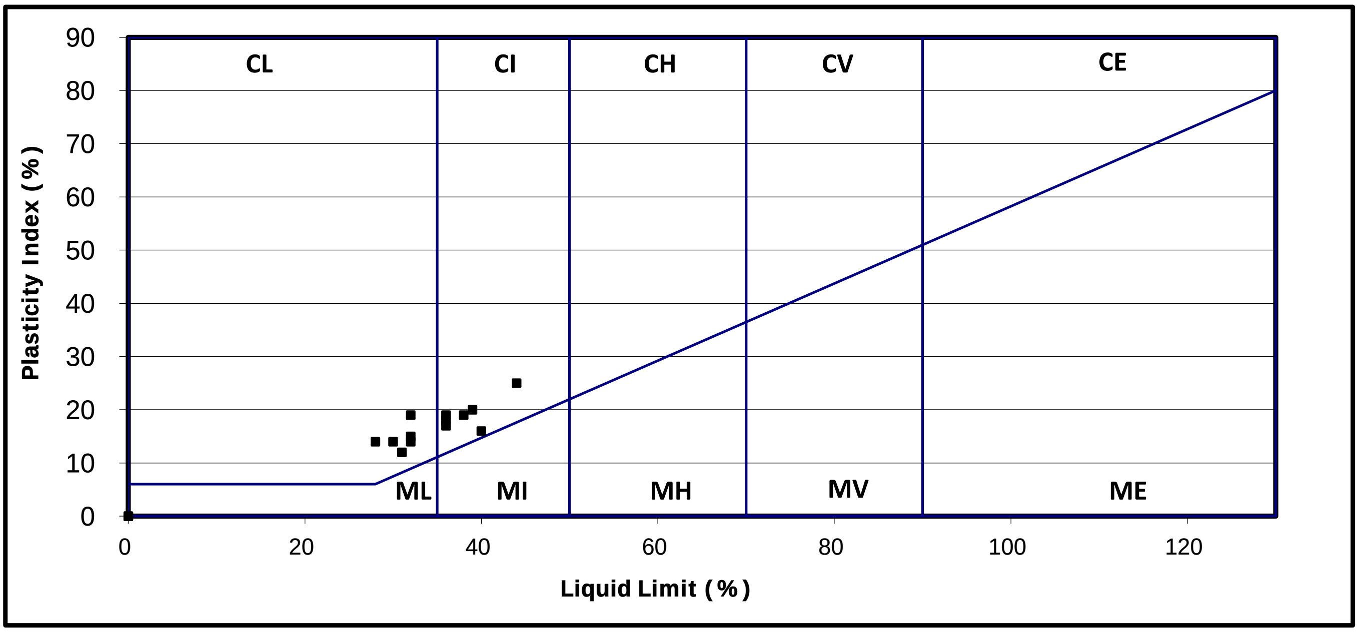
Client ref: **A096409**
Location: **A40, Llanddewi**
Contract Number: **30894-200516**

Hole / Sample Number	Sample Type	Depth m	Moisture Content % Cl. 3.2	Liquid Limit % Cl. 4.3/4.4	Plastic Limit % Cl. 5.	Plasticity Index % Cl. 6.	% Passing .425mm	Remarks
TP4/2	B	0.80 - 1.20	7.3					
TP5/1	B	0.30 - 0.50	12					
TP19/2	B	1.70 - 2.10	18	32	17	15	85	CL Low Plasticity
TP20/1	B	0.50 - 1.00	21	28	14	14	90	CL Low Plasticity
TP20/2	B	1.60 - 2.00	18	36	19	17	90	CI Intermediate Plasticity
TP20/3	B	2.90 - 3.30	16	32	13	19	85	CL Low Plasticity
TP20/4	B	3.60 - 4.00	21	44	19	25	91	CI Intermediate Plasticity
TP21/1	B	0.60 - 1.10	16	32	18	14	100	CL Low Plasticity
TP21/2	B	1.80 - 2.30	19	31	19	12	100	CL Low Plasticity
TP21/3	B	3.00 - 3.40	16	36	18	18	91	CI Intermediate Plasticity
TP21/4	B	4.00 - 4.30	19	30	16	14	85	CL Low Plasticity
TP22/1	B	0.80 - 1.20	17	39	19	20	90	CI Intermediate Plasticity
TP22/3	B	2.70 - 3.10	15	40	24	16	100	CI Intermediate Plasticity
TP23/1	B	0.50 - 0.90	21	38	19	19	90	CI Intermediate Plasticity
TP23/2	B	1.50 - 1.80	12					
TP23/3	B	2.80 - 3.30	20	36	17	19	90	CI Intermediate Plasticity
TP23/4	B	3.90 - 4.30	18	36	18	18	90	CI Intermediate Plasticity

Symbols: **NP : Non Plastic** **# : Liquid Limit and Plastic Limit Wet Sieved**

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.

BS 5930:1999+A2:2010



For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)
Date: 10.6.16

Test Report:

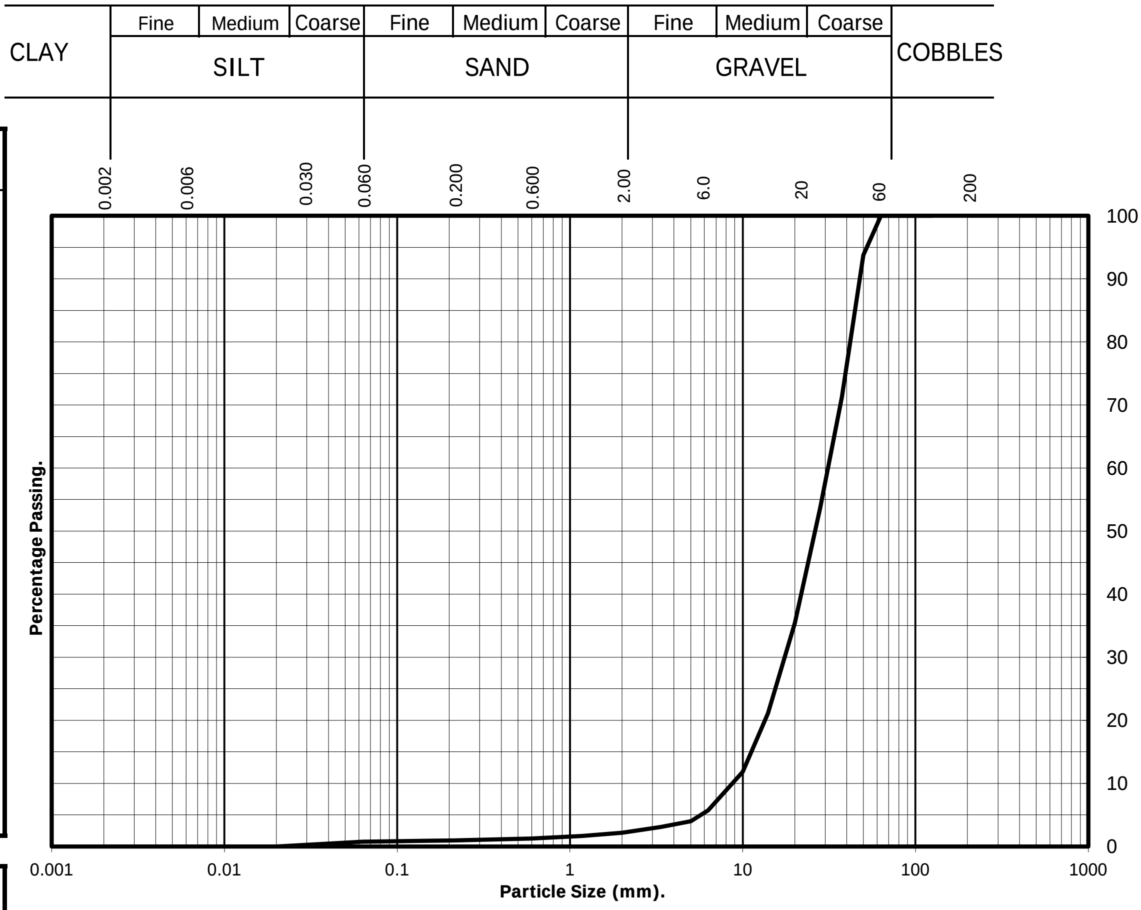
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**N/A**
Contract Number:	**30894-200516**	**Depth from (m):**	**3.30**
Hole Number:	**BH7**	**Depth to (m):**	**4.46**
		Sample Type:	**B**

Location: **A40**

Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	94
37.5	71
28	54
20	35
14	21
10	12
6.3	6
5.0	4
3.35	3
2.00	2
1.18	2
0.60	1
0.425	1
0.300	1
0.212	1
0.150	1
0.063	1



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	1	1	98	0	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

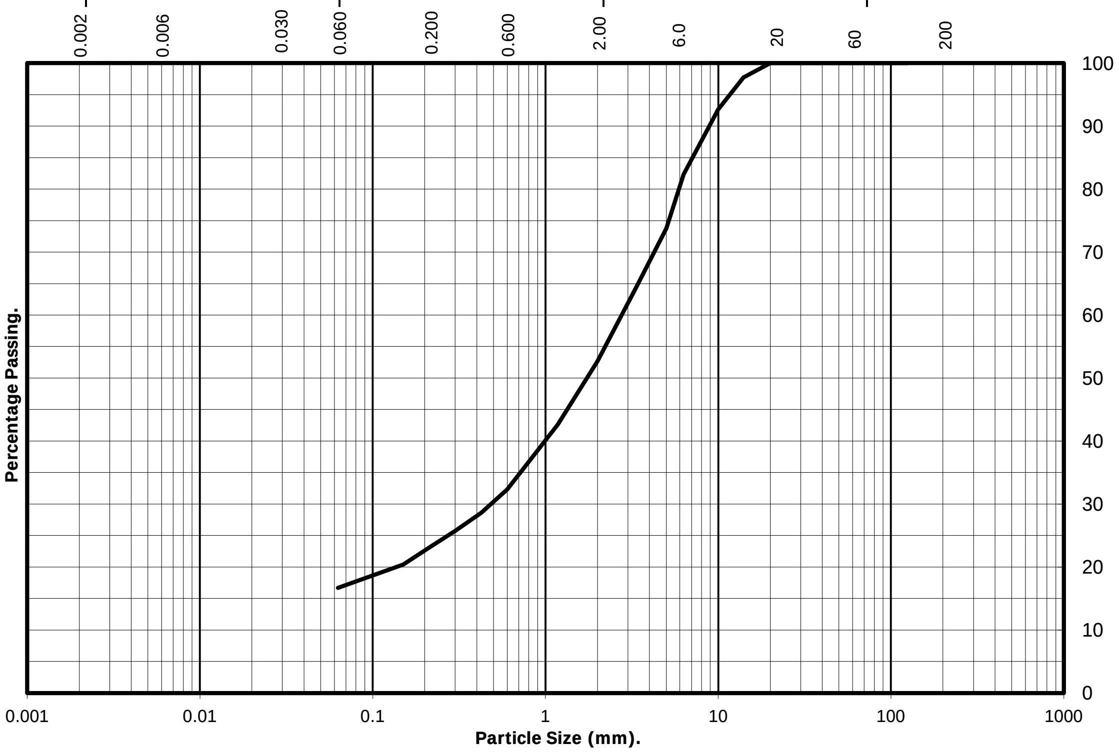
Client ref:	**A096409**	**Sample Number:**	**N/A**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.70**
Hole Number:	**BH8**	**Depth to (m):**	**2.70**
		Sample Type:	**B**

Location: **A40**

Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	98
10	93
6.3	82
5.0	74
3.35	64
2.00	53
1.18	43
0.60	32
0.425	29
0.300	26
0.212	23
0.150	20
0.063	17



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	17	36	47	0	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

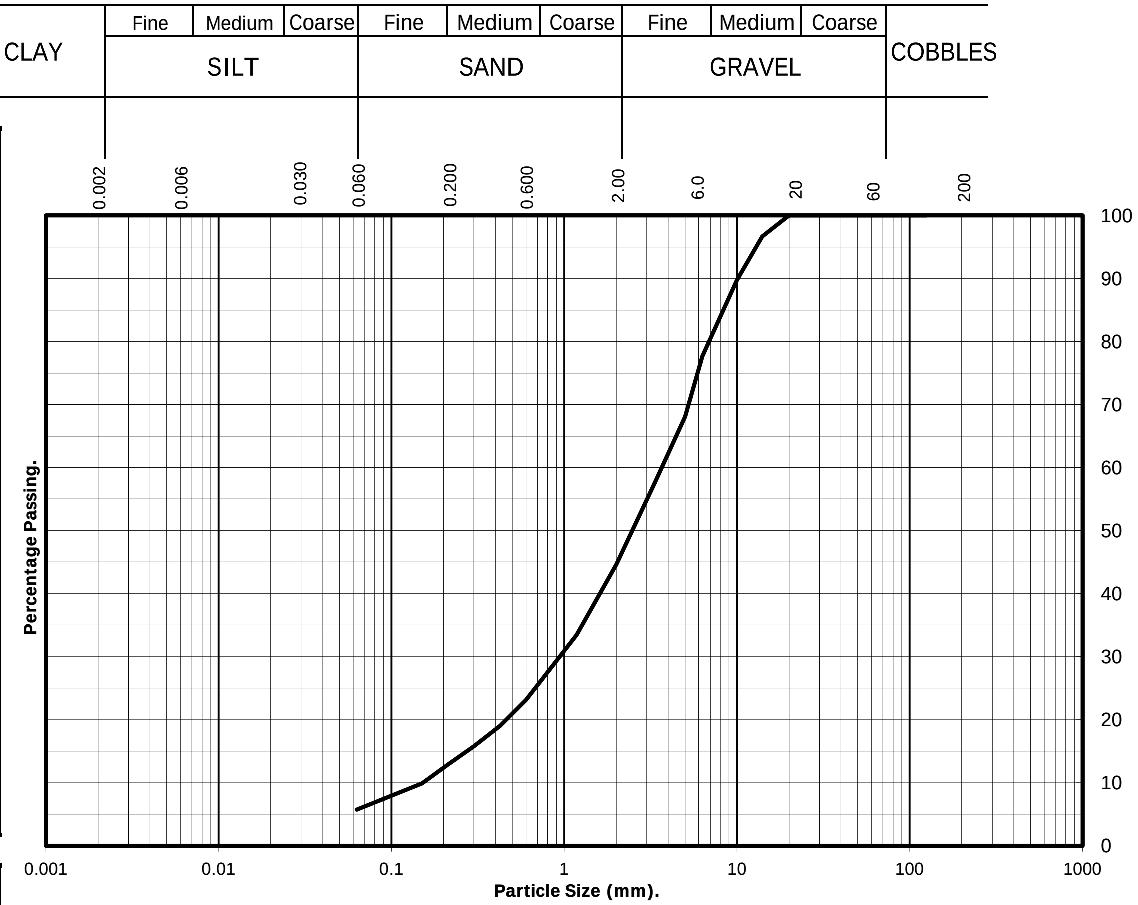
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref: A096409
Contract Number: 30894-200516
Hole Number: BH9

Sample Number: N/A
Depth from (m): 1.20
Depth to (m): 1.80
Sample Type: B

Location: A40
Description: Brown silty clayey sandy fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	100
14	97
10	90
6.3	78
5.0	68
3.35	58
2.00	45
1.18	33
0.60	23
0.425	19
0.300	16
0.212	13
0.150	10
0.063	6



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	6	39	55	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

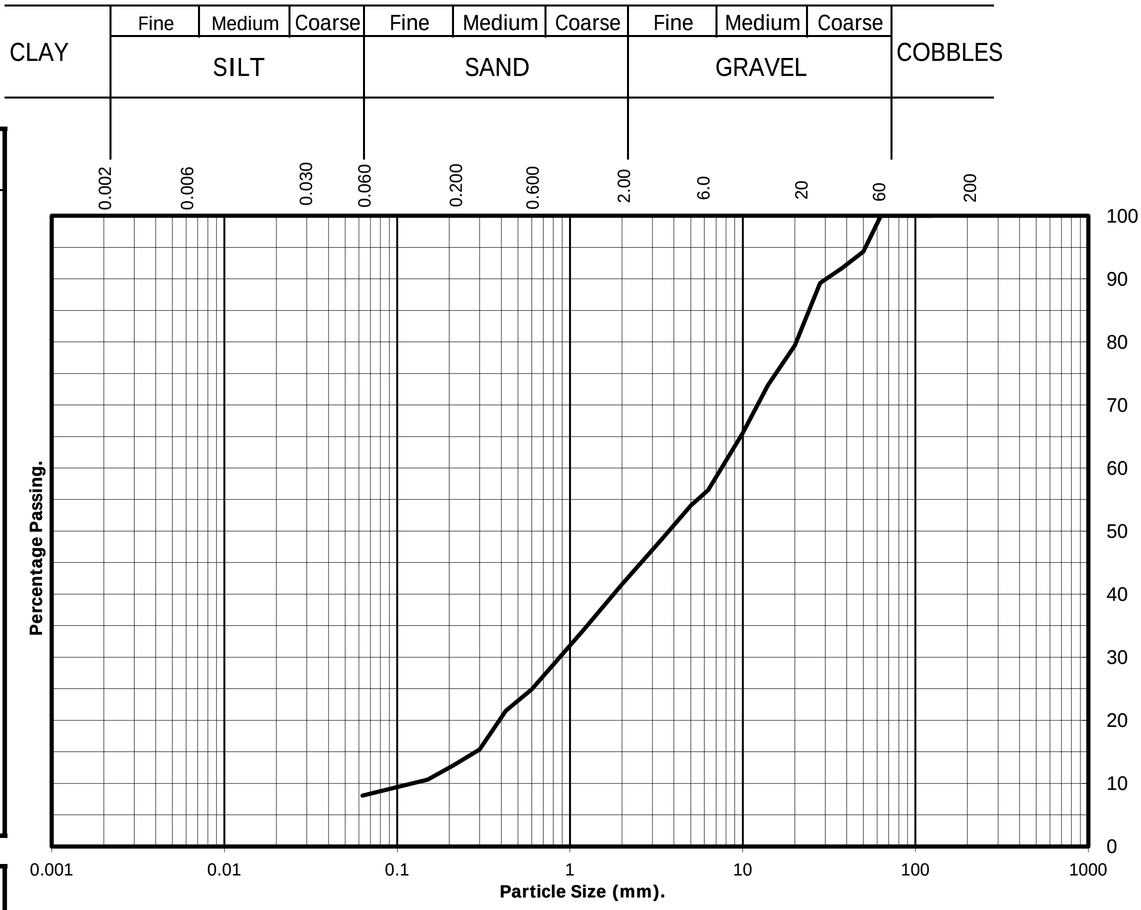
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**N/A**
Contract Number:	**30894-200516**	**Depth from (m):**	**2.90**
Hole Number:	**BH10**	**Depth to (m):**	**3.90**
		Sample Type:	**B**

Location: **A40**

Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	94
37.5	92
28	89
20	79
14	73
10	66
6.3	56
5.0	54
3.35	49
2.00	42
1.18	34
0.60	25
0.425	21
0.300	15
0.212	13
0.150	11
0.063	8



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	8	34	58	0	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

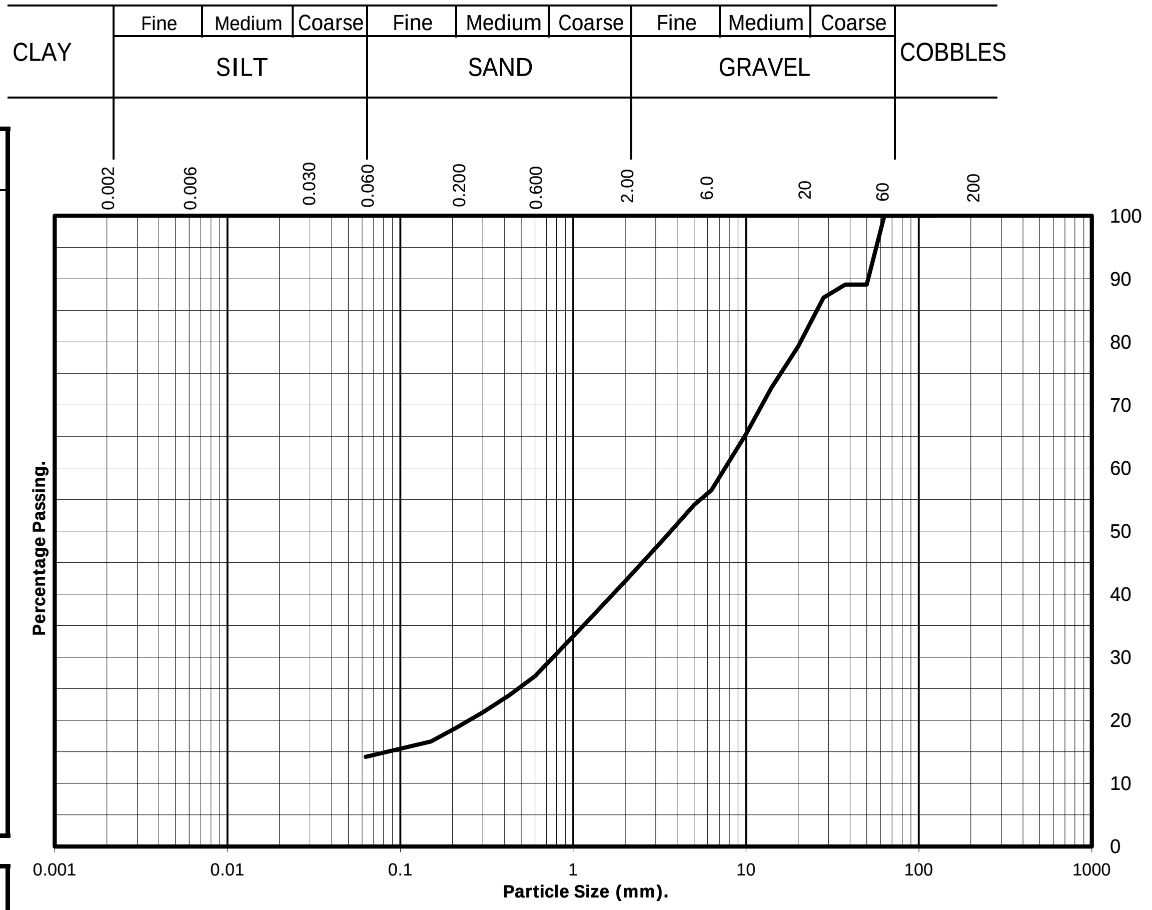
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref: A096409
Contract Number: 30894-200516
Hole Number: BH11

Sample Number: N/A
Depth from (m): 1.20
Depth to (m): 2.20
Sample Type: B

Location: A40
Description: Brown silty clayey sandy fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	89
37.5	89
28	87
20	79
14	73
10	65
6.3	57
5.0	54
3.35	49
2.00	42
1.18	35
0.60	27
0.425	24
0.300	21
0.212	19
0.150	17
0.063	14



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	14	28	58	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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2788

Test Report:

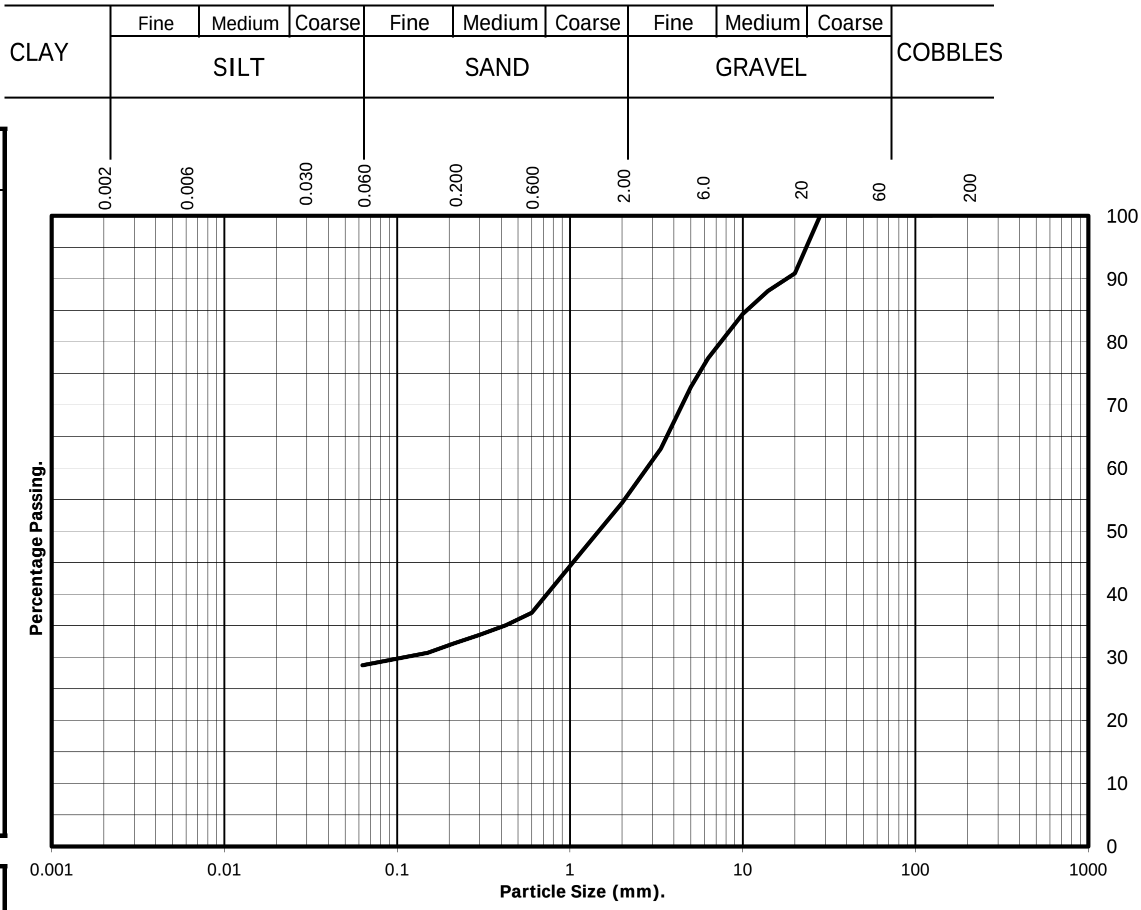
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**N/A**
Contract Number:	**30894-200516**	**Depth from (m):**	**5.50**
Hole Number:	**BH16**	**Depth to (m):**	**7.00**
		Sample Type:	**B**

Location: **A40**
Description: **Brown sandy silty clayey fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	91
14	88
10	84
6.3	77
5.0	73
3.35	63
2.00	54
1.18	47
0.60	37
0.425	35
0.300	34
0.212	32
0.150	31
0.063	29

Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#



	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	29	25	46	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

GEO SITE & TESTING SERVICES LTD

UKAS TESTING 2788

GEO/104

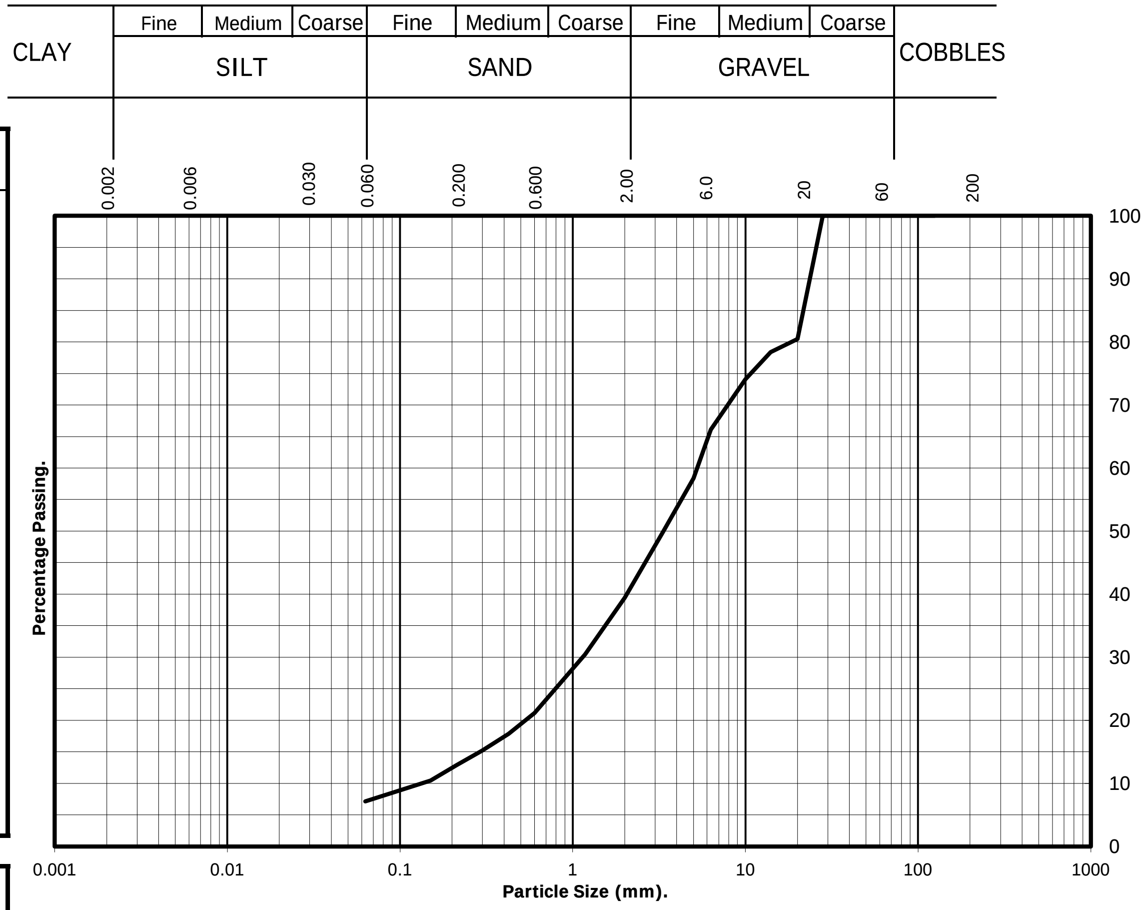
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**N/A**
Contract Number:	**30894-200516**	**Depth from (m):**	**5.20**
Hole Number:	**BH17**	**Depth to (m):**	**6.70**
		Sample Type:	**B**

Location: **A40**
Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	100
20	80
14	78
10	74
6.3	66
5.0	58
3.35	50
2.00	39
1.18	30
0.60	21
0.425	18
0.300	15
0.212	13
0.150	10
0.063	7



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	7	32	61	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

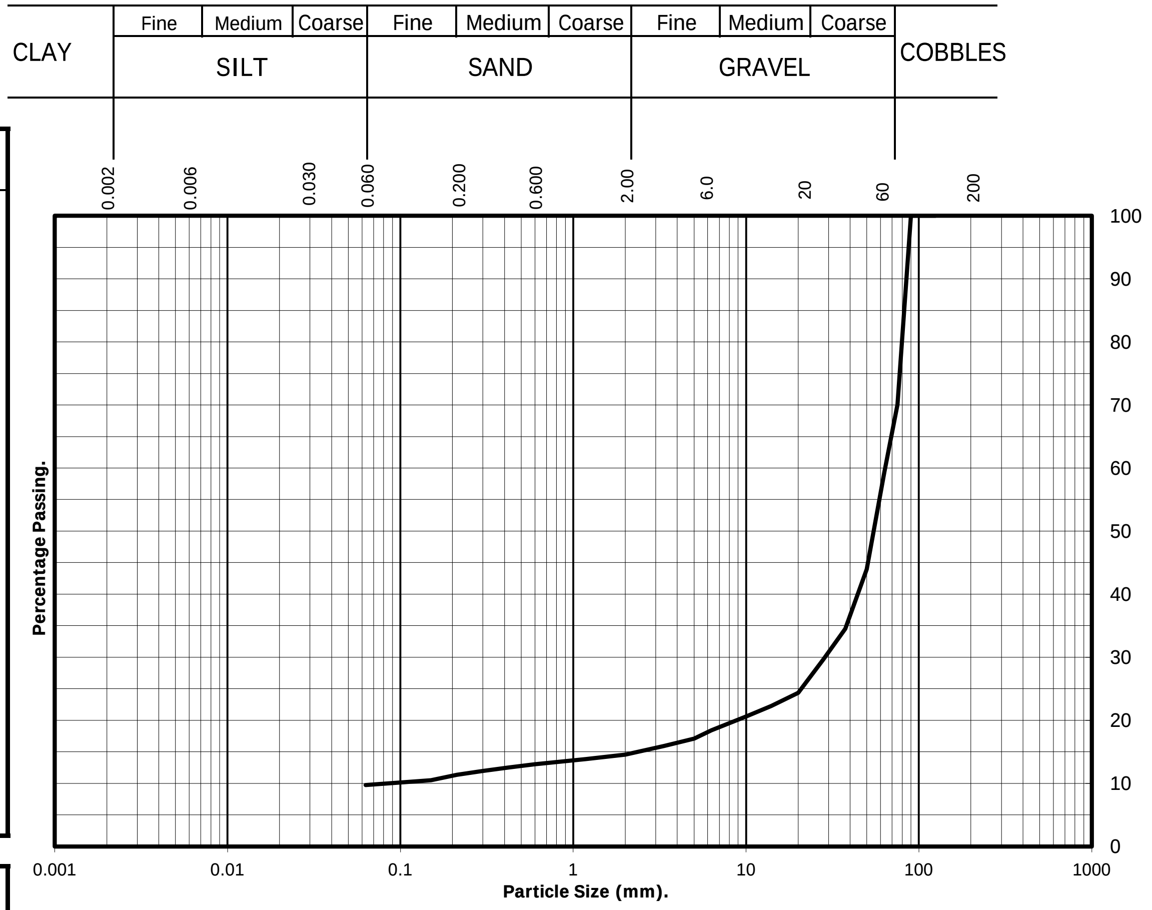
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**1**
Contract Number:	**30894-200516**	**Depth from (m):**	**3.10**
Hole Number:	**TP3**	**Depth to (m):**	**N/A**
		Sample Type:	**B**

Location: **A40**

Description: **Brown sandy silty clayey fine to coarse GRAVEL with many cobbles.**

BS Test Sieve	% Passing
125	100
90	100
75	70
63	59
50	44
37.5	35
28	30
20	24
14	22
10	21
6.3	18
5.0	17
3.35	16
2.00	15
1.18	14
0.60	13
0.425	12
0.300	12
0.212	11
0.150	10
0.063	10



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	10	5	44	41	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

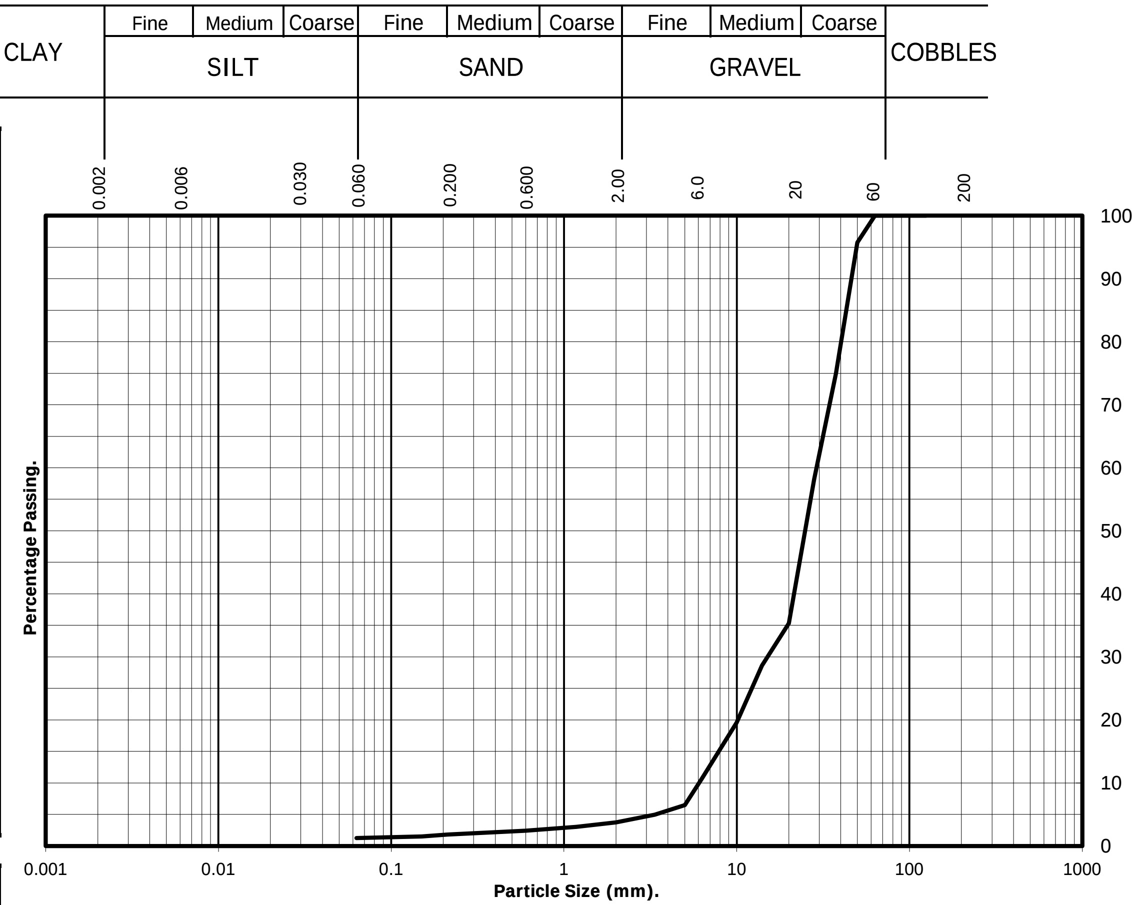
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**0.80**
Hole Number:	**TP4**	**Depth to (m):**	**1.20**
		Sample Type:	**B**

Location: **A40**

Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	96
37.5	75
28	58
20	35
14	29
10	20
6.3	11
5.0	6
3.35	5
2.00	4
1.18	3
0.60	2
0.425	2
0.300	2
0.212	2
0.150	2
0.063	1



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	1	3	96	0	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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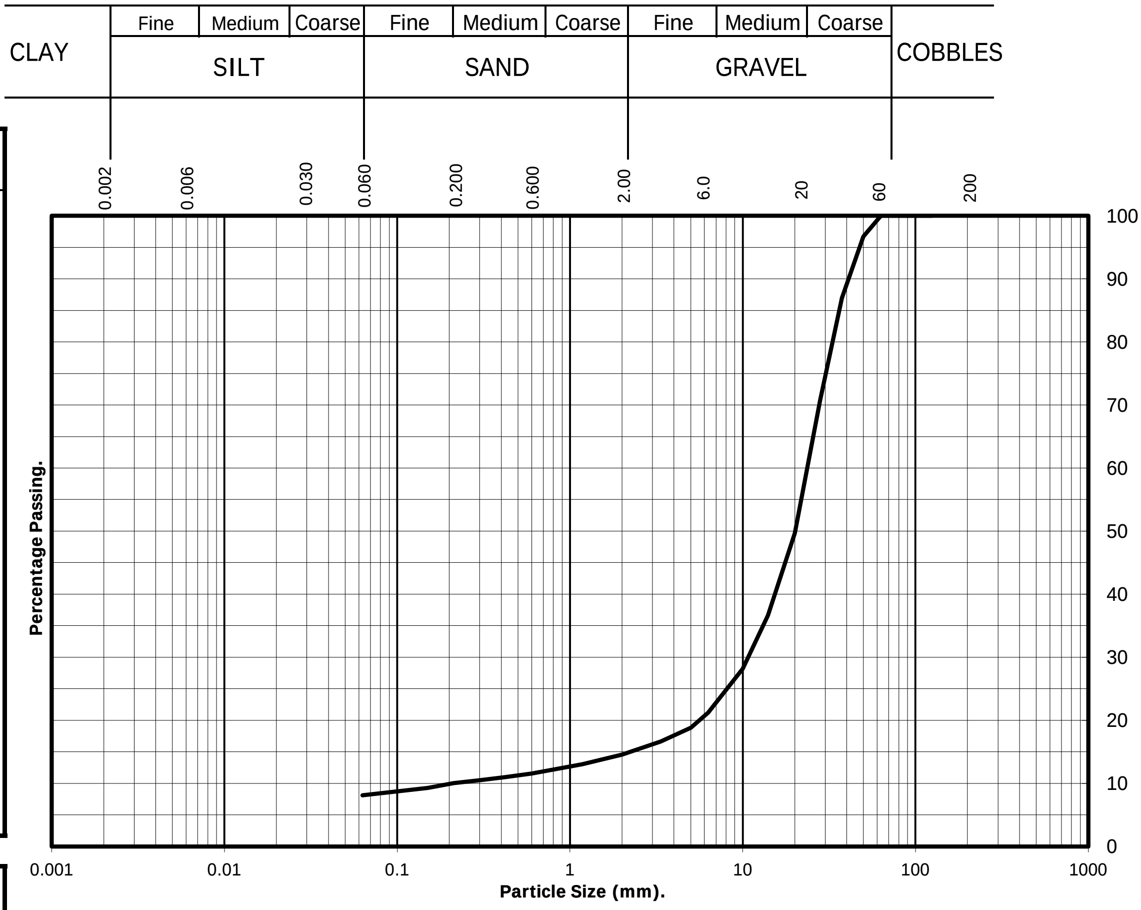
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**1**
Contract Number:	**30894-200516**	**Depth from (m):**	**0.30**
Hole Number:	**TP5**	**Depth to (m):**	**0.50**
		Sample Type:	**B**

Location: **A40**
Description: **Brown sandy silty clayey fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	97
37.5	87
28	71
20	50
14	37
10	28
6.3	21
5.0	19
3.35	17
2.00	15
1.18	13
0.60	12
0.425	11
0.300	11
0.212	10
0.150	9
0.063	8



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	8	7	85	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
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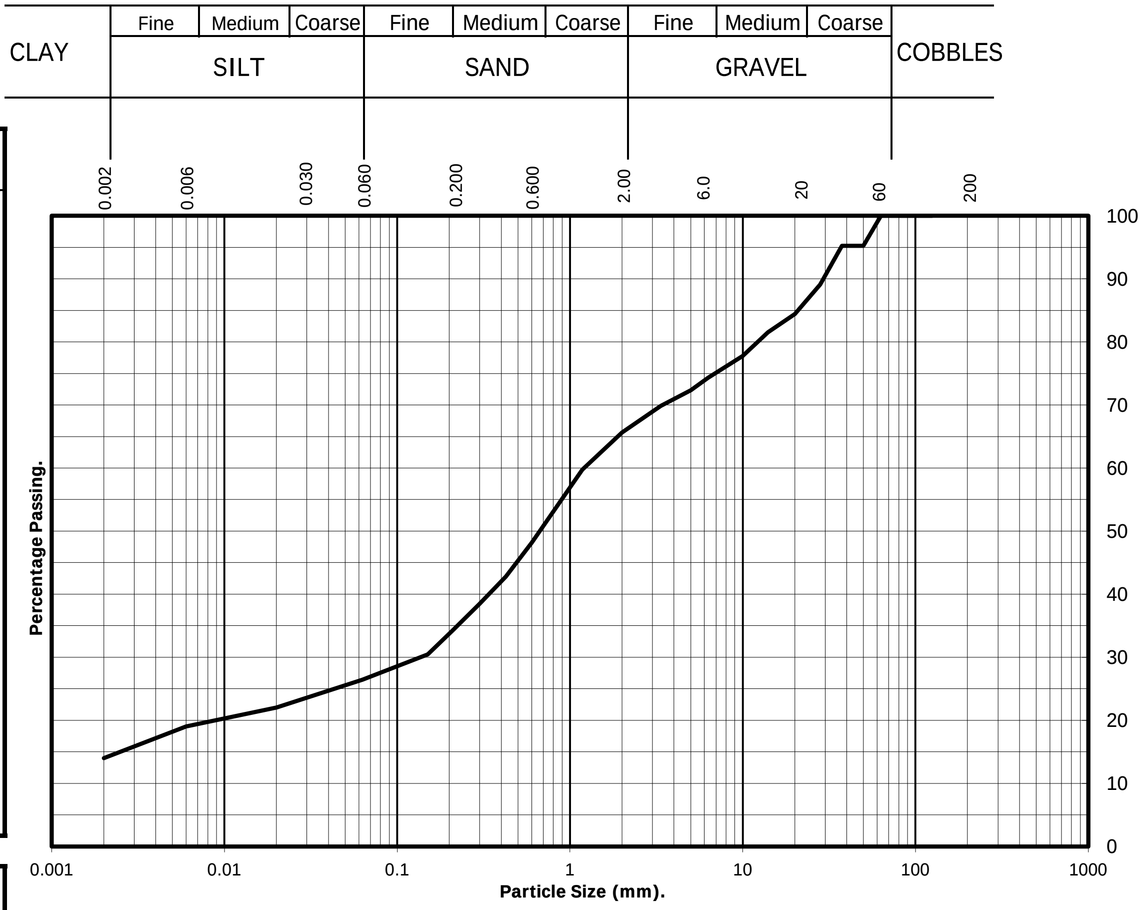
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP17

Sample Number: 2
Depth from (m): 0.80
Depth to (m): 1.10
Sample Type: B

Location: A40
Description: Brown silty clayey gravelly fine to medium SAND.



BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	95
37.5	95
28	89
20	84
14	82
10	78
6.3	74
5.0	72
3.35	70
2.00	66
1.18	60
0.60	48
0.425	43
0.300	38
0.212	34
0.150	30
0.063	26

Particle Diameter	% Passing
0.02	22
0.006	19
0.002	14

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
14	12	40	34	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.

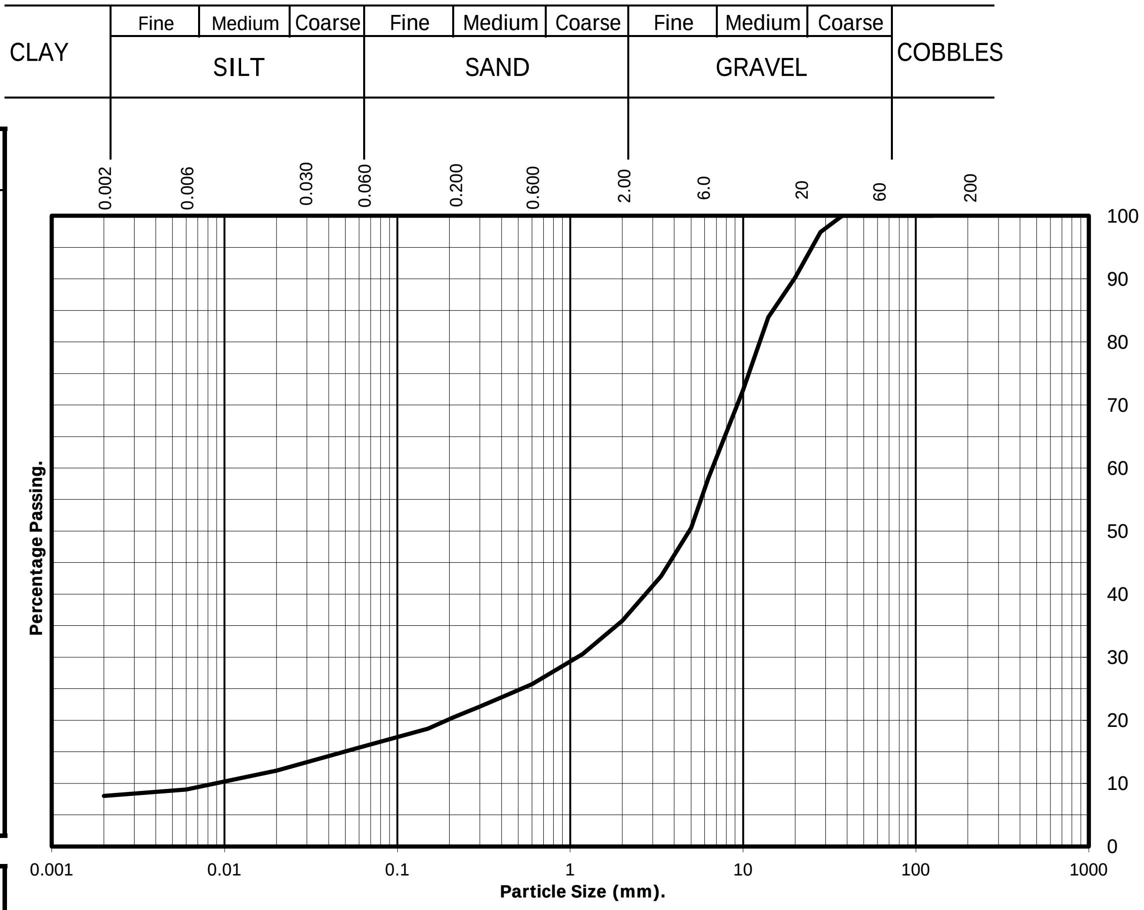
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP17

Sample Number: 3
Depth from (m): 1.70
Depth to (m): 2.00
Sample Type: B

Location: A40
Description: Brown silty clayey sandy fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	97
20	90
14	84
10	72
6.3	58
5.0	51
3.35	43
2.00	36
1.18	31
0.60	26
0.425	24
0.300	22
0.212	20
0.150	19
0.063	16



Particle Diameter	% Passing
0.02	12
0.006	9
0.002	8

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
8	8	20	64	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
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Test Report:

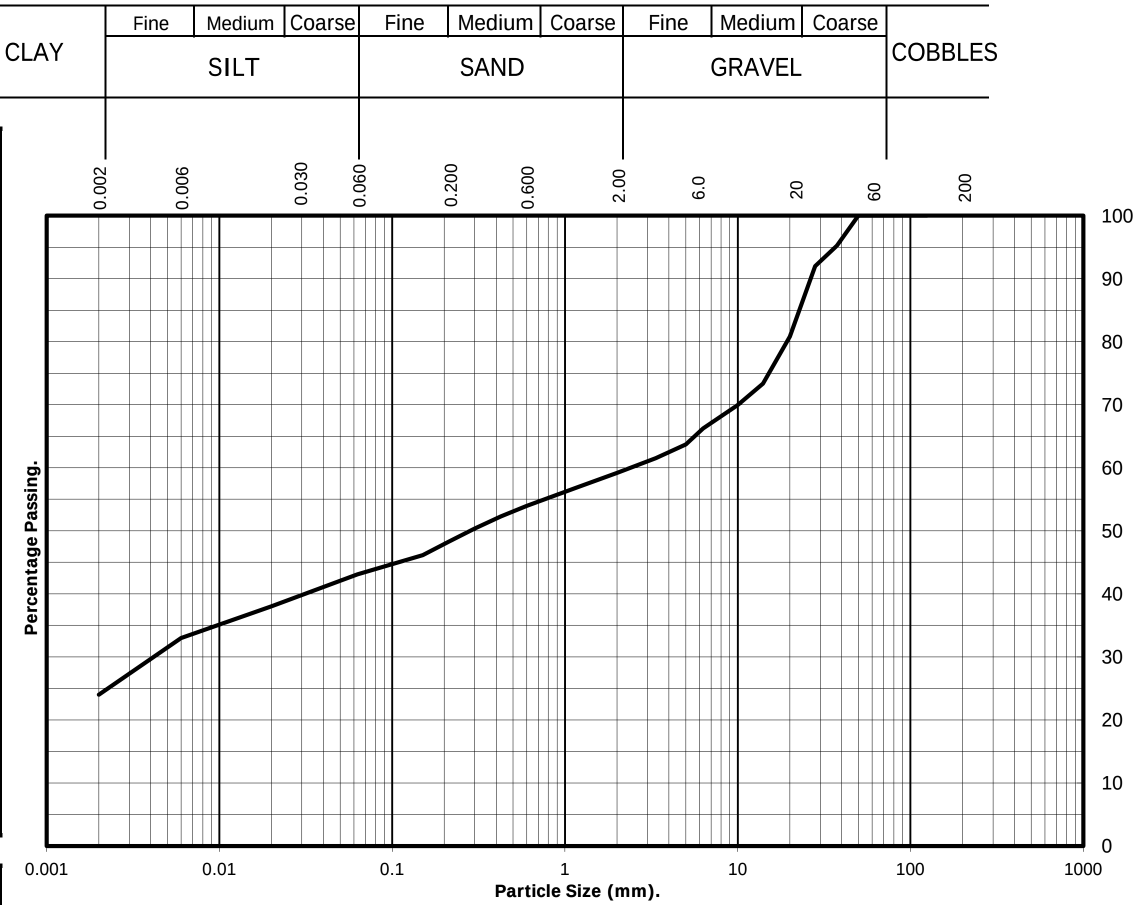
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.20**
Hole Number:	**TP18**	**Depth to (m):**	**1.50**
		Sample Type:	**B**

Location: **A40**

Description: **Brown sandy silty clayey fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	95
28	92
20	81
14	73
10	70
6.3	66
5.0	64
3.35	62
2.00	59
1.18	57
0.60	54
0.425	52
0.300	50
0.212	48
0.150	46
0.063	43



Particle Diameter	% Passing
0.02	38
0.006	33
0.002	24

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
24	19	16	41	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

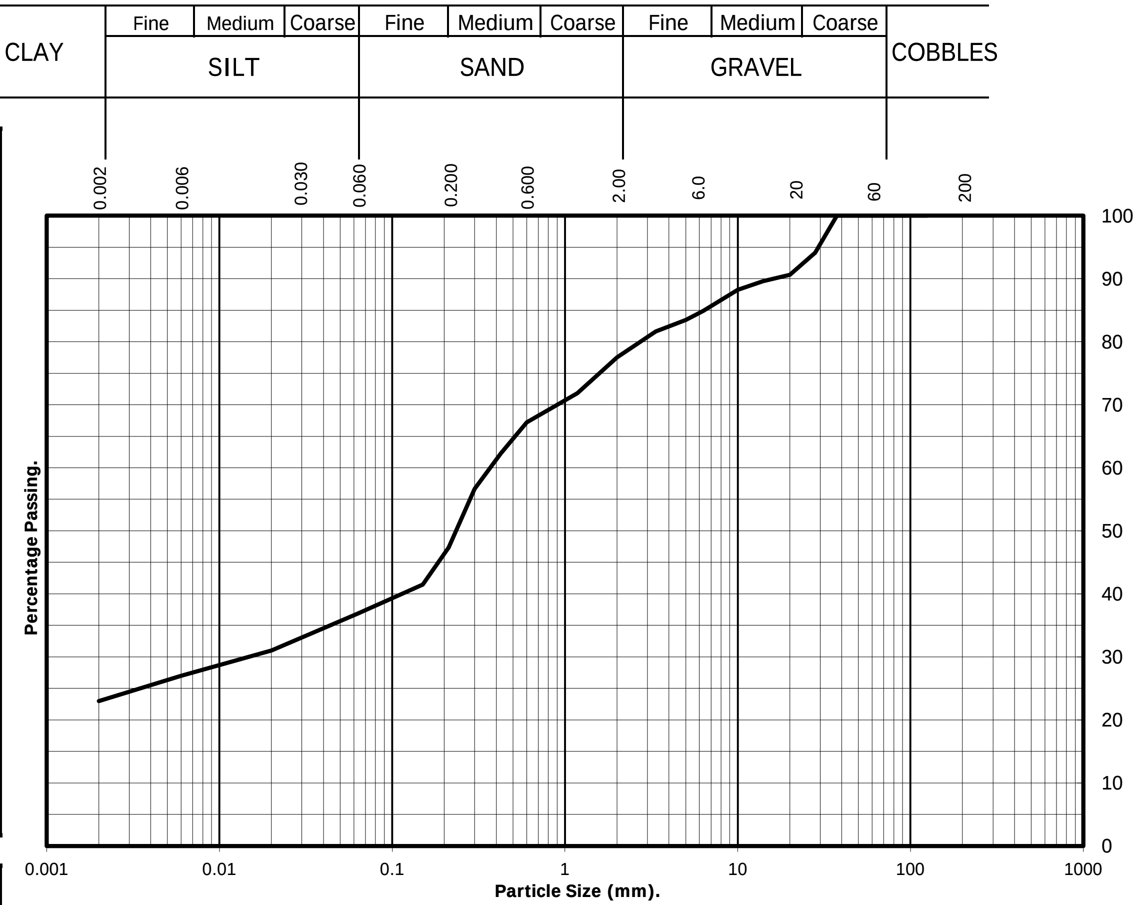
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.70**
Hole Number:	**TP19**	**Depth to (m):**	**2.10**
		Sample Type:	**B**

Location: **A40**
Description: **Brown gravelly silty clayey fine to medium SAND.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	94
20	91
14	90
10	88
6.3	85
5.0	83
3.35	82
2.00	78
1.18	72
0.60	67
0.425	62
0.300	57
0.212	47
0.150	41
0.063	37



Particle Diameter	% Passing
0.02	31
0.006	27
0.002	23

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
23	14	41	22	0	Total Percentage

Remarks:
Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
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Date: 10.6.16

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Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.

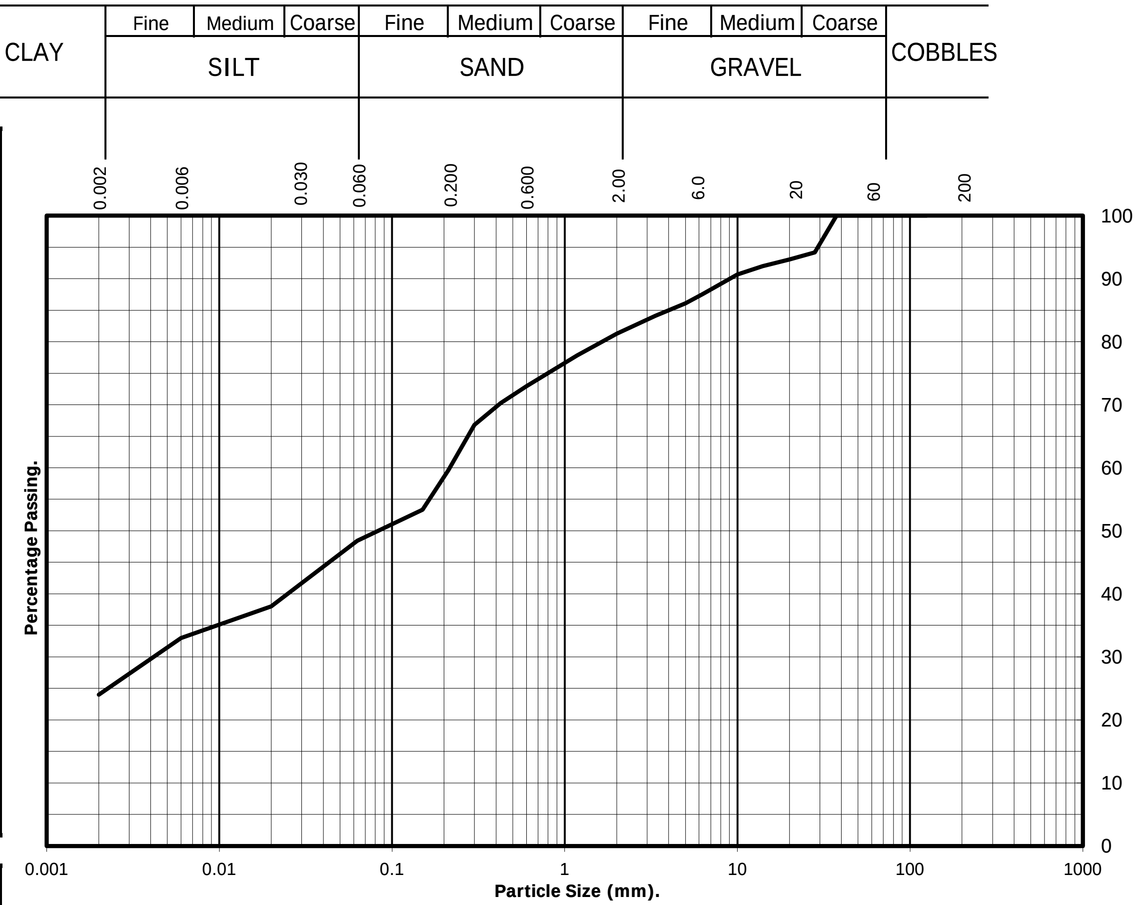
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP20

Sample Number: 2
Depth from (m): 1.60
Depth to (m): 2.00
Sample Type: B

Location: A40
Description: Brown gravelly silty clayey fine to medium SAND.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	94
20	93
14	92
10	91
6.3	88
5.0	86
3.35	84
2.00	81
1.18	78
0.60	73
0.425	70
0.300	67
0.212	60
0.150	53
0.063	48



Particle Diameter	% Passing
0.02	38
0.006	33
0.002	24

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
24	24	33	19	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

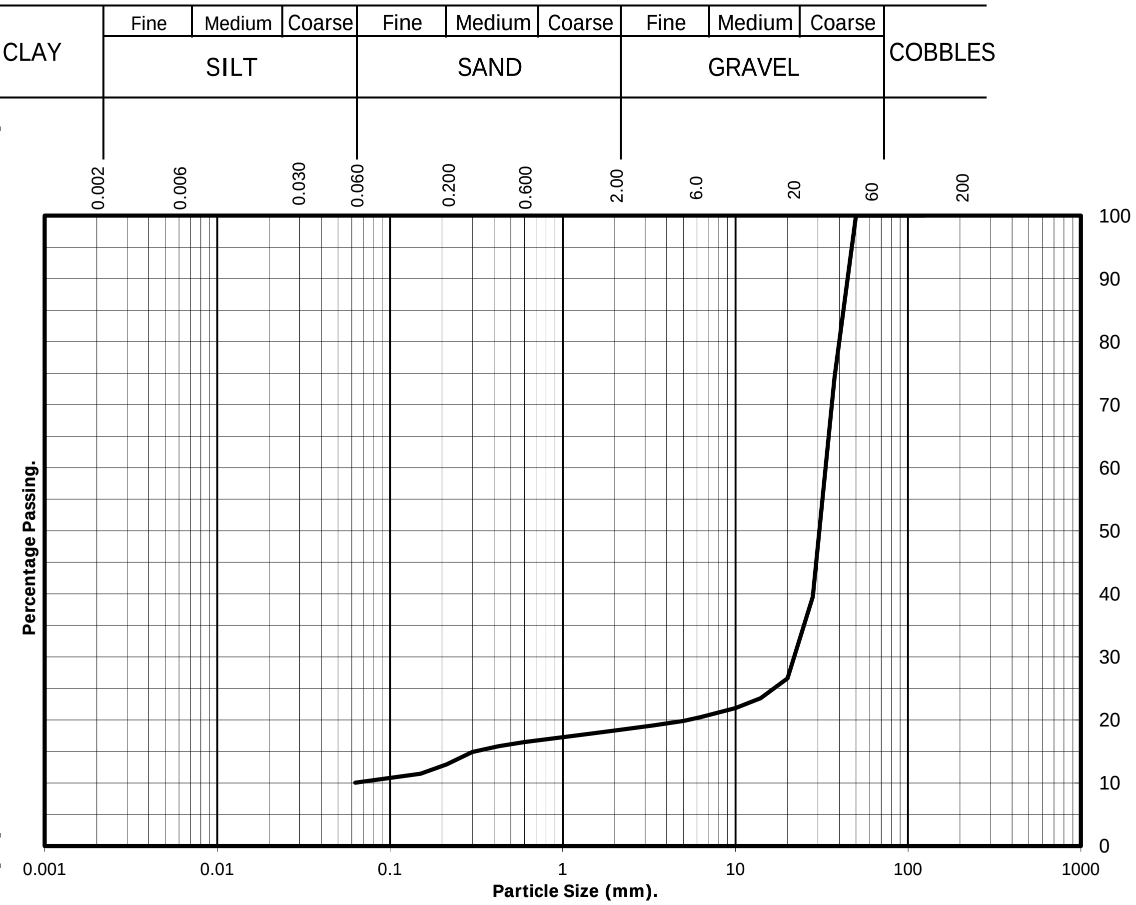
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP21

Sample Number: 2
Depth from (m): 1.80
Depth to (m): 2.30
Sample Type: B

Location: A40
Description: Brown sandy silty clayey fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	74
28	40
20	27
14	23
10	22
6.3	20
5.0	20
3.35	19
2.00	18
1.18	17
0.60	16
0.425	16
0.300	15
0.212	13
0.150	11
0.063	10



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	10	8	82	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

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Authorised By:
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Date: 10.6.16

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Test Report:

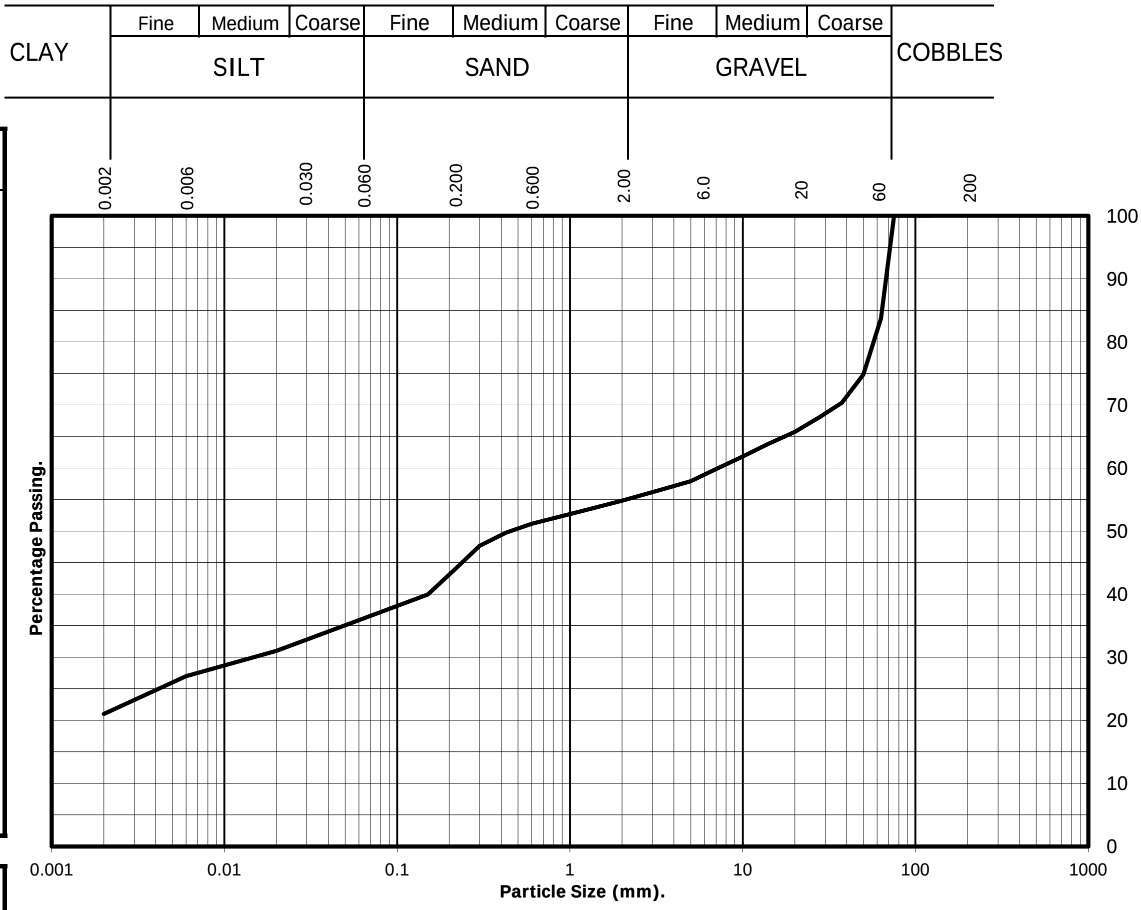
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: **A096409**
Contract Number: **30894-200516**
Hole Number: **TP22**

Sample Number: **3**
Depth from (m): **2.70**
Depth to (m): **3.10**
Sample Type: **B**

Location: **A40**
Description: **Brown sandy silty clayey fine to coarse GRAVEL with many cobbles.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	84
50	75
37.5	70
28	68
20	66
14	64
10	62
6.3	59
5.0	58
3.35	57
2.00	55
1.18	53
0.60	51
0.425	50
0.300	48
0.212	44
0.150	40
0.063	36



Particle Diameter	% Passing
0.02	31
0.006	27
0.002	21

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
21	15	19	29	16	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

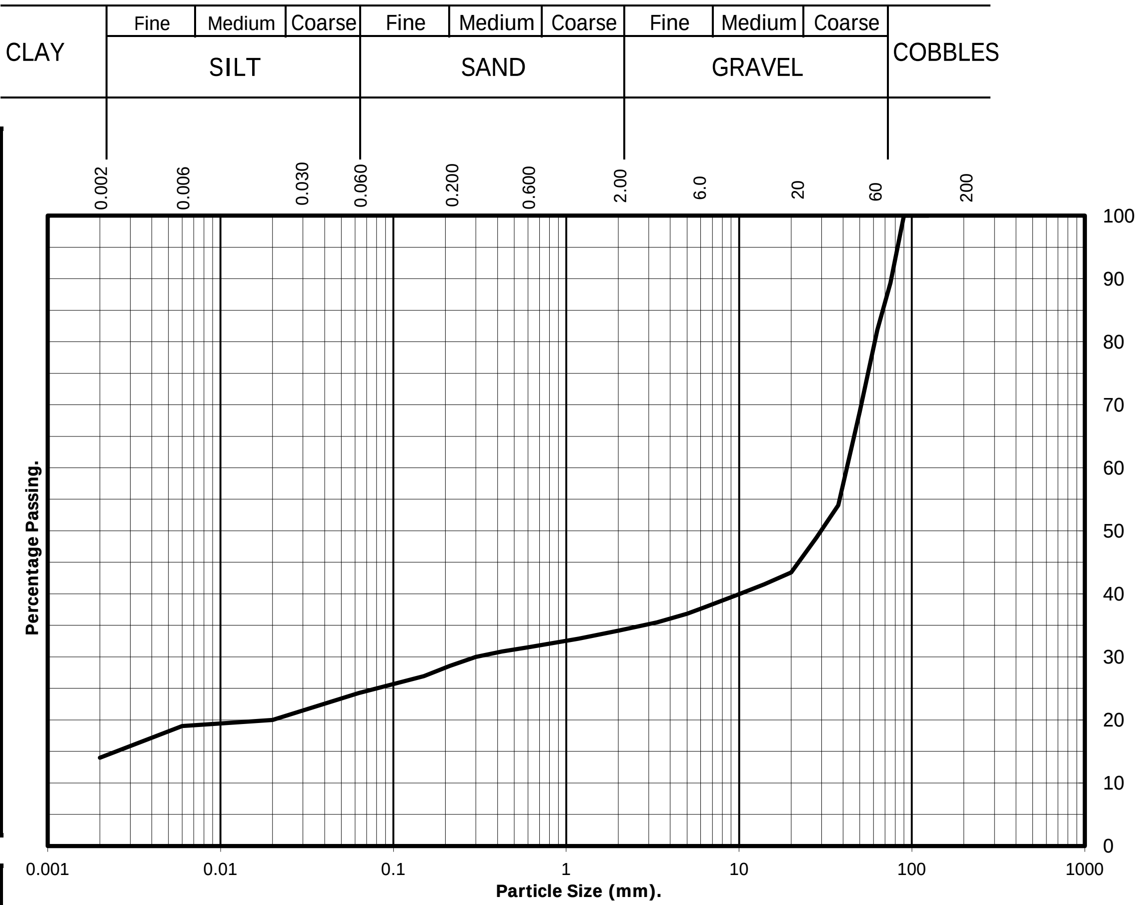
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP23

Sample Number: 2
Depth from (m): 1.50
Depth to (m): 1.80
Sample Type: B

Location: A40
Description: Brown sandy silty clayey fine to coarse GRAVEL with many cobbles.

BS Test Sieve	% Passing
125	100
90	100
75	89
63	82
50	69
37.5	54
28	49
20	43
14	42
10	40
6.3	38
5.0	37
3.35	35
2.00	34
1.18	33
0.60	32
0.425	31
0.300	30
0.212	29
0.150	27
0.063	24



Particle Diameter	% Passing
0.02	20
0.006	19
0.002	14

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
14	10	10	48	18	Total Percentage

Remarks:
Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

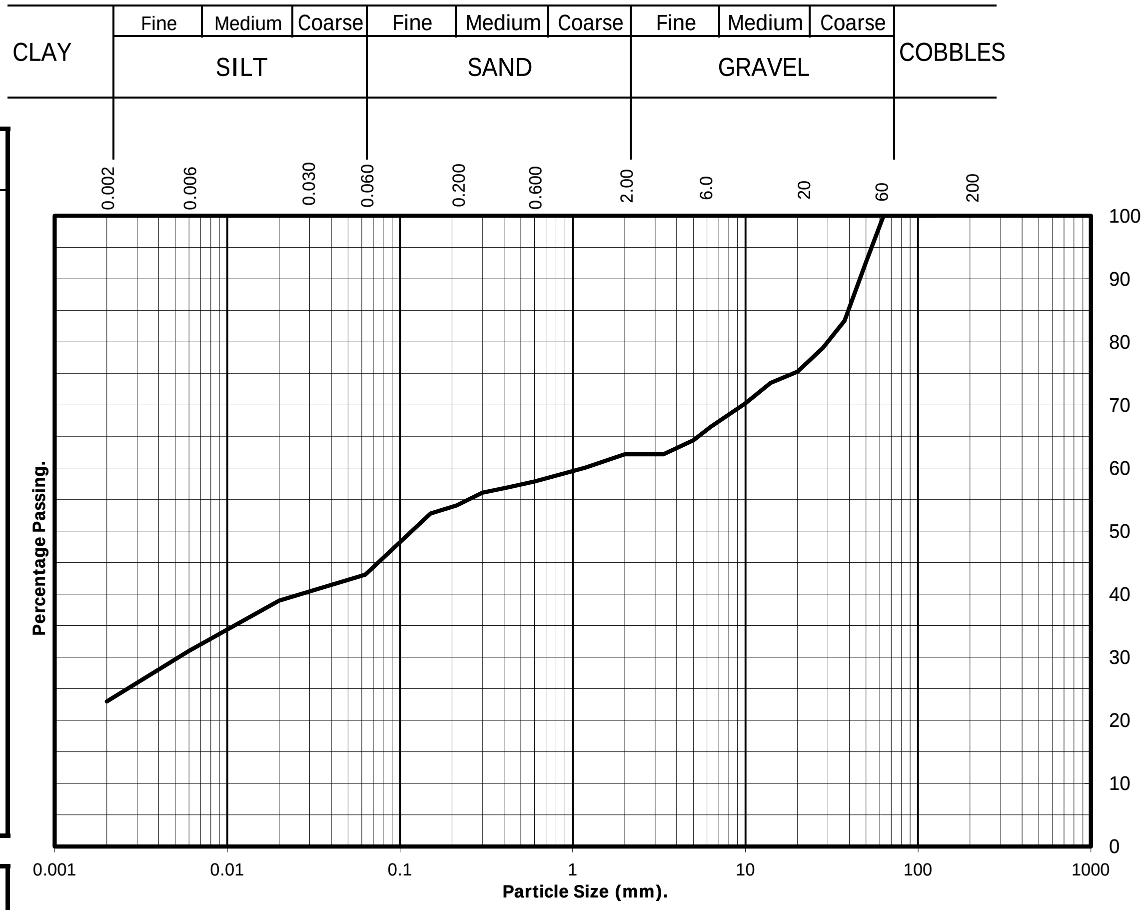
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: **A096409**
Contract Number: **30894-200516**
Hole Number: **TP24**

Sample Number: **1**
Depth from (m): **0.60**
Depth to (m): **1.00**
Sample Type: **B**

Location: **A40**
Description: **Brown sandy silty clayey fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	93
37.5	83
28	79
20	75
14	74
10	70
6.3	67
5.0	64
3.35	62
2.00	62
1.18	60
0.60	58
0.425	57
0.300	56
0.212	54
0.150	53
0.063	43



Particle Diameter	% Passing
0.02	39
0.006	31
0.002	23

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
23	20	19	38	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

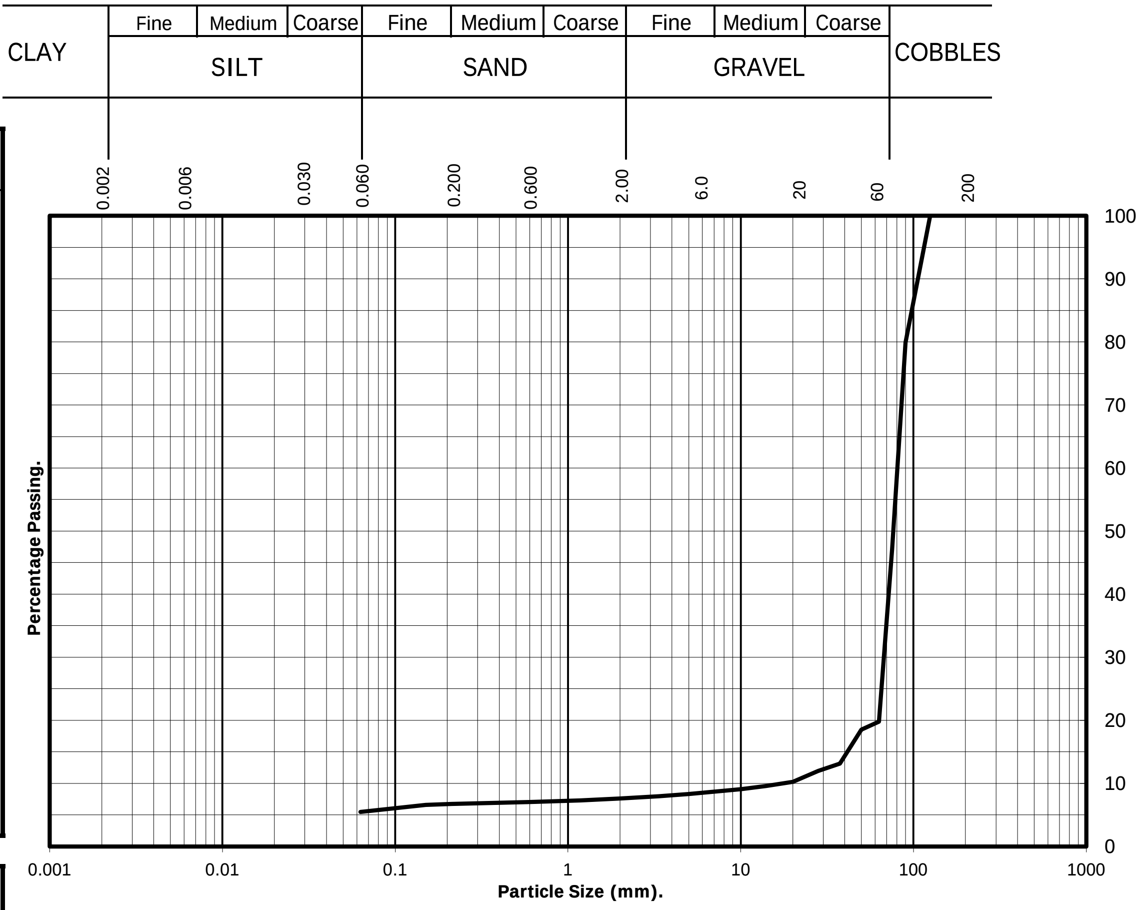
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.90**
Hole Number:	**TP25**	**Depth to (m):**	**2.30**
		Sample Type:	**B**

Location: **A40**

Description: **Brown sandy silty clayey fine to coarse GRAVEL with many cobbles.**

BS Test Sieve	% Passing
125	100
90	80
75	47
63	20
50	19
37.5	13
28	12
20	10
14	10
10	9
6.3	9
5.0	8
3.35	8
2.00	8
1.18	7
0.60	7
0.425	7
0.300	7
0.212	7
0.150	7
0.063	5



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	5	3	12	80	Total Percentage

Remarks:

#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

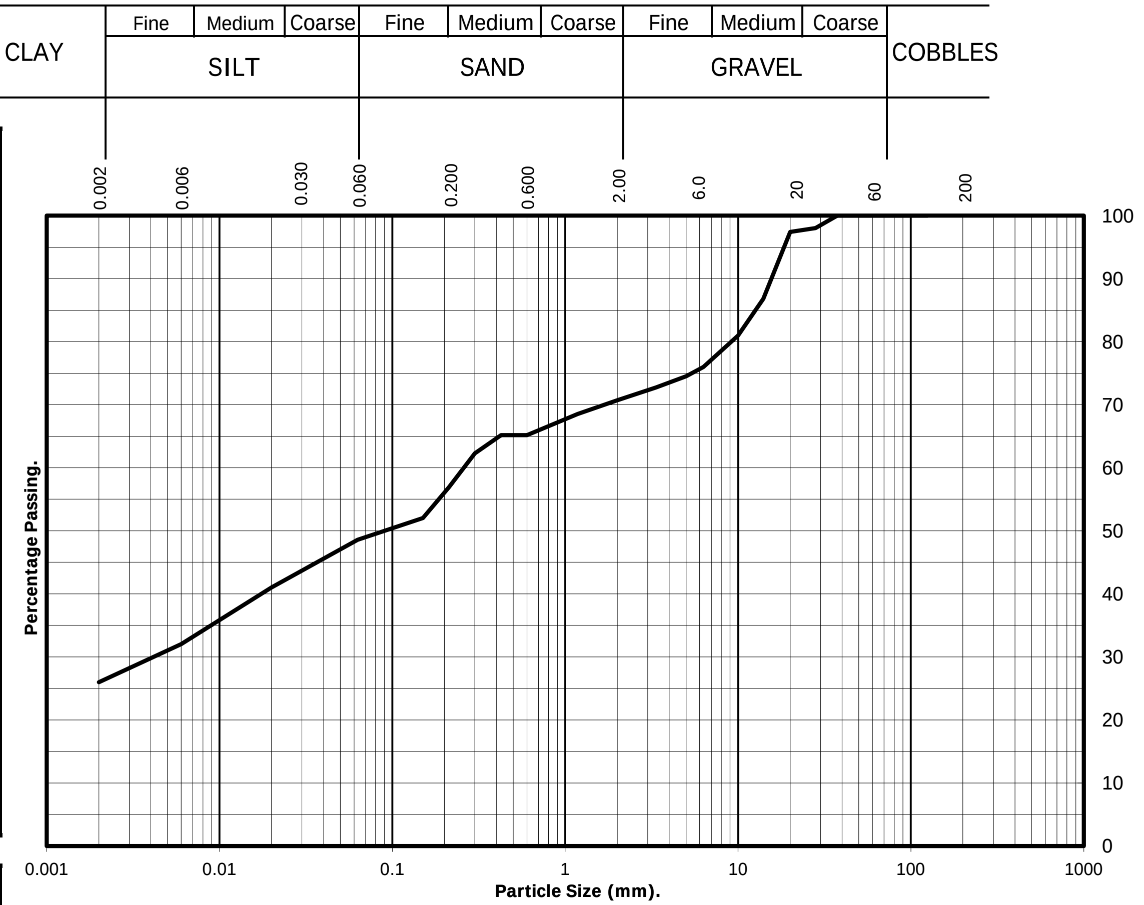
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP26

Sample Number: 2
Depth from (m): 1.50
Depth to (m): 1.90
Sample Type: B

Location: A40
Description: Brown sandy silty clayey fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	98
20	97
14	87
10	81
6.3	76
5.0	75
3.35	73
2.00	71
1.18	69
0.60	65
0.425	65
0.300	62
0.212	57
0.150	52
0.063	49



Particle Diameter	% Passing
0.02	41
0.006	32
0.002	26

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
26	23	22	29	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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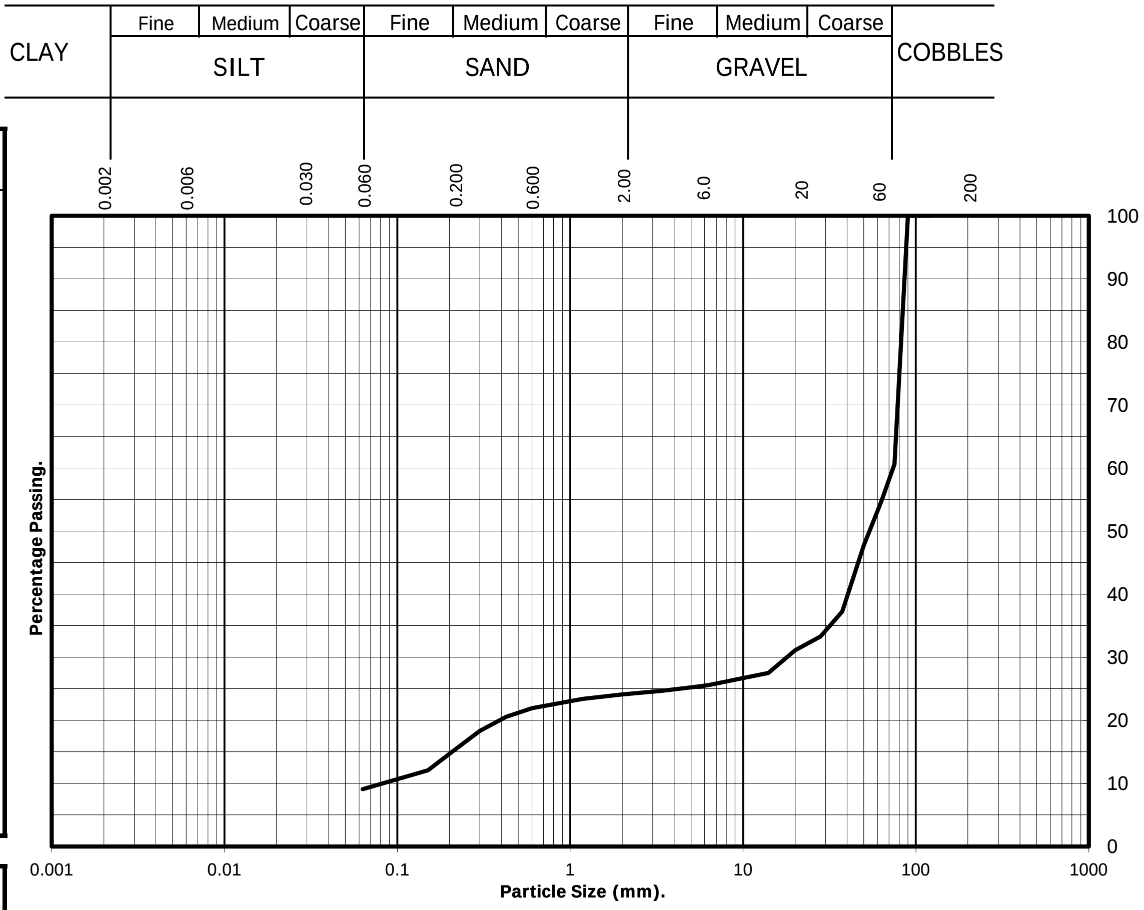
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.30**
Hole Number:	**TP27**	**Depth to (m):**	**1.60**
		Sample Type:	**B**

Location: **A40**
Description: **Brown silty clayey sandy fine to coarse GRAVEL with many cobbles.**

BS Test Sieve	% Passing
125	100
90	100
75	61
63	55
50	48
37.5	37
28	33
20	31
14	28
10	27
6.3	26
5.0	25
3.35	25
2.00	24
1.18	23
0.60	22
0.425	21
0.300	18
0.212	15
0.150	12
0.063	9



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	9	15	31	45	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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Test Report:

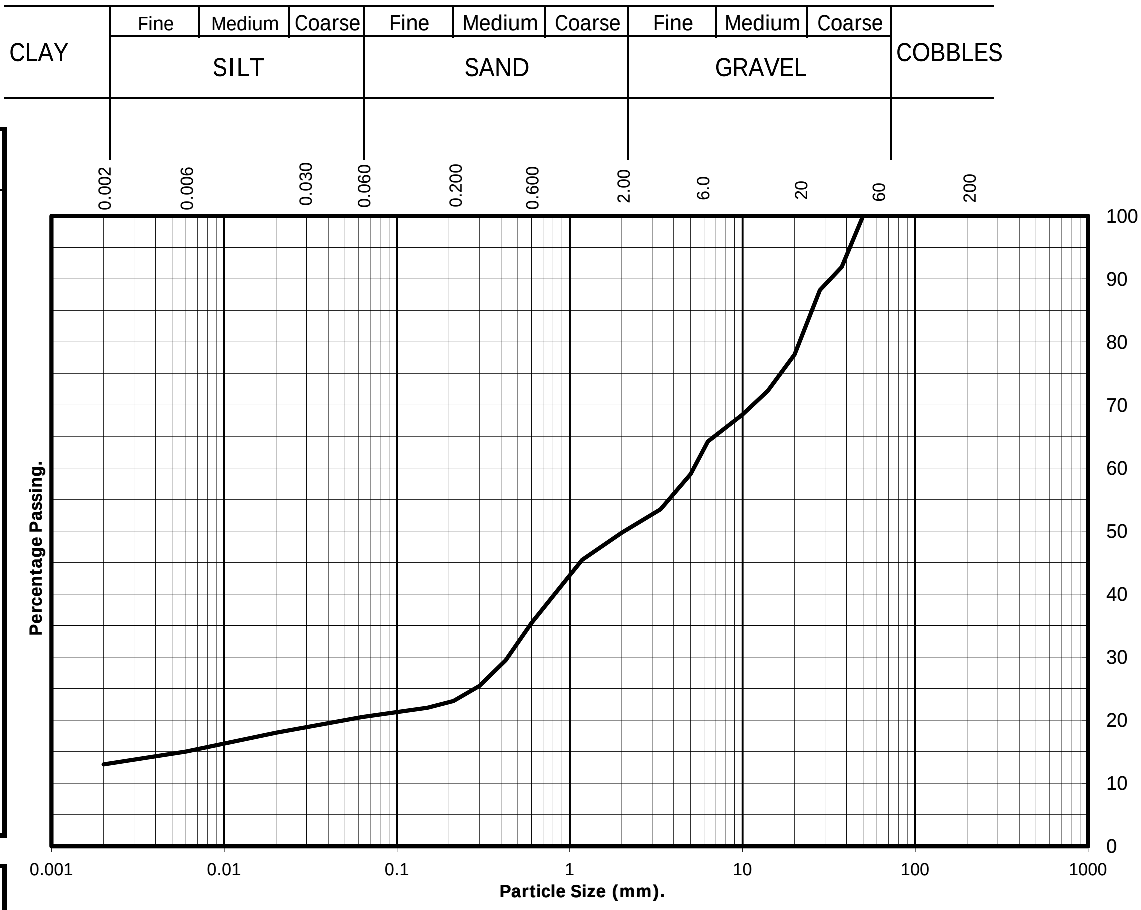
Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref: A096409
Contract Number: 30894-200516
Hole Number: TP28

Sample Number: 2
Depth from (m): 1.60
Depth to (m): 2.00
Sample Type: B

Location: A40
Description: Brown silty clayey sandy fine to coarse GRAVEL.

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	92
28	88
20	78
14	72
10	68
6.3	64
5.0	59
3.35	53
2.00	50
1.18	45
0.60	35
0.425	30
0.300	25
0.212	23
0.150	22
0.063	20



Particle Diameter	% Passing
0.02	18
0.006	15
0.002	13

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
13	7	30	50	0	Total Percentage

Remarks:

Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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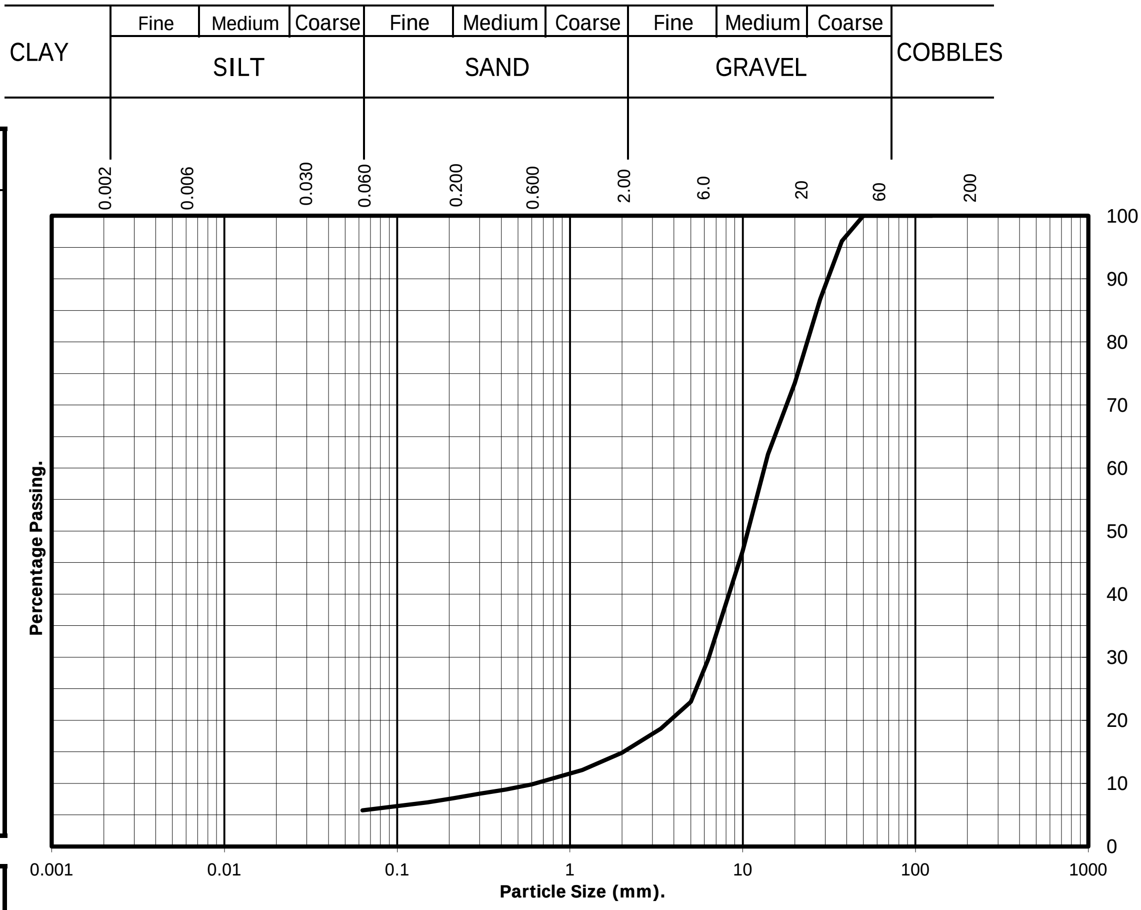
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve, Clause 9.2

Client ref:	**A096409**	**Sample Number:**	**3**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.00**
Hole Number:	**TP29**	**Depth to (m):**	**1.50**
		Sample Type:	**B**

Location: **A40**
Description: **Brown silty clayey sandy fine to coarse GRAVEL.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	96
28	87
20	74
14	62
10	47
6.3	30
5.0	23
3.35	19
2.00	15
1.18	12
0.60	10
0.425	9
0.300	8
0.212	8
0.150	7
0.063	6



Particle Diameter	% Passing
0.02	#
0.006	#
0.002	#

	Silt and Clay	Sand	Gravel	Cobbles	Soil Fraction
	6	9	85	0	Total Percentage

Remarks:
#- not determined

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

GEO SITE & TESTING SERVICES LTD

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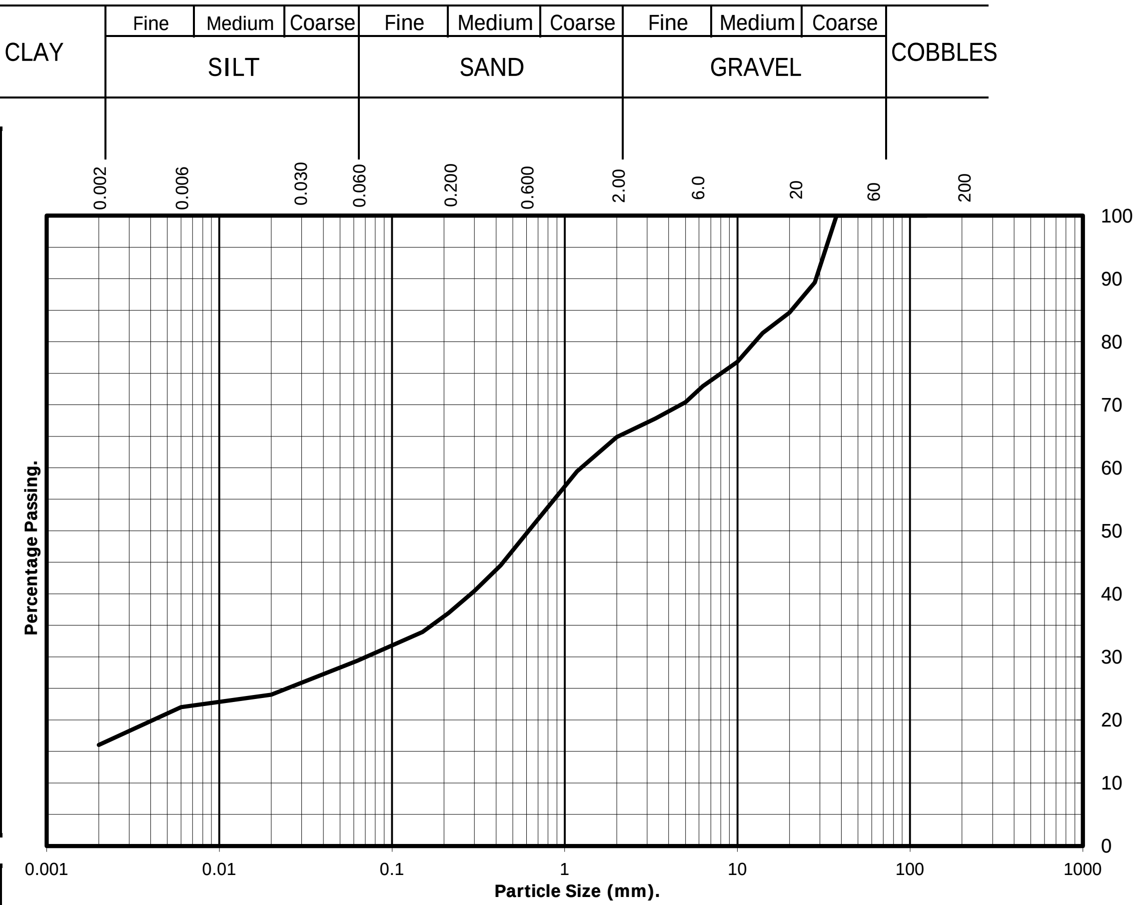
Test Report:

Particle Size Distribution Test
BS 1377 Part 2:1990.
Wet Sieve & Pipette Analysis, Clause 9.2 & 9.4

Client ref:	**A096409**	**Sample Number:**	**2**
Contract Number:	**30894-200516**	**Depth from (m):**	**1.00**
Hole Number:	**TP30**	**Depth to (m):**	**1.30**
		Sample Type:	**B**

Location: **A40**
Description: **Brown silty clayey gravelly fine to medium SAND.**

BS Test Sieve	% Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	89
20	85
14	81
10	77
6.3	73
5.0	70
3.35	68
2.00	65
1.18	59
0.60	50
0.425	45
0.300	40
0.212	37
0.150	34
0.063	29



Particle Diameter	% Passing
0.02	24
0.006	22
0.002	16

Clay	Silt	Sand	Gravel	Cobbles	Soil Fraction
16	13	36	35	0	Total Percentage

Remarks:
Cl 9.4.8 - Sample has not been pretreated

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Emma Sharp (Office Manager)

Date: 10.6.16

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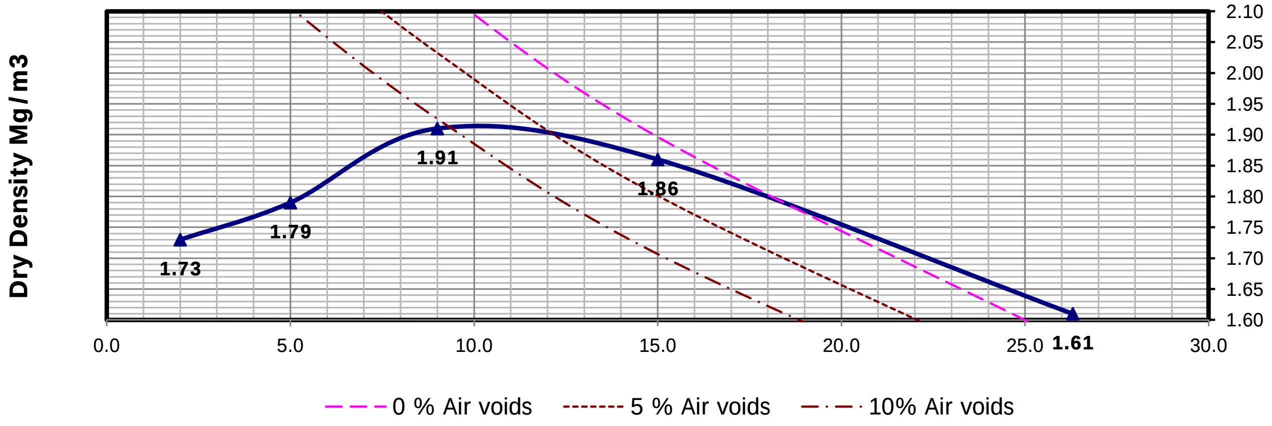
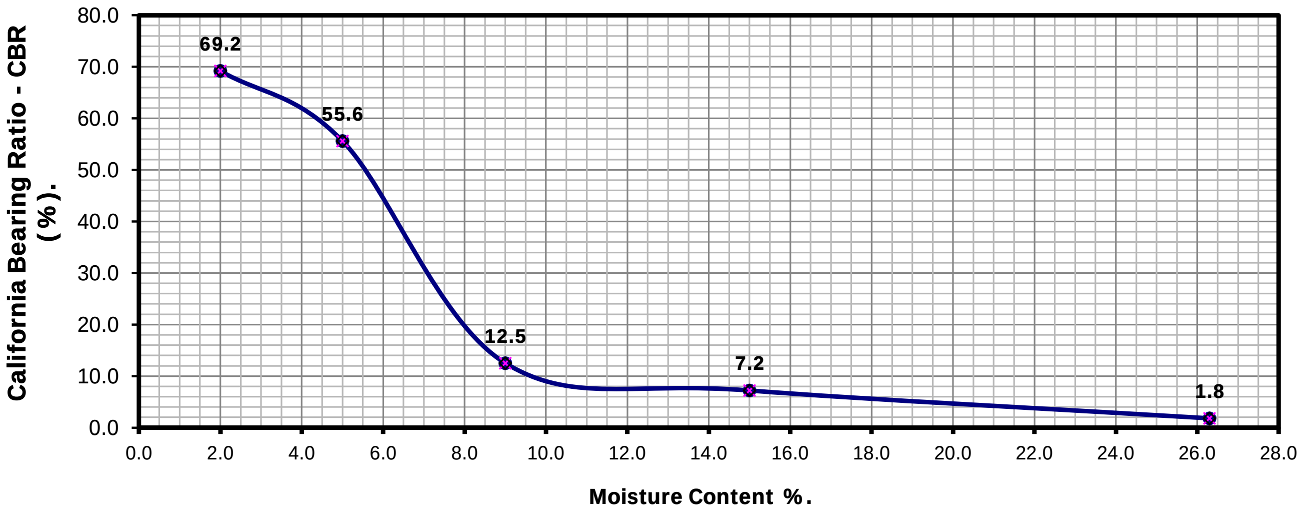
California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**BH101**
Sample Number:	
Depth (m) : from	**0.00**
Depth (m) : to	**1.20**
Sample Type	**B**





Moisture Content	2.0	5.0	9.0	15.0	26.3	
CBR Value Top	69.2	55.6	12.5	7.2	1.8	
CBR Value Bot	69.2	55.6	12.5	7.2	1.8	
Mean CBR Value	69	56	13	7	2	
Dry Density	1.73	1.79	1.91	1.86	1.61	

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		26.3	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		0	Maximum Dry Density (Mg/m^{3}	1.91
Material Retained on the 20.0mm BS Sieve (%):		11	Optimum Moisture Content (%	9
Particle Density (Mg/m^{3}) :	Assumed	2.65		

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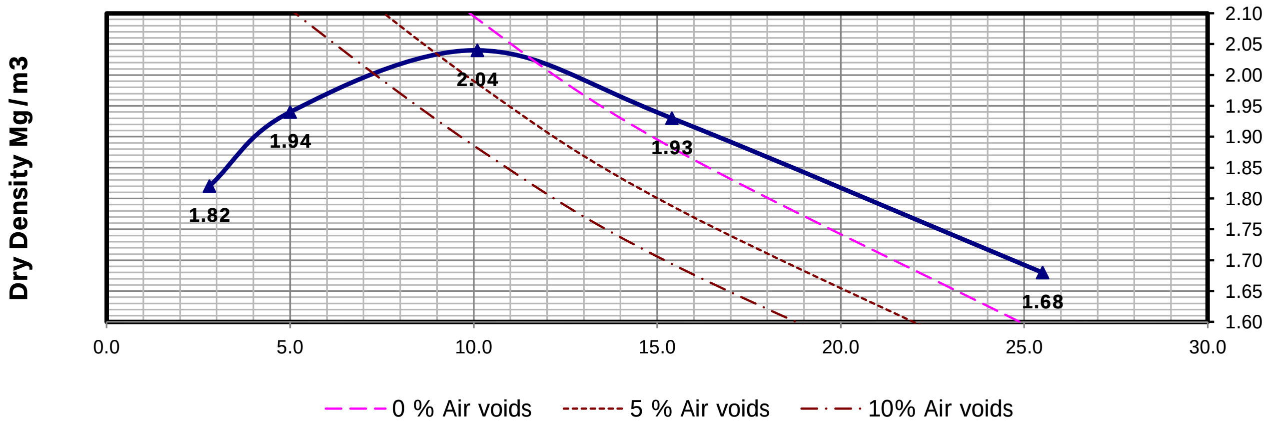
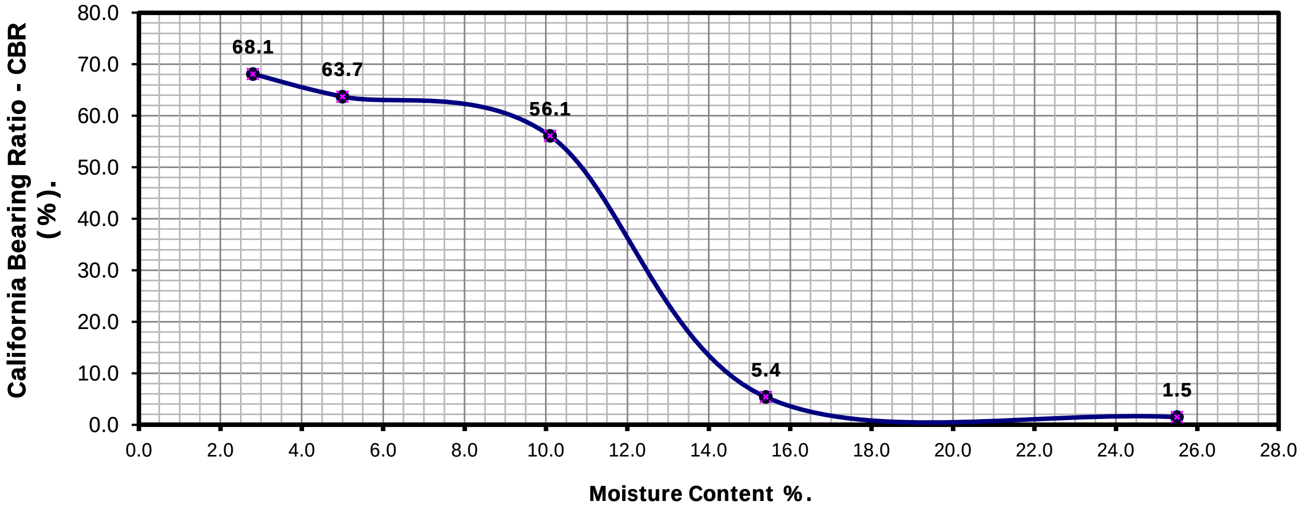
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref: A096409
Location: A40
Contract Number: 30894-
Hole Number: BH102
Sample Number:
Depth (m) : from 1.20
Depth (m) : to 2.00
Sample Type B





Moisture Content	2.8	5.0	10.1	15.4	25.5	
CBR Value Top	68.1	63.7	56.1	5.4	1.5	
CBR Value Bot	68.1	63.7	56.1	5.4	1.5	
Mean CBR Value	68	64	56	5	2	
Dry Density	1.82	1.94	2.04	1.93	1.68	

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		25.5	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		1	Maximum Dry Density (Mg/m^{3}	2.04
Material Retained on the 20.0mm BS Sieve (%):		1	Optimum Moisture Content (%	10
Particle Density (Mg/m^{3}) :	Assumed	2.65		

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Checked by	**Date**	**Approved by**	**Date**

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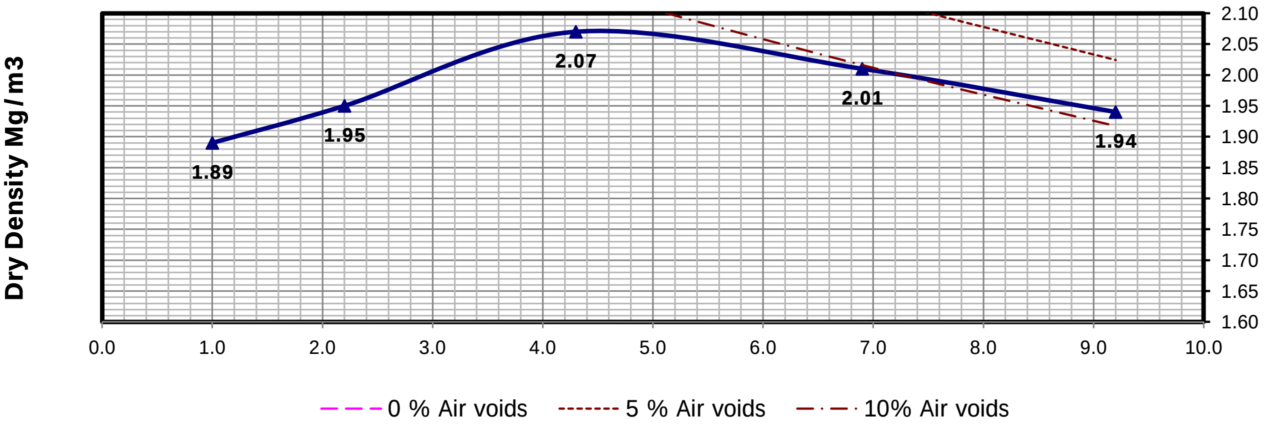
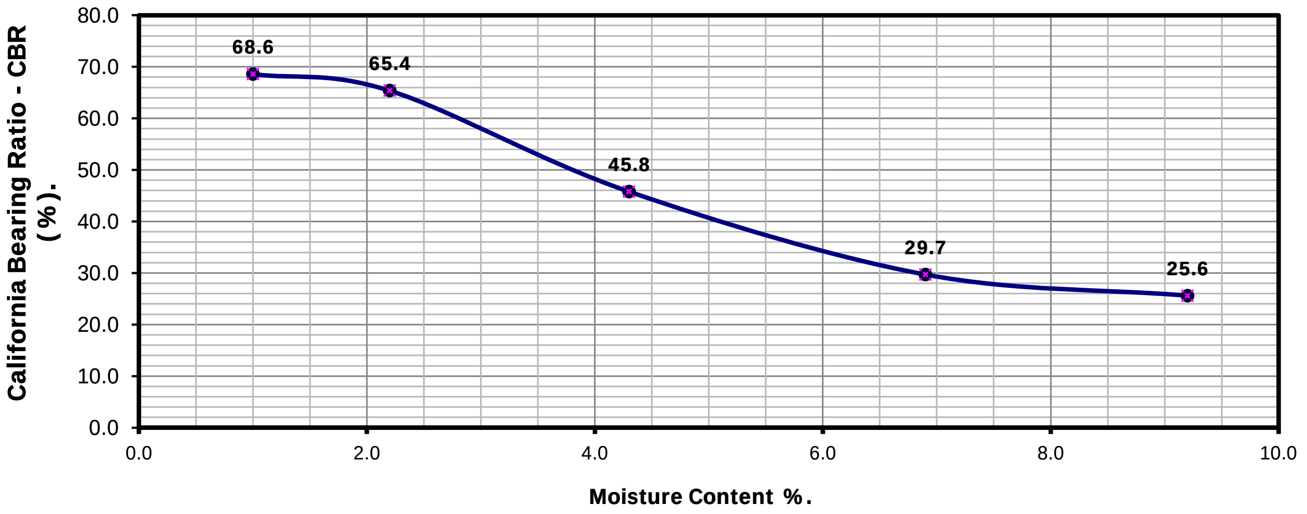
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**BH4**
Sample Number:	
Depth (m) : from	**4.50**
Depth (m) : to	**6.00**
Sample Type	**B**





Moisture Content	1.0	2.2	4.3	6.9	9.2	
CBR Value Top	68.6	65.4	45.8	29.7	25.6	
CBR Value Bot	68.6	65.4	45.8	29.7	25.6	
Mean CBR Value	69	65	46	30	26	
Dry Density	1.89	1.95	2.07	2.01	1.94	

Initial Sample Conditions:		Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):	6.9	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):	6	Maximum Dry Density (Mg/m^{3}	2.07
Material Retained on the 20.0mm BS Sieve (%):	43	Optimum Moisture Content (%	4
Particle Density (Mg/m^{3}) : Assumed	2.65		

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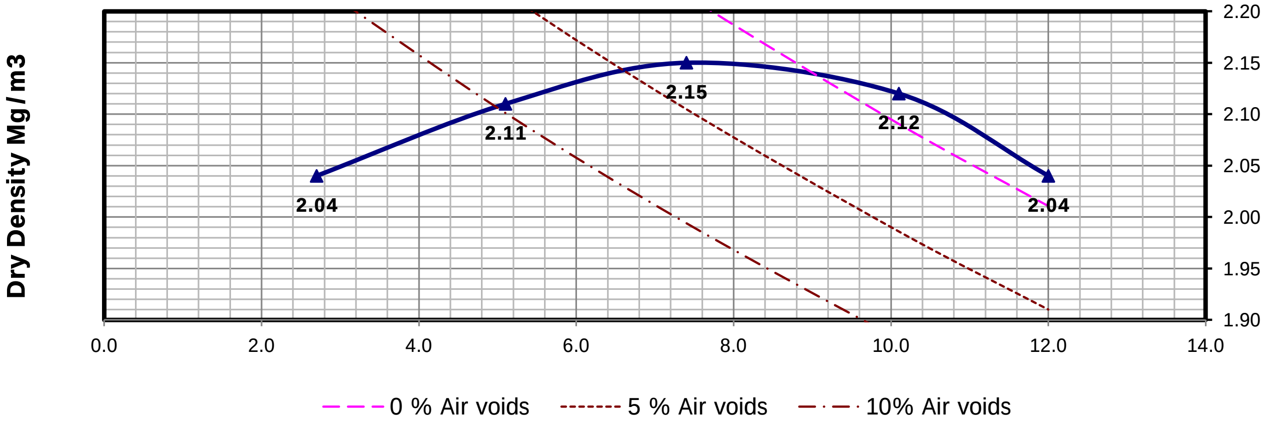
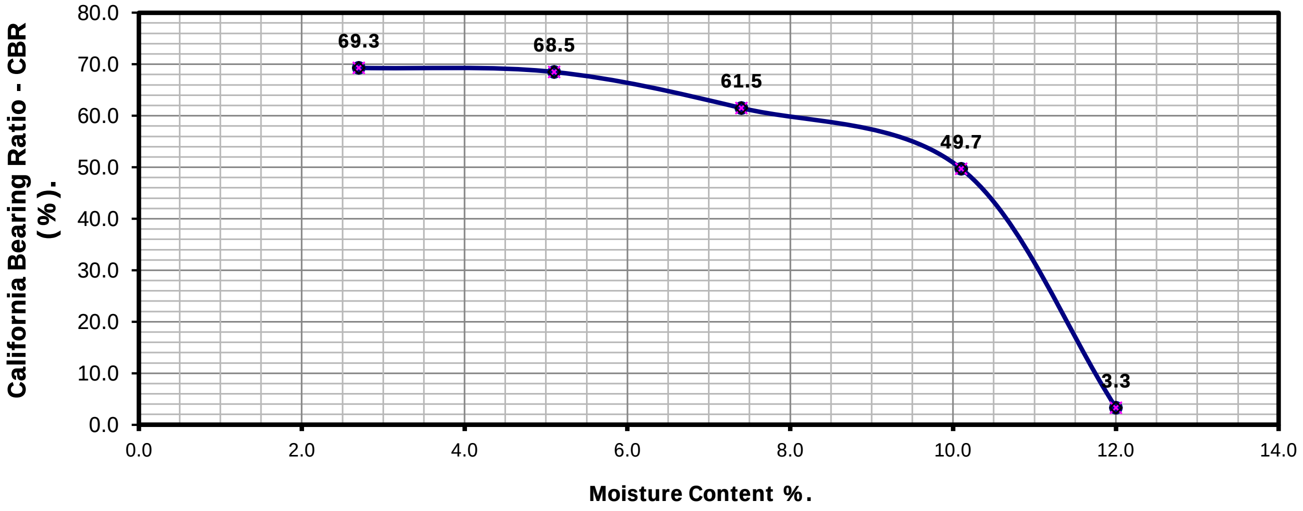
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**BH10**
Sample Number:	
Depth (m) : from	**1.20**
Depth (m) : to	**2.20**
Sample Type	**B**





Moisture Content	2.7	5.1	7.4	10.1	12.0
CBR Value Top	69.3	68.5	61.5	49.7	3.3
CBR Value Bot	69.3	68.5	61.5	49.7	3.3
Mean CBR Value	69	69	62	50	3
Dry Density	2.04	2.11	2.15	2.12	2.04

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		10.1	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		2	Maximum Dry Density (Mg/m^{3})	2.15
Material Retained on the 20.0mm BS Sieve (%):		11	Optimum Moisture Content (%	7
Particle Density (Mg/m^{3}) :	Assumed	2.65		

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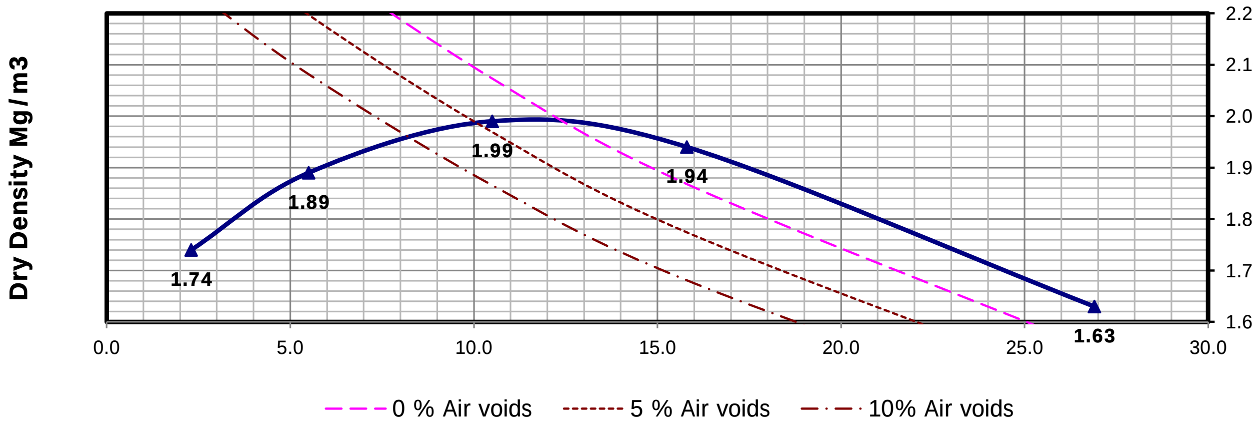
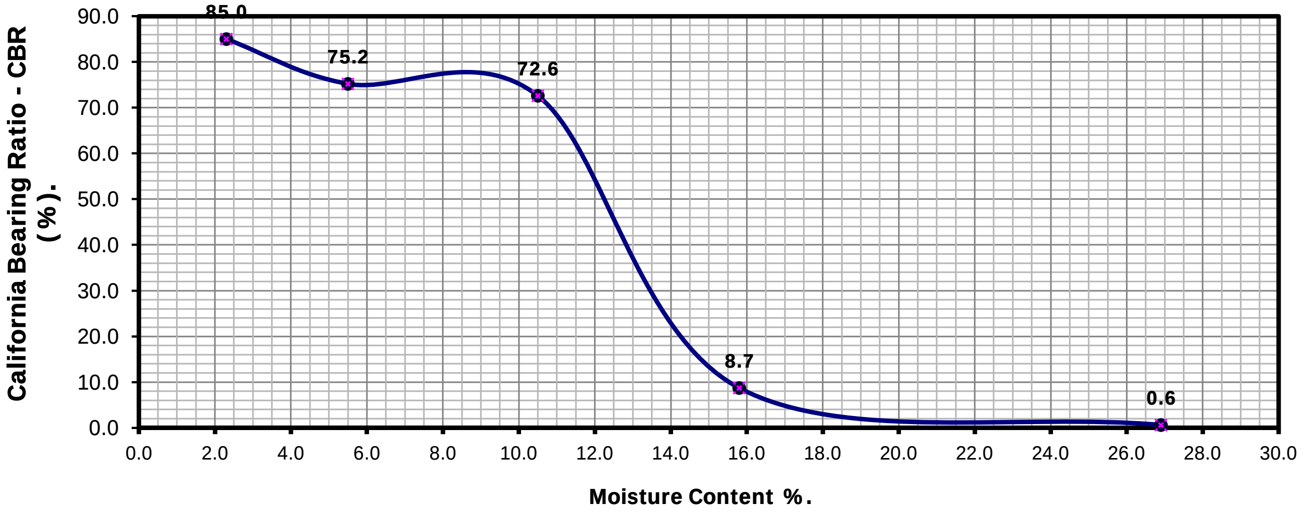
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio/Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP3**
Sample Number:	
Depth (m) : from	**3.40**
Depth (m) : to	**3.70**
Sample Type	**B**





Moisture Content	2.3	5.5	10.5	15.8	26.9
CBR Value Top	85.0	75.2	72.6	8.7	0.6
CBR Value Bot	85.0	75.2	72.6	8.7	0.6
Mean CBR Value	85	75	73	9	1
Dry Density	1.74	1.89	1.99	1.94	1.63

Initial Sample Conditions:		Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):	26.9	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):	3	Maximum Dry Density (Mg/m^{3})	1.99
Material Retained on the 20.0mm BS Sieve (%):	3	Optimum Moisture Content (%	10
Particle Density (Mg/m^{3}) : Assumed	2.65		

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Checked by	**Date**	**Approved by**	**Date**

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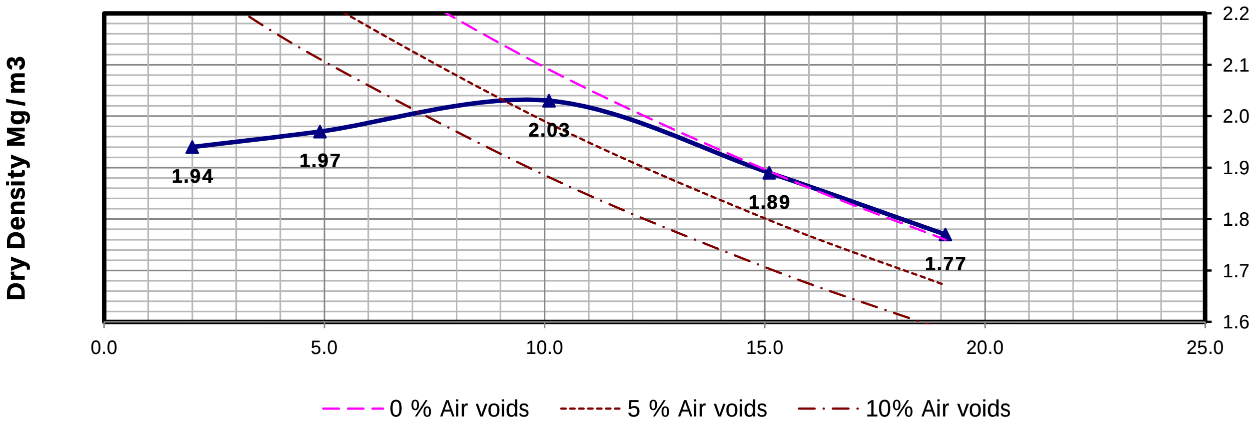
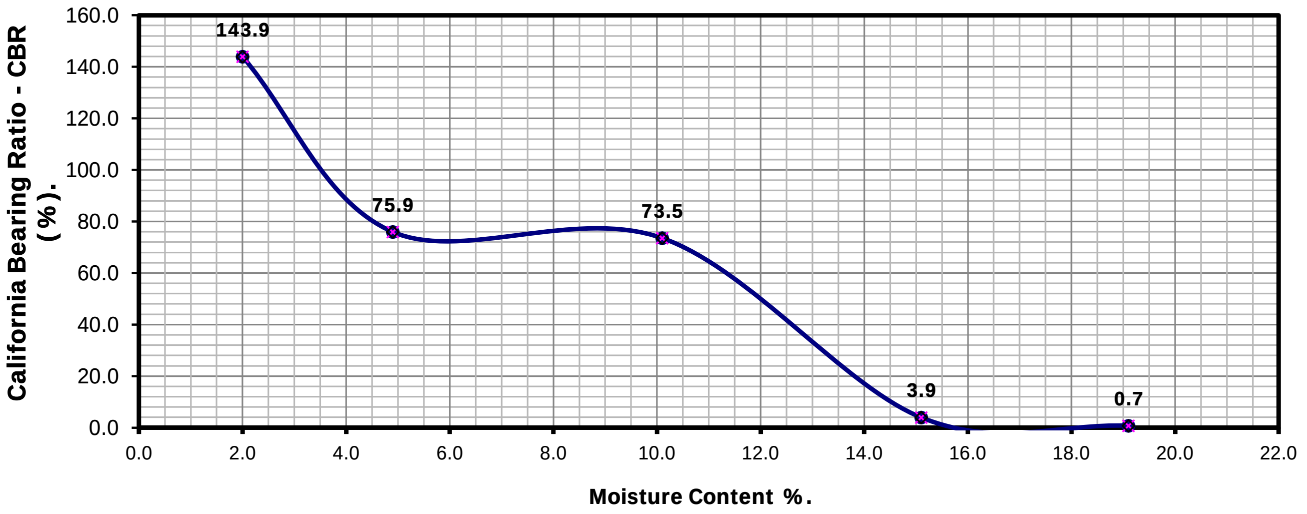
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP4**
Sample Number:	
Depth (m) : from	**1.80**
Depth (m) : to	**2.10**
Sample Type	**B**





Moisture Content	2.0	4.9	10.1	15.1	19.1
CBR Value Top	143.9	75.9	73.5	3.9	0.7
CBR Value Bot	143.9	75.9	73.5	3.9	0.7
Mean CBR Value	144	76	74	4	1
Dry Density	1.94	1.97	2.03	1.89	1.77

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		10.3	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		2	Maximum Dry Density (Mg/m^{3}	2.03
Material Retained on the 20.0mm BS Sieve (%):		6	Optimum Moisture Content (%	10
Particle Density (Mg/m^{3}) :	Assumed	2.65		

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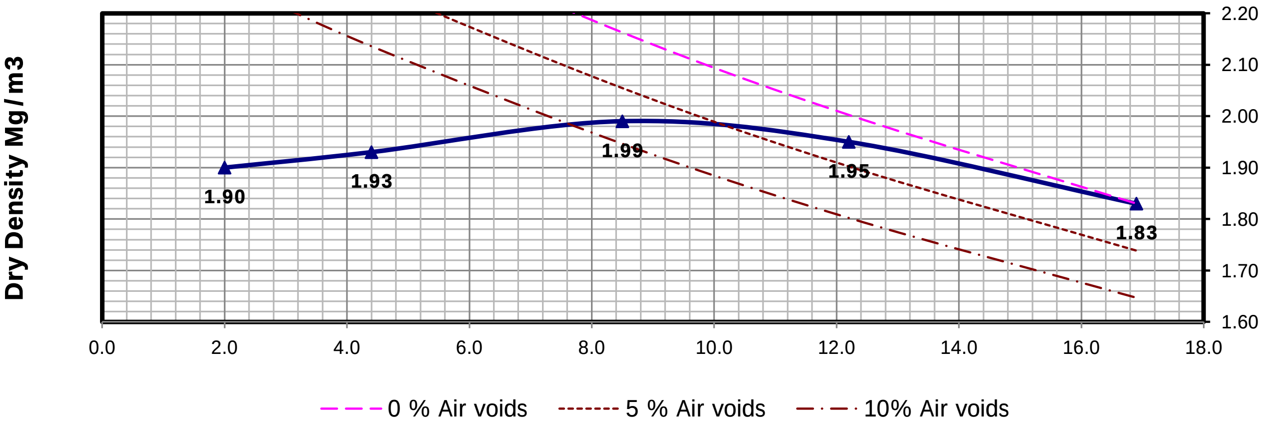
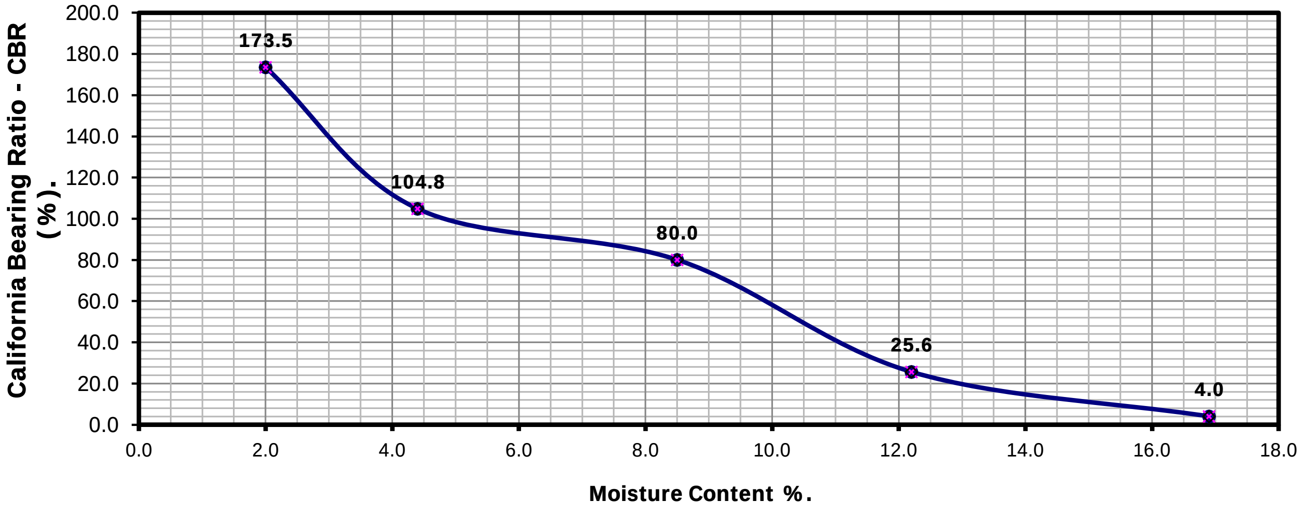
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship
BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP19**
Sample Number:	
Depth (m) : from	**3.00**
Depth (m) : to	**3.40**
Sample Type	**B**





Moisture Content	2.0	4.4	8.5	12.2	16.9	
CBR Value Top	173.5	104.8	80.0	25.6	4.0	
CBR Value Bot	173.5	104.8	80.0	25.6	4.0	
Mean CBR Value	174	105	80	26	4	
Dry Density	1.90	1.93	1.99	1.95	1.83	

Initial Sample Conditions:		Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):	19.1	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):	17	Maximum Dry Density (Mg/m^3	1.99
Material Retained on the 20.0mm BS Sieve (%):	4	Optimum Moisture Content (%	9
Particle Density (Mg/m^3) : Assumed	2.65		

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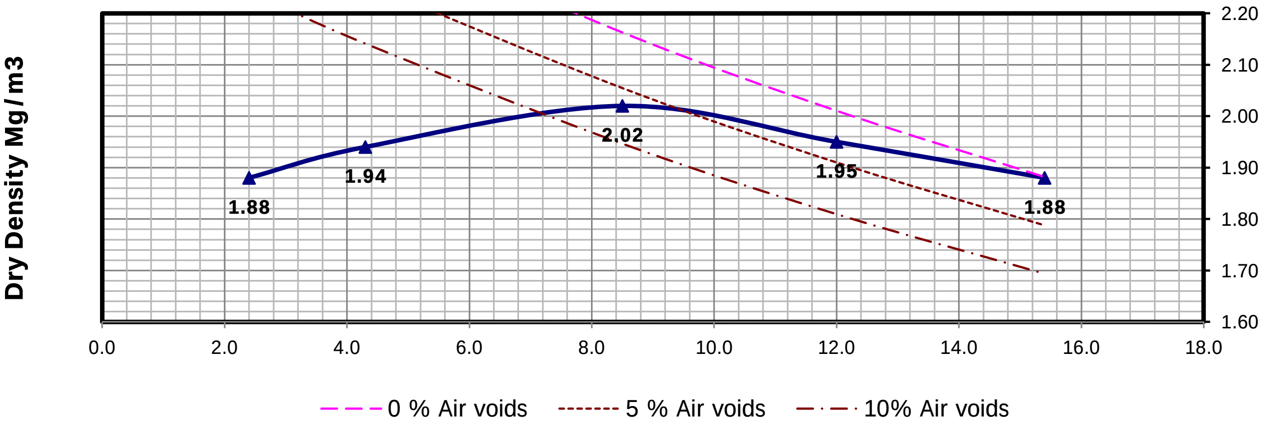
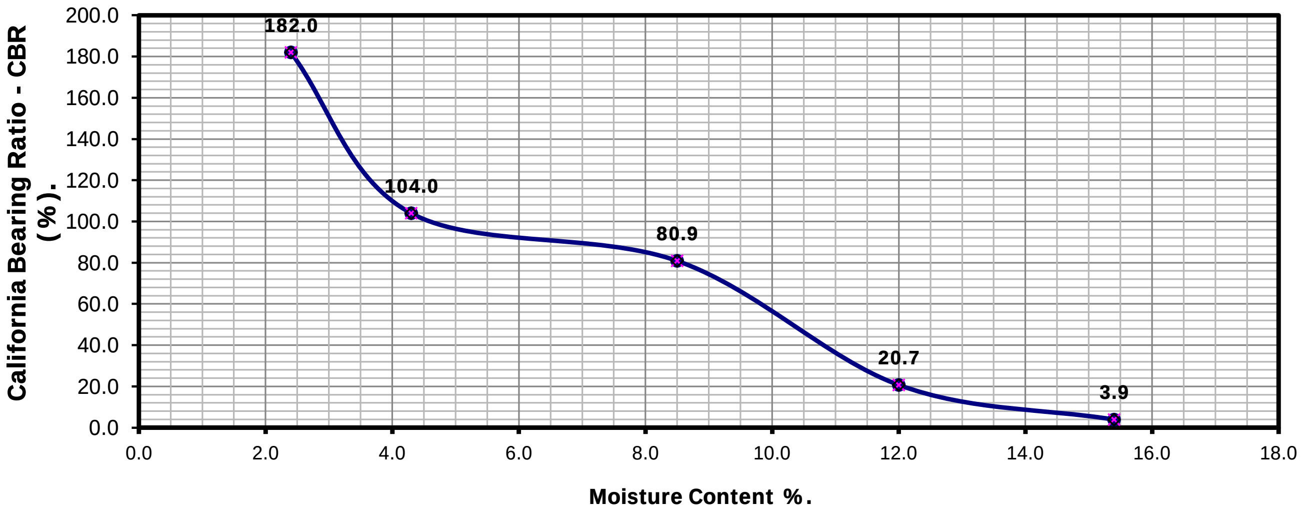
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP20**
Sample Number:	
Depth (m) : from	**2.90**
Depth (m) : to	**3.30**
Sample Type	**B**





Moisture Content	2.4	4.3	8.5	12.0	15.4
CBR Value Top	182.0	104.0	80.9	20.7	3.9
CBR Value Bot	182.0	104.0	80.9	20.7	3.9
Mean CBR Value	182	104	81	21	4
Dry Density	1.88	1.94	2.02	1.95	1.88

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		16.8	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		0	Maximum Dry Density (Mg/m^3)	2.05
Material Retained on the 20.0mm BS Sieve (%):		9	Optimum Moisture Content (%	9
Particle Density (Mg/m^3) :	Assumed	2.65		

DP Evans

Checked by **Date** **10-06-16**

Approved by **Date** **10-06-16**

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GEO SITE & TESTING SERVICES LTD

UKAS TESTING 2788

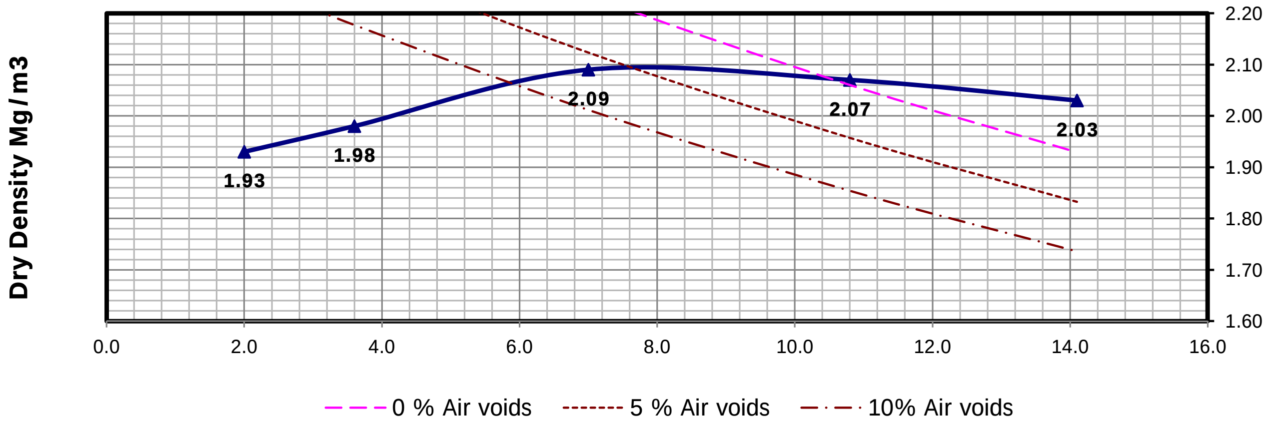
Contract No.: **30894-**

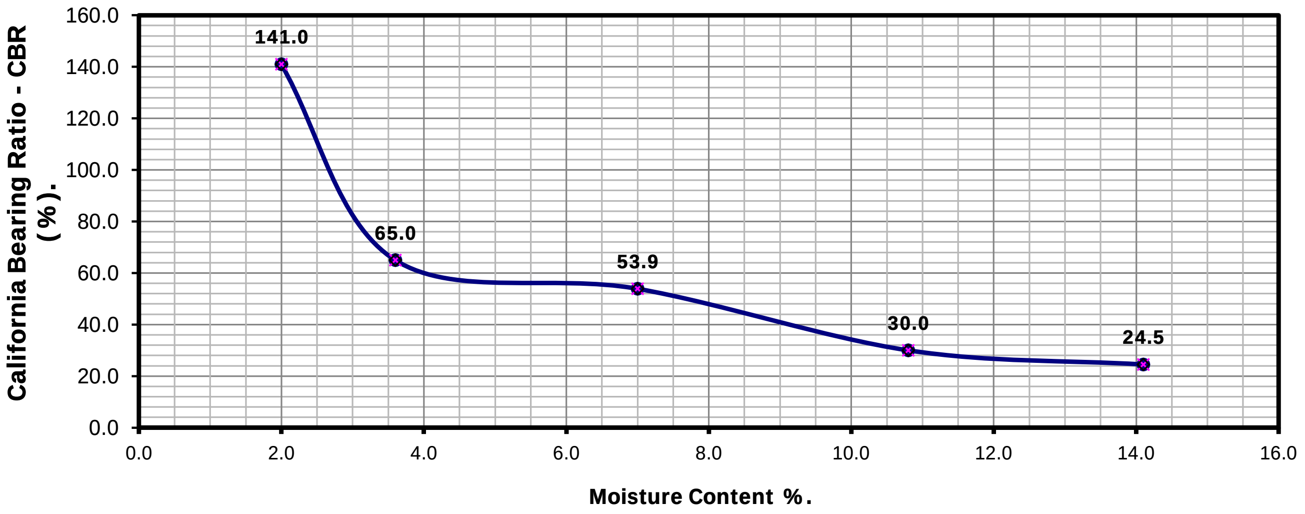
Client Ref No: **A096409**

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP21**
Sample Number:	
Depth (m) : from	**3.00**
Depth (m) : to	**3.40**
Sample Type	**B**





Moisture Content	2.0	3.6	7.0	10.8	14.1	
CBR Value Top	141.0	65.0	53.9	30.0	24.5	
CBR Value Bot	141.0	65.0	53.9	30.0	24.5	
Mean CBR Value	141	65	54	30	25	
Dry Density	1.93	1.98	2.09	2.07	2.03	

Initial Sample Conditions:		Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):	16.9	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):	0	Maximum Dry Density (Mg/m^{3}	2.09
Material Retained on the 20.0mm BS Sieve (%):	9	Optimum Moisture Content (%	7
Particle Density (Mg/m^{3}) : Assumed	2.65		

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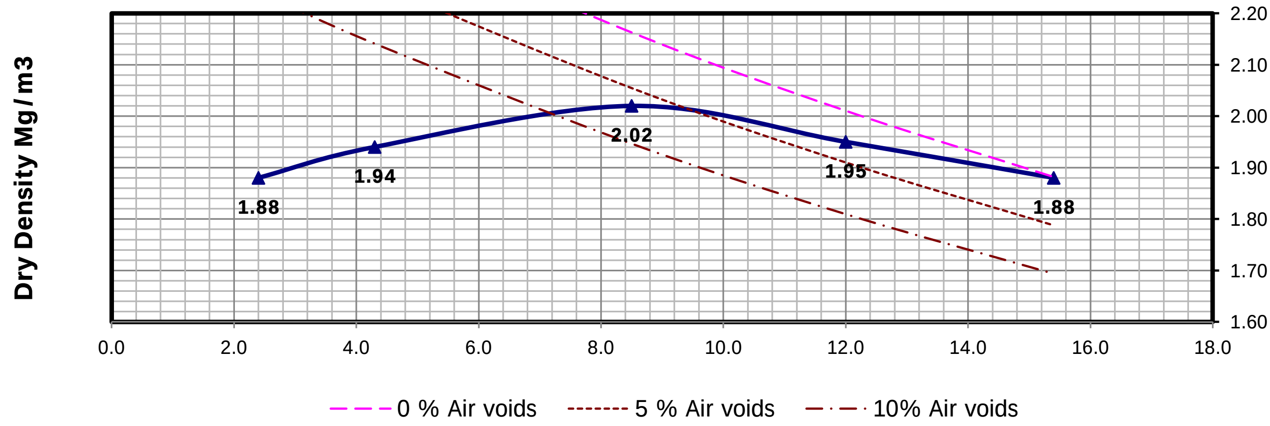
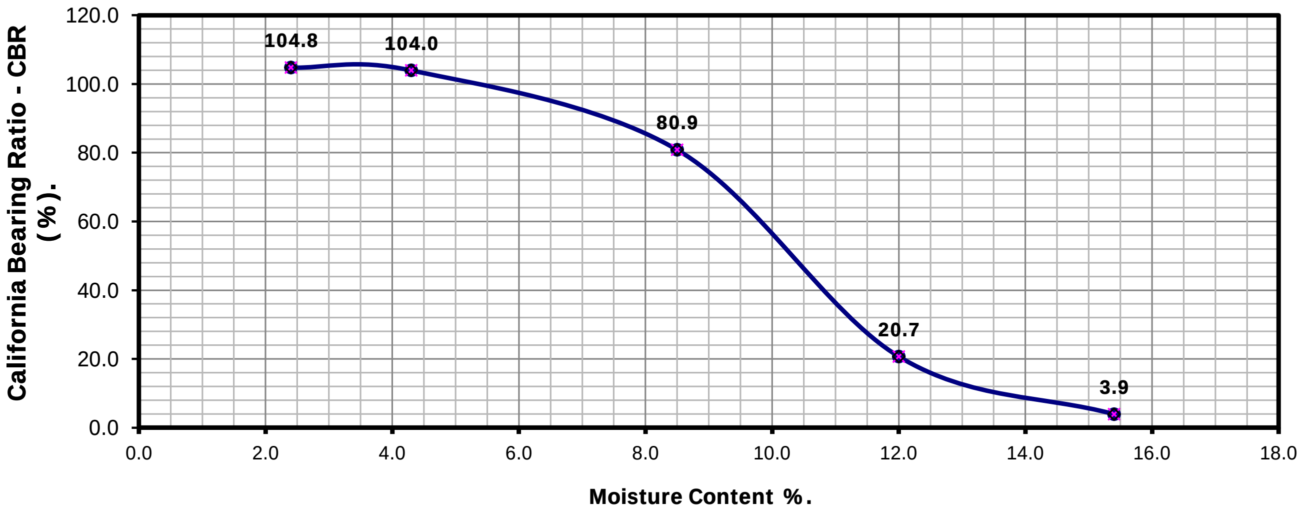
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP24**
Sample Number:	
Depth (m) : from	**1.80**
Depth (m) : to	**2.20**
Sample Type	**B**





Moisture Content	2.4	4.3	8.5	12.0	15.4
CBR Value Top	104.8	104.0	80.9	20.7	3.9
CBR Value Bot	104.8	104.0	80.9	20.7	3.9
Mean CBR Value	105	104	81	21	4
Dry Density	1.88	1.94	2.02	1.95	1.88

Initial Sample Conditions:		Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):	15.4	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):	2	Maximum Dry Density (Mg/m^3)	2.02
Material Retained on the 20.0mm BS Sieve (%):	7	Optimum Moisture Content (%	9
Particle Density (Mg/m^3) : Assumed	2.65		

10-06-16 **10-06-16**

Checked by **Date** **Approved by** **Date**

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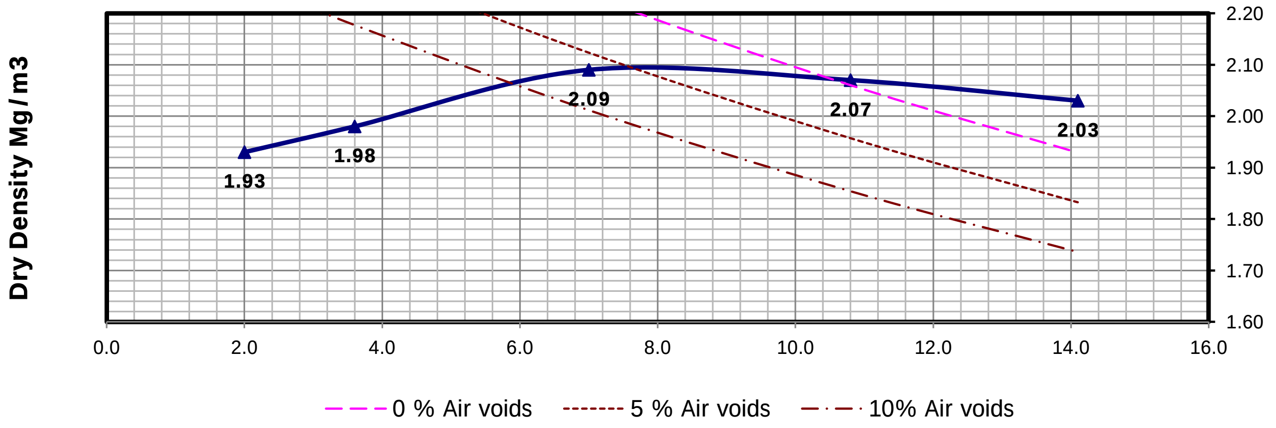
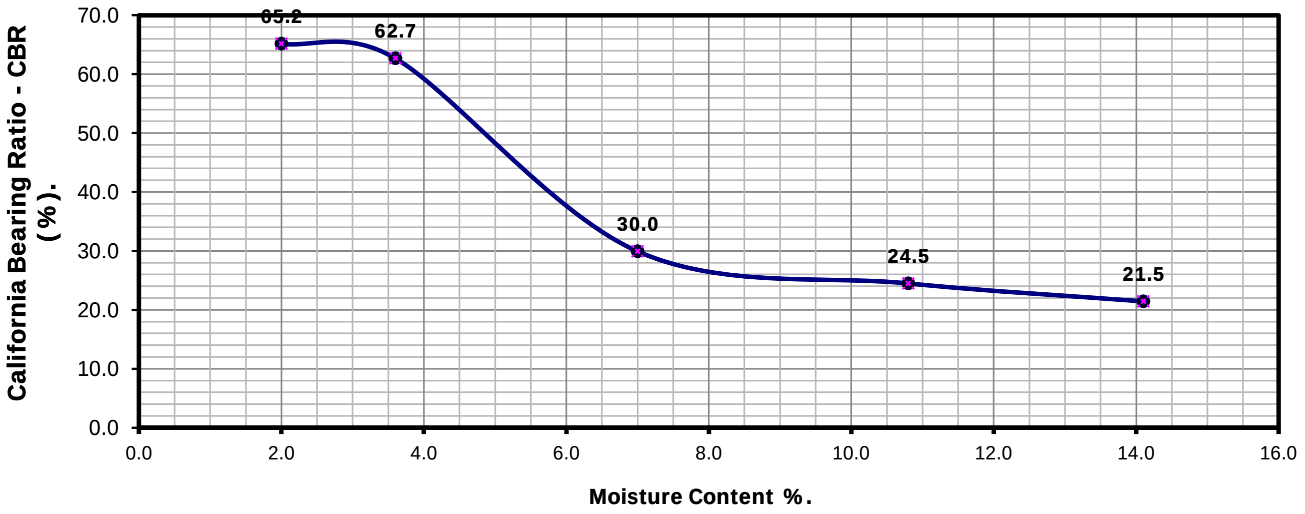
Contract No.:
30894-
Client Ref No:
A096409

California Bearing Ratio / Dry Density Moisture Content Relationship

BS 1377:Part 4:1990

Client ref:	**A096409**
Location:	**A40**
Contract Number:	**30894-**
Hole Number:	**TP29**
Sample Number:	
Depth (m) : from	**1.90**
Depth (m) : to	**2.30**
Sample Type	**B**





Moisture Content	2.0	3.6	7.0	10.8	14.1
CBR Value Top	65.2	62.7	30.0	24.5	21.5
CBR Value Bot	65.2	62.7	30.0	24.5	21.5
Mean CBR Value	65	63	30	25	21
Dry Density	1.93	1.98	2.09	2.07	2.03

Initial Sample Conditions:			Method of Compaction 4.5 KG Rammer	
Initial Moisture Content (%):		10.8	Single sample Tested	
Material Retained on the 37.5mm BS Sieve (%):		11	Maximum Dry Density (Mg/m^{3},	2.09
Material Retained on the 20.0mm BS Sieve (%):		5	Optimum Moisture Content (%	7
Particle Density (Mg/m^{3}) :	Assumed	2.65		

DP Evans

Checked by	**10-06-16** **Date**	**Approved by**	**10-06-16** **Date**

GSTL
GEO SITE & TESTING SERVICES LTD

UKAS TESTING 2788

Contract No.:
30894-
Client Ref No:
A096409

GSTL
GEO Site & Testing Services Limited

Unit 4
Heol Aur
Dafen Ind EstateDafen
Carmarthenshire
SA14 8QN
Tel: 01554 784040
01554 750752
Fax: 01554 770529
01554 784041
Web: www.geo.uk.com

Certificate of Analysis

Date: 06-06-16

Client: WYG

Our Reference: 30894-200516

Client Reference: A096409

Contract Title: A40 Llanddewi Velery

Description: (Total Samples) 16

Date Received: 20-05-16

Date Started: 31-05-16

Date Completed: 06-06-16

Test Procedures: (B.S. 1377 : PART 3 : 1990 AND BRE CP2/79)

Notes:

Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate

Approved By:

D P Evans

Authorised Signatories:	Emma Williams Laboratory Office Manager	Dafydd Simon Laboratory Team Leader	Paul Evans Quality Manager

Contract No: 30894-200516

Client Ref: A096409

Location: A40 Llanddewi Velery

Date: 06-06-2016

Summary of Chemical Analysis

(B.S. 1377 : PART 3 : 1990 AND BRE CP2/79)

Hole Number	Sample Number	Depth m	Sulphate Content SO3 (as SO_4)			Chloride Content		pH Value @ 25°C Clause 9.	Total Sulphur %	Magnesium g/l	Nitrate mg/l	Organic %
			Acid Soluble Sulphate as % SO_4 Clause 5.5.	Aqueous Extract Sulphate as g/l SO_4 Clause 5.5.	Ground-water g/l Clause 5.4.	Soluble Chloride as % equiv. NaCl Clause 7.3	Ground-water g/l Clause 7.2					
TP5		0.30-0.50	0.15 (0.19)	0.01 (0.02)				7.39	0.02			
TP20		2.90-3.30	0.12 (0.14)	<.01 (0.01)				7.90	0.01			
TP21		1.80-2.30	0.17 (0.21)	<.01 (<.01)				8.02	0.03			
BH2		5.50-6.50	0.10 (0.12)	<.01 (<.01)				7.51	<.0.01			
BH4		12.00-13.00	0.07 (0.08)	<.01 (<.01)				7.34	<0.01			
BH5		7.00-8.00	0.12 (0.14)	<.01 (<.01)				7.85	0.02			
BH5		12.00-12.23	0.14 (0.16)	0.01 (0.02)				8.08	0.03			
BH6		6.20-7.20	0.15 (0.19)	<.01 (<.01)				7.95	0.01			
BH6		16.70-17.70	0.05 (0.06)	<.01 (<.01)				8.21	<0.01			
BH10		9.30-10.80	0.10 (0.12)	<.01 (0.01)				7.82	<0.01			
BH12		1.50-3.00	0.12 (0.14)	<.01 (<.01)				7.52	0.01			
BH14		2.20-3.20	0.12 (0.14)	0.01 (0.01)				7.29	0.01			
BH15		8.30-8.66	0.10 (0.12)	0.01 (0.01)				7.75	<0.01			
BH15		2.70-4.20	0.03 (0.04)	<.01 (<.01)				7.41	<0.01			
BH17		1.20-2.20		0.01 (0.01)				7.64	0.02			
BH101		1.20-1.80	0.14 (0.16)	0.01 (0.01)				5.58	0.03			

NCP - No Chloride present

Test Report: Point Load Test

Int. J. Rock Mech. Sci. & Geomech. Abstr. Vol. 22, No. 2, pp. 51 - 60, 1985.

Client:	**WYG**
Location:	**A40**
Client Ref:	**A096409**
Contract Number:	**30894-**
Borehole Number:	**As stated below**
Core Box Number:	**N/A**
Depth (m):	**As stated below**
Date Tested:	**08-06-16**

Borehole Number	Sample Number	Depth	Type of Test		Width	Platen Separation	Failure Load	Equivalent Diameter	Point Load	Size Factor	Point Load Index	Moisture Content	Description	Angle between plane of anisotropy & core axis.	Type of anisotropy (Bedding or Cleavage).
		(m)	d a b/i	I //	(W) (mm)	(D) (mm)	(P) (kN)	(D_e) (mm)	(I_s) (MPa)	(F)	($I_{s(50)}$) (MPa)	(MC) (%)	(SC)		
BH1		6.83 - 7.27	a		74	46	6.36	66	1.47	1.13	1.66				
BH2		5.06 - 5.30	i		62	32	0.52	50	0.21	1.00	0.21				
		8.08 - 8.32	a		73	51	10.14	69	2.14	1.15	2.47				
BH3		4.00 - 4.35	d			73	2.81		0.53	1.19	0.62				
		14.60 - 14.80	a		73	59	3.41	74	0.62	1.19	0.74				
BH4		13.42 - 13.50	a		73	32	1.77	55	0.60	1.04	0.62				
		14.91 - 15.00	a		73	68	4.78	80	0.76	1.23	0.93				
		15.90 - 16.25	d			73	6.21		1.16	1.19	1.38				
			a		73	64	6.51	77	1.10	1.22	1.33				
		16.70 - 16.85	d			73	4.64		0.87	1.19	1.03				
BH5		9.70 - 9.90	a		72	50	2.52	68	0.55	1.15	0.63				
		10.40 - 10.50	d			82	0.24		0.04	1.25	0.04				
		11.30 - 11.45	d			72	6.54		1.26	1.18	1.49				
		12.00 - 12.23	d			72	4.26		0.82	1.18	0.97				
		13.35 - 13.55	d			72	1.86		0.36	1.18	0.42				
		14.20 - 14.33	a		72	52	10.54	69	2.21	1.16	2.56				
BH6		2.66 - 2.82	a		74	54	0.53	71	0.10	1.17	0.12				
		12.50 - 12.66	a		72	62	0.47	75	0.08	1.20	0.10				
		12.85 - 12.96	d			72	0.98		0.19	1.18	0.22				
		13.30 - 13.42	a		73	70	8.48	81	1.30	1.24	1.62				
		15.73 - 15.15	d			72	7.47		1.44	1.18	1.70				
		15.53 - 15.65	d			73	6.60		1.24	1.19	1.47				
BH7		5.06 - 5.30	a		74	59	4.63	75	0.83	1.20	1.00				
		8.50 - 8.70	d			73	7.64		1.43	1.19	1.70				
		10.00 - 10.15	d			73	1.06		0.20	1.19	0.24				
BH8		7.25 - 7.40	a		73	41	4.05	62	1.06	1.10	1.17				
BH9		5.00 - 5.50	d			73	0.09		0.02	1.19	0.02				
		7.85 - 8.10	d			73	0.20		0.04	1.19	0.04				
BH15		7.70 - 8.01	a		72	66	20.20	78	3.34	1.22	4.07				
		8.01 - 8.22	d			72	15.93		3.07	1.18	3.62				
		8.30 - 8.66	d			73	38.01		7.13	1.19	8.46				

Key : d = diametral; a = axial; b = block; i = irregular lump test; I = perpendicular; / / = parallel to planes of weakness.

Remarks:

GSTL
GEO SITE & TESTING SERVICES LTD

08-06-16

Checked By **Date**
Emma Sharp
Office Manager

DP Evans

08-06-16

Approved By **Date**
Paul Evans
Quality/Technical Manager

UKAS TESTING 2788

Test Report:

Determination of Unconfined Compressive Strength.
ISRM Suggested Methods Vol 16, No. 2, pp. 135-140 1979..

Date: 08-Jun-16
Contract Number: 30894-
Client reference: A096409
Location: A40
Sample Type: Core
Sample Preparation: Sawing and Grinding
Operator: Wayne Honey

Borehole Number	Depth (m) from	Depth (m) to	Diameter (mm)	Length (mm)	Initial Mass (g)	Bulk Density (Mg/m3)	Dry Density (Mg/m3)	Moisture Content (%)	Load Failure (kn)	Maximum Compressive Strength (mpa)	Date Tested
BH15	8.30	8.66	72.80	193.60	2080.2	2.58	2.56	0.80	711.2	170.8	07-Jun-16

For and behalf of GEO Site & Testing Services Limited

Paul Evans - Technical/Quality Manager ○
Emma Sharp - Office Manager ○
Ben Sharp - Contracts Manager ○
Jon Tatam - Quality/Office Assistant ●

Tatam

Date Approved: 8.6.16

GSTL
GEO SITE & TESTING SERVICES LTD

Test Report:

Method of the Determination of Resistance to Fragmentation by Los Angeles test Method

BS EN 1097:2:2010

Client:		WYG		
Client Ref:		A096409		
Contract Number:		30894-		
Location:		A40		
Date Sampled:		Unknown		
Date tested:		07-06-16		
Hole Number:		BH5		
Sample Number:		N/A		
Depth (m):	From	9.70	to	17.50
Method of Sampling:		BS 932-1 General requirements and sample preparation		
Sampled By:		Unknown		
Aggregate Type and Nominal Size:		14-10mm		
Target Specification:		N/A		

Los Angeles Coefficient 41

Remarks:

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced in full, without the prior written approval of the laboratory.

For and behalf of GEO Site & Testing Services Ltd

Authorised By:
Vaughan Edwards (Managing Director)

GSTL
GEO SITE & TESTING SERVICES LTD

Date: 8.6.16

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2788

GSTL
GEO Site & Testing Services Limited

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date:	08-Jun-16
Contract Number:	30894-
Location:	A40
Client Ref:	A096409
Hole Number:	BH2
Sample Number:	
Depth from (m):	5.50
Depth to (m):	6.50
Sample Type :	B
Nature of slaking Fluid:	Water
Temperature (^{0}C):	20
Rock type:	Greyish brown siltstone
Date Tested:	07-06-16
Operator:	Wayne Honey

Slake-Durability index (first cycle) %	**97.83**
Slake-Durability index (second cycle) %	**92.53**

Appearance of fragments retained in drum:

10 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ DP Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

GSTL
GEO Site & Testing Services Limited

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date:	08-Jun-16
Contract Number:	30894-
Location:	A40
Client Ref:	A096409
Hole Number:	BH4
Sample Number:	
Depth from (m):	12.00
Depth to (m):	13.00
Sample Type :	B
Nature of slaking Fluid:	Water
Temperature (^{0}C):	20
Rock type:	Greyish brown siltstone
Date Tested:	07-06-16
Operator:	Wayne Honey

Slake-Durability index (first cycle) %	**89.68**
Slake-Durability index (second cycle) %	**79.19**

Appearance of fragments retained in drum:

10 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ D P Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

GSTL
GEO Site & Testing Services Limited

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date:	08-Jun-16
Contract Number:	30894-
Location:	A40
Client Ref:	A096409
Hole Number:	BH5
Sample Number:	
Depth from (m):	7.00
Depth to (m):	8.00
Sample Type :	B
Nature of slaking Fluid:	Water
Temperature (^{0}C):	20
Rock type:	Greyish brown siltstone
Date Tested:	07-06-16
Operator:	Wayne Honey

Slake-Durability index (first cycle) %	**88.14**
Slake-Durability index (second cycle) %	**79.12**

Appearance of fragments retained in drum:

11 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ D P Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date: 08-Jun-16
Contract Number: 30894-
Location: A40
Client Ref: A096409
Hole Number: BH5
Sample Number:
Depth from (m): 9.70
Depth to (m): 17.50
Sample Type : B
Nature of slaking Fluid: Water
Temperature (^{0}C): 20
Rock type: Greyish brown siltstone
Date Tested: 07-06-16
Operator: Wayne Honey

Slake-Durability index (first cycle) % **89.73**

Slake-Durability index (second cycle) % **81.96**

Appearance of fragments retained in drum:

12 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ DP Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

GSTL
GEO Site & Testing Services Limited

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date: 08-Jun-16
Contract Number: 30894-
Location: A40
Client Ref: A096409
Hole Number: BH6
Sample Number:
Depth from (m): 6.20
Depth to (m): 7.20
Sample Type : B
Nature of slaking Fluid: Water
Temperature (^{0}C): 20
Rock type: Greyish brown siltstone
Date Tested: 07-06-16
Operator: Wayne Honey

Slake-Durability index (first cycle) % **90.01**

Slake-Durability index (second cycle) % **83.49**

Appearance of fragments retained in drum:

10 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ DP Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

Test Report: **Method of the Determination of the Slake Durability index.**
ISRM Part 2.2 (Page 104)

Date:	08-Jun-16
Contract Number:	30894-
Location:	A40
Client Ref:	A096409
Hole Number:	BH6
Sample Number:	
Depth from (m):	16.70
Depth to (m):	17.70
Sample Type :	B
Nature of slaking Fluid:	Water
Temperature (^{0}C):	20
Rock type:	Greyish brown siltstone
Date Tested:	07-06-16
Operator:	Wayne Honey

Slake-Durability index (first cycle) % **85.92**

Slake-Durability index (second cycle) % **77.21**

Appearance of fragments retained in drum:

14 pieces of sub-angualr to rounded rock core with some pieces with ground corners and edges

Appearance of material passing through the drum:

Sub-angular to well rounded of <2mm fragments to a silt

If there is any remaining samples it shall be retained for
a period of one month from the above date,
after which time all samples shall be disposed of.

For and behalf of GEO Site & Testing Ltd

Paul Evans - Quailty Manager ○ DP Evans

Emma Williams - Office Manager ○

Date Approved: 8.6.16

Appendix E – Environmental Laboratory Testing Suites

Jones Environmental Laboratory

Registered Address : Unit 3 Deeside Point, Zone 3, Deeside Industrial Park, Deeside, CH5 2UA. UK

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

4225

WYG
5th Floor
Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Attention :	Paul Vincent
Date :	3rd June, 2016
Your reference :	A096409
Our reference :	Test Report 16/8720 Batch 1
Location :	A40 Llandewi Velfrey
Date samples received :	11th May, 2016
Status :	Final report
Issue :	1

Eight samples were received for analysis on 11th May, 2016 of which two were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Bruce Leslie
Project Co-ordinator

Client Name:	WYG	**Report :**	**Solid**
Reference:	A096409		
Location:	A40 Llandewi Velfrey	**Solids:**	V=60g VOC jar, J=250g glass jar, T=plastic tub
Contact:	Paul Vincent		
JE Job No.:	16/8720		

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-4	25-28											
Sample ID	TP1	TP3											
Depth	0.30	2.50											
COC No / misc													
Containers	V J T	V J T											
Sample Date	09/05/2016	09/05/2016											
Sample Type	Soil	Soil											
Batch Number	1	1											
Date of Receipt	11/05/2016	11/05/2016									LOD/LOR	Units	Method No.
Arsenic $^{\#M}$	20.4	17.1									<0.5	mg/kg	TM30/PM15
Barium $^{\#M}$	245	135									<1	mg/kg	TM30/PM15
Beryllium	1.5	1.1									<0.5	mg/kg	TM30/PM15
Cadmium $^{\#M}$	<0.1	0.4									<0.1	mg/kg	TM30/PM15
Chromium $^{\#M}$	44.9	54.8									<0.5	mg/kg	TM30/PM15
Copper $^{\#M}$	18	30									<1	mg/kg	TM30/PM15
Lead $^{\#M}$	16	48									<5	mg/kg	TM30/PM15
Mercury $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM30/PM15
Nickel $^{\#M}$	33.0	26.2									<0.7	mg/kg	TM30/PM15
Selenium $^{\#M}$	<1	1									<1	mg/kg	TM30/PM15
Vanadium	34	28									<1	mg/kg	TM30/PM15
Water Soluble Boron $^{\#M}$	0.6	0.8									<0.1	mg/kg	TM74/PM32
Zinc $^{\#M}$	76	371									<5	mg/kg	TM30/PM15
TPH CWG													
Aliphatics													
>C5-C6 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C6-C8 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C8-C10	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C10-C12 $^{\#M}$	<0.2	<0.2									<0.2	mg/kg	TM5/PM16
>C12-C16 $^{\#M}$	<4	<4									<4	mg/kg	TM5/PM16
>C16-C21 $^{\#M}$	<7	<7									<7	mg/kg	TM5/PM16
>C21-C35 $^{\#M}$	<7	<7									<7	mg/kg	TM5/PM16
Total aliphatics C5-35	<19	<19									<19	mg/kg	TM5/TM36/PM12/PM16
Aromatics													
>C5-EC7	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC7-EC8	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC8-EC10 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC10-EC12	<0.2	<0.2									<0.2	mg/kg	TM5/PM16
>EC12-EC16	<4	<4									<4	mg/kg	TM5/PM16
>EC16-EC21	<7	<7									<7	mg/kg	TM5/PM16
>EC21-EC35	<7	63									<7	mg/kg	TM5/PM16
Total aromatics C5-35	<19	63									<19	mg/kg	TM5/TM36/PM12/PM16
Total aliphatics and aromatics(C5-35)	<38	63									<38	mg/kg	TM5/TM36/PM12/PM16
MTBE $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Benzene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Toluene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Ethylbenzene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
m/p-Xylene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
o-Xylene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Natural Moisture Content	4.0	21.6									<0.1	%	PM4/PM0

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent
JE Job No.: 16/8720

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-4	25-28											
Sample ID	TP1	TP3											
Depth	0.30	2.50											
COC No / misc													
Containers	V J T	V J T											
Sample Date	09/05/2016	09/05/2016											
Sample Type	Soil	Soil											
Batch Number	1	1									LOD/LOR	Units	Method No.
Date of Receipt	11/05/2016	11/05/2016											
Total Organic Carbon $^{\#}$	0.29	3.28									<0.02	%	TM21/PM24
pH $^{\#M}$	8.02	8.27									<0.01	pH units	TM73/PM11

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent

Note:

Analysis was carried out in accordance with our documented in-house methods PM042 and TM065 and HSG 248 by Stereo and Polarised Light Microscopy using Dispersion Staining Techniques and is covered by our UKAS accreditation. Samples are retained for not less than 6 months from the date of analysis unless specifically requested.

Opinions lie outside the scope of our UKAS accreditation.

Where the sample is not taken by a Jones Environmental Laboratory consultant, Jones Environmental Laboratory cannot be responsible for inaccurate or unrepresentative sampling.

Signed on behalf of Jones Environmental Laboratory:

Ryan Butterworth
Asbestos Team Leader

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Date Of Analysis	Analysis	Result
16/8720	1	TP1	0.30	2	01/06/2016	**General Description (Bulk Analysis)**	soil/stones
					01/06/2016	**Asbestos Fibres**	NAD
					01/06/2016	**Asbestos Fibres (2)**	NAD
					01/06/2016	**Asbestos ACM**	NAD
					01/06/2016	**Asbestos ACM (2)**	NAD
					01/06/2016	**Asbestos Type**	NAD
					01/06/2016	**Asbestos Type (2)**	NAD
					01/06/2016	**Asbestos Level Screen**	NAD
16/8720	1	TP3	2.50	26	01/06/2016	**General Description (Bulk Analysis)**	soil/stones
					01/06/2016	**Asbestos Fibres**	NAD
					01/06/2016	**Asbestos Fibres (2)**	NAD
					01/06/2016	**Asbestos ACM**	NAD
					01/06/2016	**Asbestos ACM (2)**	NAD
					01/06/2016	**Asbestos Type**	NAD
					01/06/2016	**Asbestos Type (2)**	NAD
					01/06/2016	**Asbestos Level Screen**	NAD

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 16/8720

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 (UKAS) accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS) accredited - UK.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
PM4	Gravimetric measurement of Natural Moisture Content and % Moisture Content at either 35°C or 105°C. Calculation based on ISO 11465 and BS1377.	PM0	No preparation is required.				
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.			AR	Yes
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.	Yes	Yes	AR	Yes
TM5/TM36	TM005: Modified USEPA 8015B. Determination of solvent Extractable Petroleum Hydrocarbons (EPH) including column fractionation in the carbon range of C10-35 into aliphatic and aromatic fractions by GC-FID. TM036: Modified USEPA 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C5-10 by headspace GC-FID.	PM12/PM16	CWG GC-FID			AR	Yes
TM21	Modified USEPA 415.1. Determination of Total Organic Carbon or Total Carbon by combustion in an Eltra TOC furnace/analyser in the presence of oxygen. The CO2 generated is quantified using infra-red detection.	PM24	Dried and ground solid samples are washed with hydrochloric acid, then rinsed with deionised water to remove the mineral carbon before TOC analysis.	Yes		AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.			AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.	Yes	Yes	AD	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes		AR	Yes
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes	Yes	AR	Yes
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.			AR	
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.	Yes		AR	
TM73	Modified US EPA methods 150.1 and 9045D. Determination of pH by Metrohm automated probe analyser.	PM11	Extraction of as received solid samples using one part solid to 2.5 parts deionised water.	Yes	Yes	AR	No
TM74	Analysis of water soluble boron (20:1 extract) by ICP-OES.	PM32	Hot water soluble boron is extracted from dried and ground samples using a 20:1 ratio.	Yes	Yes	AD	Yes

Jones Environmental Laboratory

Registered Address : Unit 3 Deeside Point, Zone 3, Deeside Industrial Park, Deeside, CH5 2UA. UK

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

WYG
5th Floor
Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Attention : Paul Vincent

Date : 3rd June, 2016

Your reference : A096409

Our reference : Test Report 16/8720 Batch 2

Location : A40 Llandewi Velfrey

Date samples received : 11th May, 2016

Status : Final report

Issue : 1

Eleven samples were received for analysis on 11th May, 2016 of which one was scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Bruce Leslie
Project Co-ordinator

Client Name:	WYG
Reference:	A096409
Location:	A40 Llandewi Velfrey
Contact:	Paul Vincent
JE Job No.:	16/8720

Report : **Solid**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	41-44											
Sample ID	TP20											
Depth	0.15											
COC No / misc												
Containers	V J T											
Sample Date	05/05/2016											
Sample Type	Soil											
Batch Number	2										LOD/LOR	Units	Method No.
Date of Receipt	11/05/2016											
Arsenic #M	11.5										<0.5	mg/kg	TM30/PM15
Barium #M	90										<1	mg/kg	TM30/PM15
Beryllium	0.8										<0.5	mg/kg	TM30/PM15
Cadmium #M	<0.1										<0.1	mg/kg	TM30/PM15
Chromium #M	34.4										<0.5	mg/kg	TM30/PM15
Copper #M	15										<1	mg/kg	TM30/PM15
Lead #M	34										<5	mg/kg	TM30/PM15
Mercury #M	<0.1										<0.1	mg/kg	TM30/PM15
Nickel #M	18.2										<0.7	mg/kg	TM30/PM15
Selenium #M	1										<1	mg/kg	TM30/PM15
Vanadium	24										<1	mg/kg	TM30/PM15
Water Soluble Boron #M	0.9										<0.1	mg/kg	TM74/PM32
Zinc #M	95										<5	mg/kg	TM30/PM15
TPH CWG												
Aliphatics												
>C5-C6 #M	<0.1										<0.1	mg/kg	TM36/PM12
>C6-C8 #M	<0.1										<0.1	mg/kg	TM36/PM12
>C8-C10	<0.1										<0.1	mg/kg	TM36/PM12
>C10-C12 #M	<0.2										<0.2	mg/kg	TM5/PM16
>C12-C16 #M	<4										<4	mg/kg	TM5/PM16
>C16-C21 #M	<7										<7	mg/kg	TM5/PM16
>C21-C35 #M	<7										<7	mg/kg	TM5/PM16
Total aliphatics C5-35	<19										<19	mg/kg	TM5/TM36/PM12/PM16
Aromatics												
>C5-EC7	<0.1										<0.1	mg/kg	TM36/PM12
>EC7-EC8	<0.1										<0.1	mg/kg	TM36/PM12
>EC8-EC10 #M	<0.1										<0.1	mg/kg	TM36/PM12
>EC10-EC12	<0.2										<0.2	mg/kg	TM5/PM16
>EC12-EC16	<4										<4	mg/kg	TM5/PM16
>EC16-EC21	<7										<7	mg/kg	TM5/PM16
>EC21-EC35	17										<7	mg/kg	TM5/PM16
Total aromatics C5-35	<19										<19	mg/kg	TM5/TM36/PM12/PM16
Total aliphatics and aromatics(C5-35)	<38										<38	mg/kg	TM5/TM36/PM12/PM16
MTBE #	<5										<5	ug/kg	TM31/PM12
Benzene #	<5										<5	ug/kg	TM31/PM12
Toluene #	<5										<5	ug/kg	TM31/PM12
Ethylbenzene #	<5										<5	ug/kg	TM31/PM12
m/p-Xylene #	<5										<5	ug/kg	TM31/PM12
o-Xylene #	<5										<5	ug/kg	TM31/PM12
Natural Moisture Content	18.3										<0.1	%	PM4/PM0

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent
JE Job No.: 16/8720

Report : **Solid**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	41-44												
Sample ID	TP20												
Depth	0.15												
COC No / misc													
Containers	V J T												
Sample Date	05/05/2016												
Sample Type	Soil												
Batch Number	2												
Date of Receipt	11/05/2016											LOD/LOR	Units	Method No.
Total Organic Carbon $^{\#}$	2.17										<0.02	%	TM21/PM24
pH $^{\#M}$	8.09										<0.01	pH units	TM73/PM11

Client Name:	WYG
Reference:	A096409
Location:	A40 Llandewi Velfrey
Contact:	Paul Vincent

Note:

Analysis was carried out in accordance with our documented in-house methods PM042 and TM065 and HSG 248 by Stereo and Polarised Light Microscopy using Dispersion Staining Techniques and is covered by our UKAS accreditation. Samples are retained for not less than 6 months from the date of analysis unless specifically requested.

Opinions lie outside the scope of our UKAS accreditation.

Where the sample is not taken by a Jones Environmental Laboratory consultant, Jones Environmental Laboratory cannot be responsible for inaccurate or unrepresentative sampling.

Signed on behalf of Jones Environmental Laboratory:

Ryan Butterworth
Asbestos Team Leader

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Date Of Analysis	Analysis	Result
16/8720	2	TP20	0.15	42	01/06/2016	**General Description (Bulk Analysis)**	Soil/Stones
					01/06/2016	**Asbestos Fibres**	NAD
					01/06/2016	**Asbestos Fibres (2)**	NAD
					01/06/2016	**Asbestos ACM**	NAD
					01/06/2016	**Asbestos ACM (2)**	NAD
					01/06/2016	**Asbestos Type**	NAD
					01/06/2016	**Asbestos Type (2)**	NAD
					01/06/2016	**Asbestos Level Screen**	NAD

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 16/8720

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

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Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

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As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS) accredited - UK.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
PM4	Gravimetric measurement of Natural Moisture Content and % Moisture Content at either 35°C or 105°C. Calculation based on ISO 11465 and BS1377.	PM0	No preparation is required.				
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.			AR	Yes
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.	Yes	Yes	AR	Yes
TM5/TM36	TM005: Modified USEPA 8015B. Determination of solvent Extractable Petroleum Hydrocarbons (EPH) including column fractionation in the carbon range of C10-35 into aliphatic and aromatic fractions by GC-FID. TM036: Modified USEPA 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C5-10 by headspace GC-FID.	PM12/PM16	CWG GC-FID			AR	Yes
TM21	Modified USEPA 415.1. Determination of Total Organic Carbon or Total Carbon by combustion in an Eltra TOC furnace/analyser in the presence of oxygen. The CO2 generated is quantified using infra-red detection.	PM24	Dried and ground solid samples are washed with hydrochloric acid, then rinsed with deionised water to remove the mineral carbon before TOC analysis.	Yes		AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.			AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.	Yes	Yes	AD	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes		AR	Yes
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes	Yes	AR	Yes
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.			AR	
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.	Yes		AR	
TM73	Modified US EPA methods 150.1 and 9045D. Determination of pH by Metrohm automated probe analyser.	PM11	Extraction of as received solid samples using one part solid to 2.5 parts deionised water.	Yes	Yes	AR	No
TM74	Analysis of water soluble boron (20:1 extract) by ICP-OES.	PM32	Hot water soluble boron is extracted from dried and ground samples using a 20:1 ratio.	Yes	Yes	AD	Yes

Jones Environmental Laboratory

Registered Address : Unit 3 Deeside Point, Zone 3, Deeside Industrial Park, Deeside, CH5 2UA. UK

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Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

WYG
5th Floor
Longcross Court
47 Newport Road
Cardiff
CF24 0AD

Attention :	Paul Vincent
Date :	3rd June, 2016
Your reference :	A096409
Our reference :	Test Report 16/8720 Batch 3
Location :	A40 Llandewi Velfrey
Date samples received :	14th May, 2016
Status :	Final report
Issue :	1

Eight samples were received for analysis on 14th May, 2016 of which two were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Bruce Leslie
Project Co-ordinator

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent
JE Job No.: 16/8720

Report : **Solid**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	65-66	80-81											
Sample ID	BH102	BH12											
Depth	0.5	2.5											
COC No / misc													
Containers	V J	V J											
Sample Date	09/05/2016	12/05/2016											
Sample Type	Soil	Soil											
Batch Number	3	3										LOD/LOR	Units	Method No.
Date of Receipt	14/05/2016	14/05/2016												
Arsenic $^{\#M}$	21.8	22.5									<0.5	mg/kg	TM30/PM15
Barium $^{\#M}$	100	63									<1	mg/kg	TM30/PM15
Beryllium	1.6	1.0									<0.5	mg/kg	TM30/PM15
Cadmium $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM30/PM15
Chromium $^{\#M}$	51.8	42.6									<0.5	mg/kg	TM30/PM15
Copper $^{\#M}$	39	22									<1	mg/kg	TM30/PM15
Lead $^{\#M}$	41	8									<5	mg/kg	TM30/PM15
Mercury $^{\#M}$	0.2	<0.1									<0.1	mg/kg	TM30/PM15
Nickel $^{\#M}$	38.1	21.7									<0.7	mg/kg	TM30/PM15
Selenium $^{\#M}$	1	<1									<1	mg/kg	TM30/PM15
Vanadium	29	19									<1	mg/kg	TM30/PM15
Water Soluble Boron $^{\#M}$	1.0	0.4									<0.1	mg/kg	TM74/PM32
Zinc $^{\#M}$	134	41									<5	mg/kg	TM30/PM15
TPH CWG													
Aliphatics													
>C5-C6 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C6-C8 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C8-C10	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>C10-C12 $^{\#M}$	<0.2	<0.2									<0.2	mg/kg	TM5/PM16
>C12-C16 $^{\#M}$	12	<4									<4	mg/kg	TM5/PM16
>C16-C21 $^{\#M}$	41	39									<7	mg/kg	TM5/PM16
>C21-C35 $^{\#M}$	9	417									<7	mg/kg	TM5/PM16
Total aliphatics C5-35	62	456									<19	mg/kg	TM5/TM36/PM12/PM16
Aromatics													
>C5-EC7	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC7-EC8	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC8-EC10 $^{\#M}$	<0.1	<0.1									<0.1	mg/kg	TM36/PM12
>EC10-EC12	<0.2	<0.2									<0.2	mg/kg	TM5/PM16
>EC12-EC16	<4	<4									<4	mg/kg	TM5/PM16
>EC16-EC21	12	<7									<7	mg/kg	TM5/PM16
>EC21-EC35	<7	127									<7	mg/kg	TM5/PM16
Total aromatics C5-35	<19	127									<19	mg/kg	TM5/TM36/PM12/PM16
Total aliphatics and aromatics(C5-35)	62	583									<38	mg/kg	TM5/TM36/PM12/PM16
MTBE $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Benzene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Toluene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Ethylbenzene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
m/p-Xylene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
o-Xylene $^{\#}$	<5	<5									<5	ug/kg	TM31/PM12
Natural Moisture Content	21.4	8.5									<0.1	%	PM4/PM0

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent
JE Job No.: 16/8720

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	65-66	80-81											
Sample ID	BH102	BH12											
Depth	0.5	2.5											
COC No / misc													
Containers	V J	V J											
Sample Date	09/05/2016	12/05/2016											
Sample Type	Soil	Soil											
Batch Number	3	3									LOD/LOR	Units	Method No.
Date of Receipt	14/05/2016	14/05/2016											
Total Organic Carbon #	0.75	0.42									<0.02	%	TM21/PM24
pH #M	6.73	7.16									<0.01	pH units	TM73/PM11

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Client Name: WYG
Reference: A096409
Location: A40 Llandewi Velfrey
Contact: Paul Vincent

Note:

Analysis was carried out in accordance with our documented in-house methods PM042 and TM065 and HSG 248 by Stereo and Polarised Light Microscopy using Dispersion Staining Techniques and is covered by our UKAS accreditation. Samples are retained for not less than 6 months from the date of analysis unless specifically requested.

Opinions lie outside the scope of our UKAS accreditation.

Where the sample is not taken by a Jones Environmental Laboratory consultant, Jones Environmental Laboratory cannot be responsible for inaccurate or unrepresentative sampling.

Signed on behalf of Jones Environmental Laboratory:

Ryan Butterworth
Asbestos Team Leader

J E Job No.	Batch	Sample ID	Depth	J E Sample No.	Date Of Analysis	Analysis	Result
16/8720	3	BH102	0.5	66	01/06/2016	**General Description (Bulk Analysis)**	Soil/Stones
					01/06/2016	**Asbestos Fibres**	NAD
					01/06/2016	**Asbestos Fibres (2)**	NAD
					01/06/2016	**Asbestos ACM**	NAD
					01/06/2016	**Asbestos ACM (2)**	NAD
					01/06/2016	**Asbestos Type**	NAD
					01/06/2016	**Asbestos Type (2)**	NAD
					01/06/2016	**Asbestos Level Screen**	NAD
16/8720	3	BH12	2.5	81	01/06/2016	**General Description (Bulk Analysis)**	Soil/Stones
					01/06/2016	**Asbestos Fibres**	NAD
					01/06/2016	**Asbestos Fibres (2)**	NAD
					01/06/2016	**Asbestos ACM**	NAD
					01/06/2016	**Asbestos ACM (2)**	NAD
					01/06/2016	**Asbestos Type**	NAD
					01/06/2016	**Asbestos Type (2)**	NAD
					01/06/2016	**Asbestos Level Screen**	NAD

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 (UKAS) accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS) accredited - UK.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
PM4	Gravimetric measurement of Natural Moisture Content and % Moisture Content at either 35°C or 105°C. Calculation based on ISO 11465 and BS1377.	PM0	No preparation is required.				
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.			AR	Yes
TM5	Modified USEPA 8015B method for the determination of solvent Extractable Petroleum Hydrocarbons (EPH) with carbon banding within the range C8-C40 GC-FID.	PM16	Fractionation into aliphatic and aromatic fractions using a Rapid Trace SPE.	Yes	Yes	AR	Yes
TM5/TM36	TM005: Modified USEPA 8015B. Determination of solvent Extractable Petroleum Hydrocarbons (EPH) including column fractionation in the carbon range of C10-35 into aliphatic and aromatic fractions by GC-FID. TM036: Modified USEPA 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C5-10 by headspace GC-FID.	PM12/PM16	CWG GC-FID			AR	Yes
TM21	Modified USEPA 415.1. Determination of Total Organic Carbon or Total Carbon by combustion in an Eltra TOC furnace/analyser in the presence of oxygen. The CO2 generated is quantified using infra-red detection.	PM24	Dried and ground solid samples are washed with hydrochloric acid, then rinsed with deionised water to remove the mineral carbon before TOC analysis.	Yes		AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.			AD	Yes
TM30	Determination of Trace Metal elements by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). Modified US EPA Method 200.7	PM15	Acid digestion of dried and ground solid samples using Aqua Regia refluxed at 112.5 °C. Samples containing asbestos are not dried and ground.	Yes	Yes	AD	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes
TM31	Modified USEPA 8015B. Determination of Methyltertbutylether, Benzene, Toluene, Ethylbenzene and Xylene by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes		AR	Yes
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.			AR	Yes

JE Job No: 16/8720

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM36	Modified US EPA method 8015B. Determination of Gasoline Range Organics (GRO) in the carbon chain range of C4-12 by headspace GC-FID.	PM12	Modified US EPA method 5021. Preparation of solid and liquid samples for GC headspace analysis.	Yes	Yes	AR	Yes
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.			AR	
TM65	Asbestos Bulk Identification method based on HSG 248.	PM42	Solid samples undergo a thorough visual inspection for asbestos fibres prior to asbestos identification using TM065.	Yes		AR	
TM73	Modified US EPA methods 150.1 and 9045D. Determination of pH by Metrohm automated probe analyser.	PM11	Extraction of as received solid samples using one part solid to 2.5 parts deionised water.	Yes	Yes	AR	No
TM74	Analysis of water soluble boron (20:1 extract) by ICP-OES.	PM32	Hot water soluble boron is extracted from dried and ground samples using a 20:1 ratio.	Yes	Yes	AD	Yes

Appendix F – Landgas and Groundwater Monitoring Results

WYG Environmental Planning and Transport
LANDGAS AND GROUNDWATER MONITORING RESULTS

5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD

Site Name: A40 Llandewi Velfrey
Job No.: A096409
Client: Welsh Assembly Government

Date Monitored: 19/05/16
Monitoring Engineer: Craig Wickham
Weather: Sunny and fine.

EQUIPMENT USED

Type	Make	Serial	Last Calibrated

LANDGAS CONCENTRATIONS - INSTALLATION CONDITIONS

Exploratory Hole No	Peak		Steady								
	CH_4 (% vol)	CO_2 (% vol)	CH_4 (% vol)	CO_2 (% vol)	O_2 (% vol)	LEL (%)	PID (ppm)	H_2S (ppm)	HCN (ppm)	CO (ppm)	Time

LANDGAS - PHYSICAL PARAMETERS

Exploratory Hole No	Atmos Pressure (m bar)	Atmos Temp (^oC)	BH Flow		BH Pressure		Remarks
			Peak (l/hr)	Steady (L/hr)	Peak (mbar)	Steady (mbar)	
							No gas monitoring undertaken.

AMBIENT ATMOSPHERIC CONDITIONS

Parameter	Before Monitoring	After Monitoring
CH_4 (% vol)	n/a	n/a
CO_2 (% vol)	n/a	n/a
O_2 (% vol)	n/a	n/a
PID (ppm)	n/a	n/a
Atmos Press. (m bar)	n/a	n/a

ATMOSPHERIC PRESSURE CONDITIONS

3 days prior (m bar)	n/a
2 days prior (m bar)	n/a
1 day prior (m bar)	n/a
during (m bar) am,midday,pm	n/a
1 day post (m bar)	n/a

GROUNDWATER / NAPL - PHYSIO-CHEMICAL PARAMETERS

Exploratory Hole No	Water Surface (mbgl)	Base Depth (mbgl)	LNAPL Surface (mbgl)	DNAPL Surface (mbgl)	Water Quality Indicators						Remarks
					Eh (mV)	EC (µs)	Ph (value)	DO (ppm)	Temp (^oC)	TDS (ppm)	
BH01	2.70	7.04	nt	nt	nt	nt	nt	nt	nt	nt	
BH04	nd	17.70	nt	nt	nt	nt	nt	nt	nt	nt	
BH08	0.18	10.52	nt	nt	nt	nt	nt	nt	nt	nt	
BH10	nd	11.48	nt	nt	nt	nt	nt	nt	nt	nt	
BH11	3.60	9.20	nt	nt	nt	nt	nt	nt	nt	nt	
BH12	nd	7.82	nt	nt	nt	nt	nt	nt	nt	nt	
BH17	4.09	6.50	nt	nt	nt	nt	nt	nt	nt	nt	
BH102	nd	8.28	nt	nt	nt	nt	nt	nt	nt	nt	

Notes

nt = not tested
nd = not detected

Data Compiled by: CW
Data Checked by: PV

WYG Environmental Planning and Transport

LANDGAS AND GROUNDWATER MONITORING RESULTS

5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD

Site Name: A40 Llandewi Velfrey
Job No.: A096409
Client: Welsh Assembly Government

Date Monitored: 01/06/16
Monitoring Engineer: Craig Wickham
Weather: Sunny and fine.

EQUIPMENT USED

Type	Make	Serial	Last Calibrated

LANDGAS CONCENTRATIONS - INSTALLATION CONDITIONS

Exploratory Hole No	Peak		Steady								
	CH_4 (% vol)	CO_2 (% vol)	CH_4 (% vol)	CO_2 (% vol)	O_2 (% vol)	LEL (%)	PID (ppm)	H_2S (ppm)	HCN (ppm)	CO (ppm)	Time

LANDGAS - PHYSICAL PARAMETERS

Exploratory Hole No	Atmos Pressure (m bar)	Atmos Temp (°C)	BH Flow		BH Pressure		Remarks
			Peak (l/hr)	Steady (L/hr)	Peak (mbar)	Steady (mbar)	
							No gas monitoring undertaken.

AMBIENT ATMOSPHERIC CONDITIONS

Parameter	Before Monitoring	After Monitoring
CH_4 (% vol)	n/a	n/a
CO_2 (% vol)	n/a	n/a
O_2 (% vol)	n/a	n/a
PID (ppm)	n/a	n/a
Atmos Press. (m bar)	n/a	n/a

ATMOSPHERIC PRESSURE CONDITIONS

3 days prior (m bar)	n/a
2 days prior (m bar)	n/a
1 day prior (m bar)	n/a
during (m bar) am,midday,pm	n/a
1 day post (m bar)	n/a

GROUNDWATER / NAPL - PHYSIO-CHEMICAL PARAMETERS

Exploratory Hole No	Water Surface (mbgl)	Base Depth (mbgl)	LNAPL Surface (mbgl)	DNAPL Surface (mbgl)	Water Quality Indicators						Remarks
					Eh (mV)	EC (µs)	Ph (value)	DO (ppm)	Temp (°C)	TDS (ppm)	
BH01	2.63	7.04	nt	nt	nt	nt	nt	nt	nt	nt	
BH04	nd	17.70	nt	nt	nt	nt	nt	nt	nt	nt	
BH08	0.35	10.52	nt	nt	nt	nt	nt	nt	nt	nt	
BH10	nd	11.48	nt	nt	nt	nt	nt	nt	nt	nt	
BH11	4.00	9.19	nt	nt	nt	nt	nt	nt	nt	nt	
BH12	nd	7.82	nt	nt	nt	nt	nt	nt	nt	nt	
BH17	4.31	6.50	nt	nt	nt	nt	nt	nt	nt	nt	
BH102	nd	8.28	nt	nt	nt	nt	nt	nt	nt	nt	

Notes

nt = not tested
nd = not detected

Data Compiled by: CW
Data Checked by: PV

WYG Environmental Planning and Transport

LANDGAS AND GROUNDWATER MONITORING RESULTS

5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD

Site Name: A40 Llandewi Velfrey
Job No.: A096409
Client: Welsh Assembly Government

Date Monitored: 07/06/16
Monitoring Engineer: Craig Wickham
Weather: Sunny and fine.

EQUIPMENT USED

Type	Make	Serial	Last Calibrated
Gas Analyser	**Landtec GA5000**	**G02044**	**May-16**

LANDGAS CONCENTRATIONS - INSTALLATION CONDITIONS

Exploratory Hole No	Peak		Steady								
	CH_4 (% vol)	CO_2 (% vol)	CH_4 (% vol)	CO_2 (% vol)	O_2 (% vol)	Balance (%)	PID (ppm)	H_2S (ppm)	HCN (ppm)	CO (ppm)	Time
BH01	0.2	1.7	0.2	1.4	21.0	78.7	nt	<1	nt	<1	09:35:00
BH04	0.1	3.3	0.1	3.1	16.2	80.5	nt	<1	nt	<1	10:01:00
BH08	0.1	0.7	0.1	0.5	19.9	78.6	nt	<1	nt	<1	12:31:00
BH10	0.1	1.1	0.1	0.9	20.7	81.1	nt	<1	nt	<1	10:27:00
BH11	0.1	1.5	0.1	1.3	21.0	81.2	nt	<1	nt	<1	10:48:00
BH12	0.1	2.7	0.1	2.2	20.2	80.4	nt	<1	nt	1	11:16:00
BH17	0.1	0.7	0.1	0.6	20.7	79.9	nt	<1	nt	<1	12:02:00
BH101	0.1	0.5	0.1	0.3	20.6	79	nt	<1	nt	2	11:35:00

LANDGAS - PHYSICAL PARAMETERS

Exploratory Hole No	Atmos Pressure (m bar)	Atmos Temp (°C)	BH Flow		BH Pressure		Remarks
			Peak (l/hr)	Steady (L/hr)	Peak (mbar)	Steady (mbar)	
BH01	1011	19.0	<0.1	<0.1	0.1	0.1	
BH04	1008	19.0	<0.1	<0.1	0.1	0.1	
BH08	1006	18.0	<0.1	<0.1	0.1	0.1	
BH10	1012	19.0	<0.1	<0.1	-0.1	-0.1	
BH11	1012	19.0	<0.1	<0.1	-0.1	-0.1	
BH12	1014	19.0	<0.1	<0.1	0.1	0.1	
BH17	1010	20.0	<0.1	<0.1	0.1	0.1	
BH101	1014	20.0	<0.1	<0.1	0.1	0.1	

AMBIENT ATMOSPHERIC CONDITIONS

Parameter	Before Monitoring	After Monitoring
CH_4 (% vol)	0.1	0.1
CO_2 (% vol)	0.1	0.1
O_2 (% vol)	21.5	21.7
PID (ppm)	nt	nt
Atmos Press. (m bar)	1011.0	1010.0

ATMOSPHERIC PRESSURE CONDITIONS

3 days prior (m bar)	1018
2 days prior (m bar)	1020
1 day prior (m bar)	1020
during (m bar) am,midday,pm	1011, 1010, 1010
1 day post (m bar)	1020

GROUNDWATER / NAPL - PHYSIO-CHEMICAL PARAMETERS

Exploratory Hole No	Water Surface (mbgl)	Base Depth (mbgl)	LNAPL Surface (mbgl)	DNAPL Surface (mbgl)	Water Quality Indicators						Remarks
					Eh (mV)	EC (µs)	Ph (value)	DO (ppm)	Temp (°C)	TDS (ppm)	
BH01	2.56	7.04	nt	nt	nt	nt	nt	nt	nt	nt	None
BH04	nd	17.70	nt	nt	nt	nt	nt	nt	nt	nt	None
BH08	0.48	10.51	nt	nt	nt	nt	nt	nt	nt	nt	None
BH10	nd	11.48	nt	nt	nt	nt	nt	nt	nt	nt	None
BH11	4.20	9.19	nt	nt	nt	nt	nt	nt	nt	nt	None
BH12	nd	7.82	nt	nt	nt	nt	nt	nt	nt	nt	None
BH17	4.43	6.50	nt	nt	nt	nt	nt	nt	nt	nt	None
BH102	nd	8.28	nt	nt	nt	nt	nt	nt	nt	nt	None

Notes

nt = not tested
nd = not detected

Data Compiled by: CW
Data Checked by: PV

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Ground Investigation Report

A40LVP-ARP-VGT-SWI-RP-C-0001

P05 | S4

10/07/19

Contents

Tables

1 Executive summary

1.1.1 A preliminary ground investigation has been undertaken along the proposed route of the A40 Llanddewi Velfrey to Penblewin Road Improvement. The proposed route includes a 2.5km section on or near the existing A40 and a 2.5km section of offline bypass around the village of Llanddewi Velfrey. The investigation included boreholes and trial pits carried out at regular interval along the scheme alignment, to provide information on the variation in ground conditions, and at locations where major structures and earthworks are proposed to provide parameters for geotechnical design.

1.1.2 The preliminary ground investigation has identified ground conditions to be present along the route as summarised below. Superficial deposits are generally absent along the proposed route. The only exception to this is an area of glaciofluvial deposits by Penblewin Roundabout and an area of diamicton till east of Pen-troydin-fawr which are shown on the geological maps. Typical ground conditions comprise a layer of topsoil, underlain in some places by made ground, overlying bedrock with a weathered upper zone. The bedrock beneath the scheme comprises three formations; Slade and Redhill Formation (shale and mudstone), Portfield and Haverford Mudstone Formation (shale, sandstone and conglomerate) and the Haverford Mudstone Formation (mudstone). The area has undergone various stages of folding and faulting resulting in varying dip angles and directions throughout the scheme.

1.1.3 For the first 2.5km (western) section, shallow cuttings and embankments are proposed, predominantly through the Haverford Mudstone Formation, with each end of this section within the Slade and Redhill Formation. For the offline bypass in the eastern section, two major embankments and two major cuttings as well as a series of cuttings for a new roundabout are proposed; this section being predominantly through the Slade and Redhill Formation.

1.1.4 Groundwater monitoring indicated shallow groundwater to be present within the lower lying areas of the scheme and in the vicinity of watercourses. Seepages were recorded during drilling and spring lines on hillsides are anticipated to be as a result of groundwater flows through permeable layers in the rock which may be encountered in the proposed cuttings.

1.1.5 Limited ground investigation was undertaken between Ch. 2+000m and Ch. 3+500m which includes proposals for two major embankments and one major cutting.

1.1.6 The main structures on the scheme, the overbridge and the footbridge, are anticipated to be founded on shallow foundations within the bedrock.

2 Introduction

2.1 Scope and objective of the report

2.1.1 The geotechnical aspects of design will be undertaken in accordance with DMRB Standard HD22/08, Managing Geotechnical Risk [1] and HD22/08: Managing Geotechnical Risk Implementation Guidance – Wales [2]. The objective is to identify and properly manage the geotechnical risks associated with the project. The scheme has been classified as Category 2 in accordance with the guidelines stipulated in HD22/08 [1] (see Section 2.3).

2.1.2 This Ground Investigation Report (GIR) presents available geotechnical information including details of geological features and relevant desk study data. Reference is made to the Factual Report (see Section 4.3.4) which has been produced by the specialist ground investigation contractor and contains all of the factual information and test results from the ground investigation works. This GIR includes a geotechnical evaluation of the ground investigation information, stating the assumptions made in the interpretation of the information and test results.

2.1.3 This GIR has been written on the basis of the highway model and scheme proposals as of May 2017. Any subsequent change will be captured in the Key Stage 6 Geotechnical Design Report.

2.2 Description of project

Site description

2.2.1 The A40 forms the key link road between south-east Wales and Haverfordwest and in turn the ports of Fishguard and Milford Haven, in addition to connecting central and north Pembrokeshire. This scheme considers 5km of single carriageway improvement between Llanddewi Velfrey and Penblewin. A site location plan is shown on Drawing A40LVP-ARP-GEN-SWI-SK-J-0001.

Context

2.2.2 In February 2017 the Welsh Government appointed Carillion, with Arup and RML (the ‘Carillion Team’) as their technical and environmental advisors, to develop the design of the proposed A40 Llanddewi Velfrey to Penblewin Improvements up to publication of draft Orders.

2.2.3 Carillion entered liquidation in January 2018. The Welsh Government subsequently appointed Arup, supported by RML, to continue the development of the design up to publication of draft Orders and to support the Welsh Government through the Statutory process.

2.2.4 The need for the improvement of the A40 arose in December 2004 when the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study came about as a result of a number of previous reports that all concluded that the A40 needed improvement.

Background

2.2.5 In December 2004, the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvements would use the 2+1 configuration allowing overtaking on the two-lane direction, with overtaking prohibited in the one lane direction and would be delivered in the following phases:

a) A40 Penblewin - Slebech Park

2.2.6 A40 Llanddewi Velfrey - Penblewin.

2.2.7 The first of these projects, Penblewin – Slebech Park, was completed in March 2011.

2.2.8 In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

> *“Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements.”*

2.2.9 On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary:

> *“In terms of transport links, I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey.”*

2.2.10 In June 2015, in a written statement on the A40 Improvement Study the Minister noted "It is my intention to progress delivery of the A40 Llanddewi Velfrey to Penblewin scheme as soon as possible…"

Proposed scheme

2.2.11 The proposed route for the project identifies a 2.5km bypass to the north of the village of Llanddewi Velfrey and a 2.5km section of on or slightly offline improvement west of Ffynnon Wood, where the bypass re-joins the existing trunk road at Penblewin roundabout. A new roundabout next to Bethel Chapel, a large embankment and cutting in the offline section and a new bridge carrying the Llanfallteg Road over a cutting are the key features of the scheme.

The problems

2.2.12 Consultation with key stakeholders, including the Local Authority, Welsh Government Departments and the Regional Transport Planner has identified the following problems:

a) The road is substandard and where overtaking provision does exist it is currently not spread along the length of the A40 such as there are long lengths in each direction with no safe overtaking opportunities

b) Limited overtaking opportunities lead to poor journey time reliability and driver frustration.

c) Occasional convoys of heavy goods vehicles from the ferry ports and slow moving agricultural vehicles contribute to periods of platooning and journey time unreliability, which is exacerbated with limited overtaking opportunities.

d) Seasonal spikes in traffic volumes along the A40 especially during the summer months leads to slow moving traffic causing journey time unreliability, which is exacerbated with limited overtaking opportunities.

e) The community of Llanddewi Velfrey is severed by the A40, which reduces accessibility, increases risks of non-motorised user accidents and results in noise and air pollution.

f) There are many side road junctions and direct accesses to properties and agricultural fields off the A40, which contributes to operational problems along the road.

g) A mix of traffic types using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents.

h) A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.

Scheme objectives

2.2.13 A number of transport planning objectives have been developed iteratively during previous development work and engagement on the A40 project, aiming to address one or more of the identified problems. During the early stages of Key Stage 3 the problems and objectives were refreshed during a focused workshop event with key stakeholders to take into account the WelTAG 2017 guidance and Wellbeing of Future Generations (Wales) Act wellbeing goals. The scheme objectives are:

O1	To enhance network resilience and improve accessibility along the east-west transport corridor to key employment, community and tourism destinations.
O2	To improve prosperity and provide better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard, Milford Haven and Pembroke Dock.
O3	To reduce community severance and provide health and amenity benefits.
O4	To reduce the number and severity of collisions.
O5	To promote active travel by cycling, horse riding and walking to provide opportunities for healthy lifestyles.
O6	To deliver a scheme that promotes social inclusion and integrates with the local transport network to better connect local communities to key transport hubs.
O7	Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.
O8	Give due consideration to the impact of transport on the environment and provide enhancement when practicable.

2.3 Geotechnical Category of project

2.3.1 The Statement of Intent produced by Mott MacDonald [3] indicates the project to be classified as Geotechnical Category 2. Based on the current scheme proposals, this classification is considered to be appropriate.

2.4 Other relevant information

2.4.1 The Statement of Intent [3] and the Preliminary Sources Study Report (PSSR) [4] produced by Mott MacDonald have been reviewed as part of this report.

3 Existing information

3.1 Topographical maps

3.1.1 The summary of the topography as presented in the PSSR has been updated based on supplementary information obtained from the site walkover (see Section 4.1) with the revised summary presented below. Features along the alignment of the proposed scheme are presented on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008.

3.1.2 The current alignment of the A40 is generally located on top of a local west to east orientated ridge, bounded in the northeast by the Afon Taf valley and in the south by the Afon Marlais valley as shown in Appendix A. Ground levels vary between 75mAOD and 130mAOD. The length of the proposed route crosses undulating terrain as described below.

"*heading east from Penblewin Roundabout the topography of the online alignment is at grade (approximately 90 metres Above Ordnance Datum (mAOD)).*" *[4]*

3.1.3 The existing topography dips gently to the south in this section of the scheme.

"*At Ffynnon Chapel the alignment goes offline to the north and the topography gradually rises in elevation north-easterly towards Pen-troydin-fawr (approximately 100 mAOD).*" *[4]*

3.1.4 Immediately east of Ffynnon Chapel, the ground levels drop sharply in a watercourse valley before rising again gently up to Pen-troydin-fach farm further east.

"*At approximate Ch.3000 the topography drops to approximately 80 mAOD (2 No. incised watercourses) then rises gradually to approximately 125 mAOD at CH.3600. A Ch. 3000 the proposed road alignment also changes direction and heads south-easterly towards Bethel Chapel.*" *[4]*

3.1.5 The bottom of the valley at the location of the two watercourses between approximate Ch. 3+000m and Ch. 3+120m is at around 75mAOD. Moving east, ground levels then gradually rise to 125mAOD at Ch. 3+600m. From Ch. 3+120m to Ch. 3+600m, the existing topography drops to the north-northwest.

"*After Ch.3600 the topography gradually drops to c120 mAOD at the proposed location of Bethel Roundabout and continues to drop* *eastwards along the proposed alignment where it rejoins the existing A40, at approximately 105 mAOD." [4]*

3.1.6 From Ch. 3+600m to the Bethel Roundabout in the east, the topography drops sharply to the northeast perpendicular to the scheme alignment. At the eastern end of the scheme, approximately 300m east of the roundabout, the ground level drops sharply to the south of the proposed alignment.

3.2 Geological maps and memoirs

3.2.1 A review of the 1:50,000 geological map [4], the 6 inch county maps [6] [7], the geological memoir [8] and the BGS webviewer [9] and Lexicon [10] has been undertaken. The fieldslips for the area have been viewed at the BGS Cardiff office. These have been found to be consistent with the information provided in the 6 inch county maps. A study of the geological sequence of the area by Cocks and Price [11] has also been considered.

3.2.2 The identified geology is shown on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints Plan) and is summarised in the below sections.

3.2.3 A conceptual geological long section has been produced (see Figure 1) as well as conceptual geological cross sections through the two main cuttings (see Figures 2 and 3).

Superficial deposits

3.2.4 An isolated area of glaciofluvial deposits approximately 250m in length and 50m in width has been recorded at the western end of the scheme, crossing the proposed alignment between Ch. 0+430m and Ch. 0+510m. The county maps note a "*pit in gravel 7ft+*" within this area. An area of boulder clay is also indicated to encroach on the scheme alignment between Ch. 3+010m and Ch. 3+090m. The county map shows this area to extend 250m further to the south than on the 1:50,000 map.

3.2.5 An area of alluvium associated with the watercourse near the Ffynnon Chapel is recorded as being present approximately 200m north of the proposed alignment at Ch. 1+650m. The county map shows the alluvium to extend 50m further to the south than the 1:50,000 map. An additional area of alluvium is recorded on the county map as being present approximately 300m south of Ch. 2+400m, close to the existing sewage works.

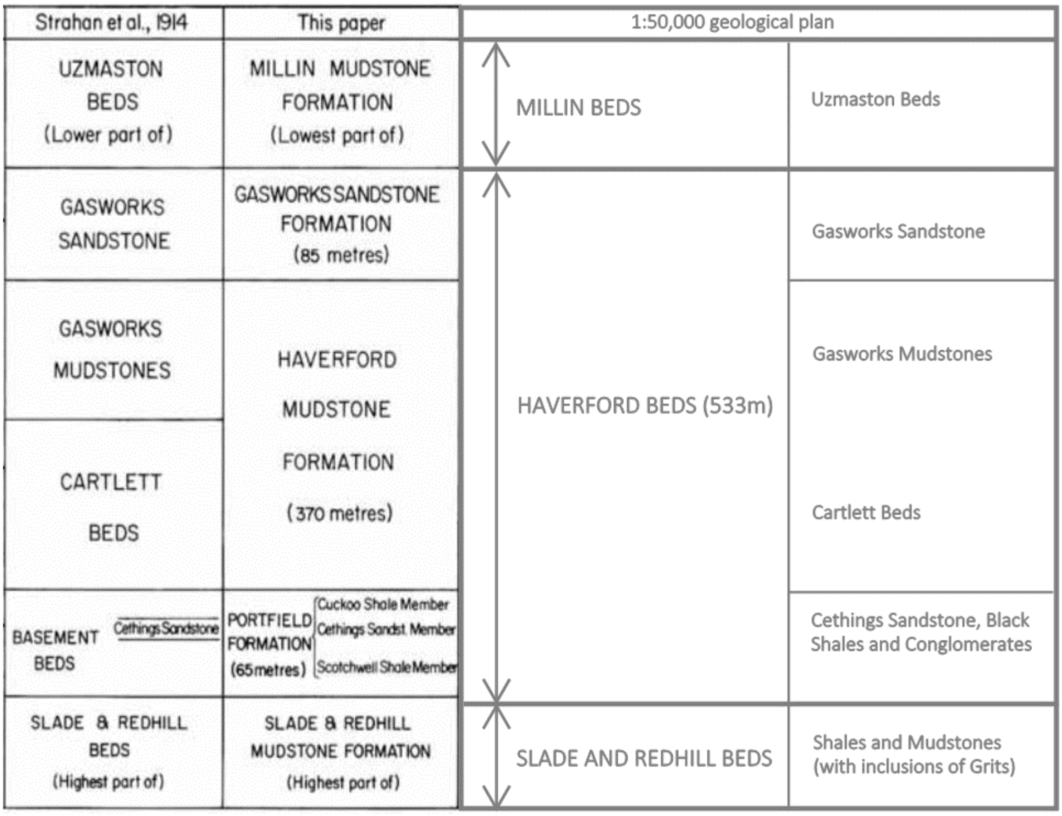
3.2.6 It should be noted that other areas of superficial deposits that have not been recorded on the geological maps could be present.

Bedrock

3.2.7 The bedrock beneath the scheme comprises three formations; primarily the Slade and Redhill Formation in the east, and the Haverford Mudstone Formation in the west along with some discrete areas of the Portfield and Haverford Mudstone Formation (see Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008).

3.2.8 The geological sequence of the three formations comprises the Haverford Mudstone Formation, overlying the Portfield and Haverford Mudstone Formation (undifferenciated), which in turn is underlain by the Slade and Redhill Formation. This sequence is described by Cocks and Price [11] and is reproduced in Table 1 below (with the exception that the 'Portfield Formation' referred to by Cocks and Price' is currently named the 'Portfield and Haverford Mudstone Formation').

Table 1 Stratigraphical terminology within the Haverfordwest area reproduced from Cocks and Price, 1975 [11] and supplemented with geological sequence from the 1:50,000 geological plan [4]



Strahan et al., 1914	This paper	1:50,000 geological plan	
UZMASTON BEDS (Lower part of)	MILLIN MUDSTONE FORMATION (Lowest part of)	MILLIN BEDS	Uzmaston Beds
GASWORKS SANDSTONE	GASWORKS SANDSTONE FORMATION (85 metres)	HAVERFORD BEDS (533m)	Gasworks Sandstone
GASWORKS MUDSTONES	HAVERFORD MUDSTONE FORMATION (370 metres)		Gasworks Mudstones
CARTLETT BEDS			Cartlett Beds
BASEMENT BEDS Cethings Sandstone	PORTFIELD FORMATION (65metres) Cuckoo Shale Member Cethings Sandst Member Scotchwell Shale Member		Cethings Sandstone, Black Shales and Conglomerates
SLADE & REDHILL BEDS (Highest part of)	SLADE & REDHILL MUDSTONE FORMATION (Highest part of)	SLADE AND REDHILL BEDS	Shales and Mudstones (with inclusions of Grits)

3.2.9 It should be noted that the data displayed by the BGS web viewer [9] does not correspond to the 1:50,000 geological plan [4], the geological sheet memoir [9] and the Cocks and Price publication [11]. The discrepancies identified on the BGS web viewer [9] and Lexicon [10] are summarised below:

a) The Haverford Mudstone Formation is referred to as the 'Portfield Formation' on the BGS web viewer.

b) The accompanying Lexicon entry for the 'Portfield Formation' appears to be the information relevant to the underlying Portfield and Haverford Mudstone Formation.

c) The Lexicon entry for the Portfield and Haverford Mudstone Formation is mostly blank. The only information provided is the age range which appears to have been incorrect and but would be correct for the overlying Haverford Mudstone Formation.

3.2.10 Arup contacted the BGS in regards to the potential errors in the web viewer and Lexicon and for clarification on the names of the formations. The BGS have acknowledged that there appear to be errors in the naming of the formations and indicated that the names of the formations as presented in this report are correct. The BGS indicated that the web viewer and Lexicon would be updated, but could not confirm a date when this would be completed.

3.2.11 The BGS web viewer names and sequence may have been used as a basis for some of the text of the PSSR [4] and the ground investigation factual report [17]. As part of this report, the position of formations across the scheme area, and the geological formations of the rock encountered as part of the ground investigation works, have been re-interpreted as shown in Figure 1.

3.2.12 As shown on Table 1, the 1:50,000 geological plan [4] further sub-divides and describes the three formations as follows:

a) Haverford Mudstone Formation into the Gasworks Mudstones and the Carlett Beds

b) Portfield and Haverford Mudstone Formation (undifferenciated) into the Cethings Sandstone, Black Shales and Conglomerates

c) Slade and Redhill Formation into Shales and Mudstones with Grits

3.2.13 Both the Haverford Mudstone Formation and the Portfield and Haverford Mudstone Formation (undifferenciated) are indicated to be part of the Haverford Beds. The formations and descriptions as presented on the 1:50,000 geological plan [4] broadly correspond to those provided in the 1914 sheet memoir [8], which also refers to the Portfield and Haverford Mudstone Formation as the Basement Beds.

3.2.14 Further descriptions of the sub-divisions of each formations is provided below.

Haverford Mudstone Formation

3.2.15 The Gasworks Mudstone is described as typically comprising "*massive sandy mudstones often showing spheroidal structure*" underlain by "*thin-bedded shaly green mudstones, with occasional sandstone-bands*" of up to 150mm in thickness. These are underlain by the Cartlett Beds described in the memoir [8] as "*dark olive-green soft mudstones of homogenous texture*" with a "*greater mass of harder mudstone*" in the upper levels of the beds. However, lithologically there is no sharp change that can be used to distinguish between the two formations [11].

Portfield and Haverford Mudstone Formation

3.2.16 The Cethings Sandstone, Black Shales and Conglomerates have a thickness of approximately 70m [4]. In the memoir [8], these are characterised by "*black shales and black flaggy"* mudstones. Locally in the lower part are the Basal Conglomerates and in the upper part the Cethings Sandstone. The Basal Conglomerates are described as "*coarse conglomerate"* up to 30m in thickness and which have been observed to contain "*pebbles of vein-quartz up to 5 inches in length"* on the south side of the large anticline north of Ffynnon Chapel. The Cethings Sandstone is described as "*a fine-grained grey sandstone*" overlain by "*soft blue-black shales which on weathering display an orange and vermilion surface-staining*".

Slade and Redhill Formation

3.2.17 The Shales and Mudstones from the Slade and Redhill Formation have thicknesses ranging from 152m to 610m [4]. The Redhill Beds are described as "*sharped-based sandstones with basal shell lags and bioturbated tops, interbedded with grey, silty mudstones*" whilst in the overlying Slade Beds, "*the frequency and thickness of these beds is greater and the associated mudstones are more fossiliferous*" [12]. These two beds have been grouped into a single formation due to the vague boundary region between the two beds [11]. Slade and Redhill Beds of the 'southern type' beneath the scheme are described as "*blue-grey mudstones, with frequent thin bands of brown to grey micaceous sandstone and highly calcareous layers weathering to a brown sandy rottenstone*". The memoir [8] records these to be present in the western end of the scheme at Penblewyn where they are indicated to be approximately 110m in thickness, of which around 90m is made of the Slade.

3.2.18 There are two north-west to south-east trending faults crossing the site at Llanddewi Velfrey and at Penblewin. The most eastern fault is shown on a section on the 1:50,000 plan as an inversed fault, down-throwing to the north-east at an angle estimated to be approximately 15° from the horizontal. Between the faults, the Haverford Mudstone Formation that overlies the undifferentiated Portfield and Haverford Mudstone Formation is generally shown as being present from the ground surface beneath the scheme, with the exception of an area north of Ffynnon Wood where the underlying formation is recorded due to the presence of an anticline and the section between Caermaenau-fach farm and the lorry park.

3.2.19 A syncline trending in a north-west south-east direction is shown to the north of Llanddewi Velfrey. Dip angles of 50° to 60° and 10° to 30° are recorded on the northern and the southern limbs respectively.

3.2.20 It is noted that some solid geology boundaries have been recorded as ‘no evidence’ and ‘supposed’ on the county maps.

3.3 Aerial photographs

3.3.1 The aerial photographs available at the Welsh Government Aerial Photography Unit were reviewed by a geotechnical engineer on 5th March 2017. The photographs covered the period from 1946 to 2013.

3.3.2 The additional features to those previously presented in the PSSR are summarised below and indicated on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints Plan).

a) A pit along Llanfallteg Road is shown on the 23rd September 1964 photographs to the south of Ch. 2+860m.

b) The photographs dated 7th July 1946 show a brighter area in the field north of Ch. 3+730m which could be associated with a backfilled pit.

c) The photographs dated 1983 provide a particularly clear view with minimal vegetation compared to more recent aerial photographs.

3.4 Records of mines and mineral deposits

3.4.1 Records of mines and mineral deposits have been reviewed from the Review of Mining Instability in Great Britain report [13] for metalliferous mining (non-ferrous), rock mining, coal mining (and associated minerals), iron mining (non-coalfield) and evaporite mining, and from review of the Coal Authority online viewer [14] in relation to coal mining.

3.4.2 No records of mines or mineral deposits have been identified for the scheme area in the above sources. However, a number of quarries and gravel pits have been identified (see Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008).

3.5 Land use and soil survey information

3.5.1 The study area is in a rural setting and comprises agricultural land, grazing pastures and local landowner properties. Assessment of potential agricultural impacts is to be carried out as part of the Environmental Impact Assessment, and reported within the Environmental Statement for the scheme.

3.5.2 The historical maps show that the existing A40 has been aligned approximately along the present day alignment since 1809.

3.6 Archaeological and historical investigation

3.6.1 Burnt mounds have been recorded around the scheme area. Further archaeological investigation is to be undertaken.

3.7 Existing ground investigations

3.7.1 No existing ground investigation information has been identified along the proposed scheme alignment. The BGS web viewer records the nearest exploratory holes approximately 500m east of the proposed Bethel Chapel roundabout (SN11NE87 and SN11NE88) and therefore are anticipated to be of limited relevance to the proposed scheme.

3.7.2 No ground investigations have been carried out specifically for the scheme prior to the 2016 investigation.

3.8 Consultation with Statutory Bodies and Agencies

Welsh Government

3.8.1 The Welsh Government IRIS database has been reviewed [15]. A summary of the findings relevant to the on-line works for the scheme is presented in Table 2 below.

Table 2 Welsh Government IRIS database summary table

Earthwork type	Side	Approx. start chainage (m)*	Approx. end chainage (m)*	Observation
Embankment	North	1+640	1+640	Embankment toe excavated to allow access for footpath. Has left vertical slope 0.6m high, unlikely to lead to failure
Embankment	North	1+660	1+710	Tension cracks / desiccation beneath barrier
Embankment	North	1+660	1+710	Section with extensive burrowing causing undercutting in slope. Minor burrowing
Embankment	South	1+680	1+810	Settlement between posts of crash barrier
Embankment	South	1+710	1+710	Historical soil slip at toe of lower slope, soil slip is 3m deep and 1m wide, debris at toe
Embankment	North	3+900	3+950	Historical soil slip at toe of cutting, 2m width 1m height
Embankment	South	4+120	4+320	Tension cracks and extensive burrowing at crest of embankment. Minor shallow topsoil movement -burrow related
*Start and end chainages estimated from IRIS web viewer				

Natural Resources Wales

3.8.2 Natural Resources Wales have been contacted with respect to the following data:

a) Abstraction licences;

b) Groundwater source protection zones and aquifer designation maps;

c) Pollution incidents;

d) Industrial activities;

e) Consented discharges to surface or ground water bodies;

f) Historical and licenced landfill sites;

g) Licenced waste management facilities.

3.8.3 We have been informed that the data pertaining to all of the above, except for abstraction licences, is currently available on the Welsh Government Data Portal Lle (www.lle.gov.wales) or British Geological Survey online portal (www.bgs.gov.uk). The information regarding the abstraction licences has been received. The data has been reviewed and incorporated into this report.

Pembrokeshire County Council

3.8.4 Pembrokeshire County Council have been contacted with respect to the following data:

a) Part II A designations and any known remediation;
b) Sites of potential concern under Part II A;
c) Historical underground storage tanks;
d) Part A and B IPPC processes;
e) Storage and usage of radioactive materials;
f) Private water supply locations within 1km of the scheme alignment;
g) Details of aggregate resources within the county (land bank figures);
h) Local waste management infrastructure within the county.

3.8.5 The data received has been reviewed and incorporated as part of this report.

3.9 Flood records

3.9.1 The Natural Resources Wales Flood Risk online viewer has been reviewed [16]. No area designated at being at risk of flooding from rivers or the sea is recorded. A risk of flooding from surface water has been identified: along the proposed route in the western part of the scheme along the existing A40; around the Ffynnon Chapel area; next to Pen-troydin-fach farm, along the watercourse east of Llanfallteg Road; and at the eastern extremity of the scheme as shown on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints Plan).

3.10 Contaminated land

3.10.1 The review of the information presented in the PSSR identified the following potential sources of contamination:

a) Made ground associated with the existing road infrastructure located online and offline along the scheme alignment. Made ground materials may be a potential source of metals, hydrocarbons and asbestos.

b) Activities associated with operation of the existing road network located within the proposed scheme alignment and its close proximity. These activities may have resulted in accidental spillages or leakages of fuel, which may have impacted the soils and groundwater primarily with hydrocarbons.

c) Sewage discharge to ground (via a soakaway) located approximately 140m north of the proposed alignment at approximate chainage 1+700m. This may have resulted in groundwater becoming impacted by sewage and related contaminants such as metals and ammonical nitrogen.

d) Trefanor Burial Ground located approximately 210m north of the proposed alignment at approximate chainage 1+120m.

e) A sewage works with an adjacent spout approximately 160m south of the proposed alignment at chainage 2+180m.

f) Infilled disused quarries and pits:

    i. A disused possibly infilled quarry located approximately 190m north of Penblewin Roundabout;

    ii. A disused possibly infilled sand, gravel and clay pit approximately 250m north of Penblewin Roundabout;

    iii. A disused possibly infilled gravel pit adjacent to the proposed alignment at approximate chainage 0+450m;

    iv. A disused possibly infilled gravel pit located approximately 260m south of the proposed alignment at approximate chainage 0+750m;

    v. A disused possibly infilled quarry located approximately 30m north of the proposed alignment at approximate chainage 1+300m;

    vi. Two infilled disused quarries located adjacent and approximately 40m north of the proposed alignment from approximate chainage 1+700m to 1+800m;

vii. Three disused possibly infilled gravel pits located approximately 100m south of the proposed alignment at approximate chainage 2+400m and adjacent to the proposed alignment at approximate chainages 2+850m and 3+250m;

viii. A disused possibly infilled sand/gravel pit located approximately 50m south of the proposed alignment at approximate chainage 3+550;

ix. A disused possibly infilled quarry encroaching on the southern edge of the proposed alignment at approximate chainage 3+850;

x. In addition to the above, a possible disused pit has been identified at chainage 3+740m.

3.10.2 These may be sources of a range of potential contaminants depending on the origin of the fill materials. Typical contaminants that may be present include metals, hydrocarbons and asbestos.

3.11 Other relevant information

Hydrology and hydrogeology

3.11.1 The PSSR [4] provides an overview of the hydrology and hydrogeological setting of the scheme. Further review of the OS maps and Envirocheck report (included in the PSSR [4]) is presented below.

3.11.2 The majority of the proposed scheme is located within the Afon Taf catchment with numerous direct and indirect tributaries (including the Afon Daulan) present directly to the south and north of the proposed alignment. The following water courses transect the proposed alignment:

a) Unnamed watercourses: two indirect tributaries to the Afon Daulan, currently culverted beneath the existing A40 between chainage 1+700m and 1+800m.

b) Unnamed watercourse: indirect tributary to the Afon Daulan, crossing the proposed alignment at chainage 2+640m.

c) Unnamed watercourse: direct tributaries to the Afon Daulan, crossing the proposed alignment at chainage 3+110m.

d) Unnamed watercourse: indirect tributaries to the Afon Daulan, crossing the proposed alignment at chainage 3+110m.

3.11.3 The western part of the proposed scheme (chainage 0+000m to approximately 1+200m) is located in the catchment of the Cleddau Ddu River. No tributaries to the Cleddau Ddu transect the proposed alignment with the nearest watercourse located approximately 100m to the south of the scheme alignment.

3.11.4 The bedrock underlying the proposed scheme is classed as a Secondary Aquifer. No superficial deposits are shown to overlie the bedrock except for isolated deposits of glaciofluvial deposits at approximately chainage 0+500m and till at approximate chainage 3+100m. The glaciofluvial deposits comprise sands and gravels and are classed as a Secondary A aquifer. The till deposits are classed as unproductive strata.

3.11.5 Based on a review of the topographical information and the location of surface water features shown on the Ordnance Survey maps, groundwater springs are present emanating from hillsides. The interrelation between springs and water bearing strata within the bedrock may be difficult to establish due to the geology of the area being relatively complicated, as a result of the folding and faulting of the strata.

3.11.6 The following private water supplies have been identified within 1km of the proposed scheme alignment:

a) Cilrath Fach Farm, SA67 7EY (approximately 650m northwest of Penblewin Roundabout);

b) Pantygorphwys Cottage, SA67 7NX (approximately 750m south of Penblewin Roundabout);

c) A well located approximately 60m north of the proposed scheme alignment at approximate chainage 2+220m associated with Pen-troydin-fach;

d) Fron, Fron Hill, SA34 0RG (approximately 950m east of Llanddewi Velfrey Roundabout);

e) Cwm Saeson, Pencawse Hill, SA34 0RH (spring) (approximately 880m southeast of Llanddewi Velfrey Roundabout);

f) Waundwrgi, Pencawse Hill, SA34 0RH (well) (approximately 880m southeast of Llanddewi Velfrey Roundabout);

g) Upper Fron, SA67 7EJ (approximately 360m southeast of Llanddewi Velfrey Roundabout);

h) Hendre, SA67 7EG (approximately 130m north of the proposed scheme alignment at approximate chainage 3+650m);

i) Cyncoed, SA67 7EG (approximately 130m north of the proposed scheme alignment at approximate chainage 3+650m);

j) Parc y Teg, SA67 7EG (approximately 130m north of the proposed scheme alignment at approximate chainage 3+650m); and

k) Brynhafod, SA67 7EG (approximately 130m north of the proposed scheme alignment at approximate chainage 3+650m).

3.11.7 The following water abstraction locations have been identified in the locality of the scheme:

a) Two wells adjacent to the proposed scheme alignment between chainage 1+600m and 1+630m;

b) A well located approximately 100m north of the proposed scheme alignment at approximate chainage 1+770m;

4 Field and laboratory studies

4.1 Walkover survey

4.1.1 A walkover survey was undertaken by a geotechnical and a geo-environmental engineer on 23rd March 2017. The key features identified are labelled on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints Plan) and photographs of pertinent features are included in Appendix B.

4.1.2 It should be noted that due to land access restrictions the walkover survey was limited to public rights of way.

4.2 Geomorphological / geological mapping

4.2.1 The following geomorphological and geological observations and measurements were made during the site walkover survey and are recorded on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints Plan):

a) Cutting to the east of the scheme: thinly to thickly laminated dark grey mudstone dipping 10° to 20° to the north-north-west. The northern side slopes dip at approximately 70° and the southern side at approximately 50°. Rock could be broken by hammer blows when a sample was held in hand indicating that the mudstone is at least moderately strong.

b) Rock exposure at Ch. 3+800m: thinly laminated light grey mudstone. Gravel size lumps could be broken in half under heavy hand pressure indicating a weak strength.

c) Quarry at Ch. 3+250m: thinly to thickly laminated brownish mudstone. Thin slabs, corners and edges could be broken off with heavy hand pressure indicating a moderately weak strength. A large boulder of what appeared to be conglomerate comprising gravels cemented in a silty sandy matrix was also identified in the quarry.

d) Rock exposure at Ch. 2+230m: weathered mudstone on the exposure face, broken down to a gravel on the ground.

e) Quarry at Ch. 1+800m: thinly laminated to very thinly bedded sandstone dipping at 30° to 45° to the north. Quarry face is approximately 3m high and slopes at 60° to 85°.

4.3 Ground investigations

4.3.1 A ground investigation was specified and supervised by Mott MacDonald in 2016. The originally proposed scope of ground investigation comprised the following:

a) 30 machine excavated trial pits at regular centres along the alignment

b) 17 rotary percussive boreholes spaced along the alignment and at the locations of the proposed bridleway underpass and overbridge.

c) 14 in-situ California Bearing Ratio (CBR) tests at regular spacing along the proposed alignment.

d) Installation of gas and groundwater monitoring wells within some of the boreholes, with six rounds of groundwater monitoring and sampling.

e) Geotechnical and geo-environmental sampling and laboratory testing.

Description of fieldwork

4.3.2 The ground investigation was undertaken by WYG Environment Planning Transport Ltd between 11th April and 11th May 2016. Due to land access constraints, TP6 to TP16 and five in-situ CBRs were cancelled. In addition, BH13 was cancelled due to difficulties accessing the proposed position. Two boreholes (BH101 and BH102) were added to the scope.

4.3.3 The completed scope of ground investigation was as follows:

a) 19 machine excavated trial pits.

b) 18 rotary percussive boreholes.

c) 9 in-situ California Bearing Ratio (CBR) tests.

d) 3 rounds of groundwater monitoring without sampling.

e) Geotechnical and geo-environmental sampling and laboratory testing.

Factual report

4.3.4 The factual results from the ground investigation including exploratory hole logs and test results are contained within the Factual Report [17]. The exploratory hole positions are shown on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Features and Constraints

Plan). The geotechnical test results are discussed in Section 6 and presented on Figures 12 to 24. The results of the geo-environmental testing are included in the Factual Report [17].

Results of in situ tests

4.3.5 In-situ testing comprised Standard Penetration Tests (SPT) and CBR tests. The results of the in-situ testing are discussed in detail in Section 6.

4.4 Drainage studies

4.4.1 No drainage studies were undertaken as part of the ground investigation.

4.5 Geophysical survey

4.5.1 No geophysical surveys have been undertaken.

4.6 Pile tests

4.6.1 No pile tests have been undertaken.

4.7 Laboratory investigation

Description of tests

Geotechnical laboratory tests

4.7.1 The following geotechnical laboratory tests were undertaken on samples of superficial deposits and fully weathered rock:

a) Moisture content.

b) Atterberg limits.

c) Particle size distribution (by wet sieving and pipette).

d) pH and sulphate testing.

e) Dry density and moisture content relationship testing, with CBR tests at each compaction point.

4.7.2 The following geotechnical laboratory tests were undertaken on samples of the bedrock:

a) Moisture contents

b) Uniaxial compressive strengths

c) Point load strength index tests

d) Los Angeles abrasion tests

e) Slake durability tests

Geo-environmental laboratory tests

4.7.3 The following geo-environmental laboratory tests were undertaken on samples of the made ground:

a) Petroleum hydrocarbons with speciated aliphatic and aromatic compounds and carbon banding and BTEX compounds (benzene, toluene, ethylbenzene, xylenes)

b) Total organic carbon

c) Metals (arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc)

d) pH

e) Asbestos screening

Copies of test results

4.7.4 The test results are provided in the Factual Report (see Section 4.3.3). The results of the geotechnical tests are also shown on Figures 12 to 24.

5 Ground summary

5.1.1 The scheme has been divided into different earthworks zones, following constructability advice from a contractor. In accordance with the guidance provided in HD22/08 [1], ground models have been identified for each relevant section and these have been presented in the summary forms in Appendix C. The approximate extents of each section are shown on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008 (Constraints Plan).

5.1.2 Based on the results of the ground investigation across the site, the ground conditions typically comprise topsoil overlying weathered bedrock, with the degree of weathering typically reducing with depth. Discrete areas of Made Ground were encountered in some of the exploratory holes. No other superficial deposits were encountered during the ground investigation. However, the geological map indicates localised areas of glaciofluvial deposits and till (see Section 3.2).Table 3 below provides a summary of the anticipated ground conditions within each of the earthworks zones and should be read in conjunction with Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008.

5.1.3 Groundwater levels are anticipated to be high in low lying areas and adjacent to watercourses. There is also the potential for groundwater flows through permeable zones in the bedrock.

5.1.4 The exploratory hole logs included in the Factual Report [17], include interpreted geological formations for each strata. Following the review of the geological information as presented in Section 3.2, reinterpretation of the geological rock formations has been undertaken by Arup. The geological formations are shown graphically on the long sections (Figure 4, 5 and 6).

Table 3 Ground summary table

Earthworks Zone	**Chainage (m)**	**Relevant Exploratory Hole**	**Max. Earthworks Height**	**Ground Conditions**
Penblewin Roundabout	Includes 0+000 to 0+040	TP28, TP29, TP30	5m	Published geology indicates the Slade and Redhill formation to be present beneath the majority of the junction. The northern exit of the proposed roundabout is shown to be within the overlying Portfield and Haverford Mudstone Formation. Dip angles typically 15° to the north. Weathered Mudstone of Slade and Redhill formation encountered during ground investigation. Depth to base of Weathered Mudstone is unproven with the maximum depth encountered as 3.2m bgl. Weathered Mudstone was typically described as orange brown to grey slightly clayey sandy flat and friable gravels of mudstone. Localised pockets of brown clay and mudstone cobble inclusions. No groundwater encountered during the ground investigation in this zone.
Embankment 1	0+040 to 0+370	TP27, TP28, BH16, BH17, CBR01	2.5m	Published geology indicates the bedrock comprises Slade and Redhill Formation, with the boundary of the overlying Portfield and Haverford Mudstone Formation located immediately to the north of the alignment. Dip angles are variable from 15° to 77° in a northerly direction. Weathered Mudstone (Slade and Redhill formation) typically encountered during the ground investigation, extending to depths greater than 8m bgl. Weathered Mudstone typically described as orange brown to dark grey sands, silts and clays with numerous sub-angular to sub-rounded mudstone and sandstone gravels. Occasional cobble inclusions and localised pockets of brown clay. Weathered Conglomerate was encountered in BH16 only, from the ground level to >8mbgl and is anticipated to be of the overlying Portfield and Haverford Mudstone Formation. Boundary of Portfield and Haverford Mudstone Formation may to be further to the south than shown on geological plans in this location. Groundwater seepages recorded at 1.2m and 5.2m depth in BH16 and BH17 respectively. Groundwater monitoring shows groundwater levels between 4.1m and 4.4m depth in BH17 within the Weathered Mudstone of the Portfield and Haverford Mudstone Formation.

Earthworks Zone	Chainage (m)	Relevant Exploratory Hole	Max. Earthworks Height	Ground Conditions
Embankment 2	0+370 to 1+610	TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, BH14, BH15, CBR01, CBR02, CBR03, CBR04, CBR05, CBR06, CBR07, CBR08	4m (localised cutting <2m at western end)	Published geology indicates the location of a Glaciofluvial superficial deposit at the westernmost extent of the earthworks zone although this was not identified in any of the exploratory holes. The boundary between the Haverford Formation and underlying Portfield Formation lies immediately to the north of the proposed highway alignment. Geological maps indicate an anticline to the north of the alignment and a syncline to the south. Shallow Made Ground to 0.85mbgl was encountered locally in BH14 and is described as sandy silty clays and gravels with metal and clay pipe inclusions. Encountered ground conditions typically comprise Weathered Mudstone with bands of Weathered Sandstone of the Haverford Mudstone Formation. The weathered material is typically described as brown to grey sands, silts and clays with sub-rounded to sub-angular gravels and occasional cobbles. The base of the weathered bedrock extends beyond 14.5m bgl. Weathered Siltstone and Siltstone was encountered from the ground surface to the base of the hole in BH15 and is anticipated to be the underlying Portfield and Haverford Mudstone Formation. The Weathered Siltstone was encountered to 6.2m and is described as silts and clays with frequent fine to coarse siltstone gravels and cobbles. The Siltstone is described as moderately strong siltstone with very closely spaced sub horizontal planar smooth bedding discontinuities. The boundary of the Portfield and Haverford Mudstone Formation may to be further to the south than shown on geological plans in this location. Groundwater only encountered in BH14 with a seepage at 4.5m depth. No groundwater monitoring installation was installed.
Embankment 3	1+610 to 2+030	TP17, BH102, BH12, CBR11	9m	Published geology indicates the bedrock in the earthworks zone to comprise the Haverford Formation and underlying Portfield Formation. An axis of an anticline passes through the earthworks zone with dip angles indicated as 40° to 75° either side of the axis. Made Ground deposits of up to 4.1m bgl (described as ‘Probable Made Ground’) encountered and typically described as dark grey to brown gravelly clay and sandy gravel. The gravel is coarse angular to sub-angular mudstone and sandstone.

Earthworks Zone	**Chainage (m)**	**Relevant Exploratory Hole**	**Max. Earthworks Height**	**Ground Conditions**
				Encountered ground conditions typically comprise Weathered Mudstone overlying Mudstone. Weathered Mudstone was encountered to depths of 3.2m to 6.9m bgl and is typically described as orange brown to grey slightly sandy clays and gravels, gravels are coarse angular flat and friable mudstone. The underlying Mudstone is typically described as grey mudstone with red brown staining with very closely spaced 45° planar smooth bedding discontinuities. Weathered Mudstone underlain by Sandstone bedrock was encountered in BH12 only and is anticipated to be of the underlying Portfield and Haverford Mudstone Formation. Groundwater only encountered in BH102 with seepage at 1.2m depth. Groundwater monitoring installed in BH12 and BH102 remained dry.
Cutting 1	2+030 to 2+460	BH101	6m	Limited ground investigation information available in earthworks zone. Geology indicated to be Slade and Redhill Formation with overlying Portfield and Haverford Mudstone Formation immediately to the south of the cutting with dip angles of 25° to the south. The Portfield and Haverford Mudstone Formation was interpreted to be present in BH101 and therefore the boundary of the Portfield and Haverford Mudstone Formation may be further to the northwest than shown on geological plans. In the absence of any further ground investigation in this area, the ground is typically anticipated to comprise Weathered Mudstone overlying Mudstone. Conglomerate and Sandstone of the Portfield and Haverford Mudstone Formation is likely to be encountered in the south face of the cutting, as per BH101. Groundwater seepage at 3.2m depth in BH101. No groundwater monitoring installation was installed.
Embankment 4	2+460 to 2+720	BH11	11m	Limited ground investigation information available in the earthworks zone. Published geology indicates bedrock to comprise the Slade and Redhill Formation. Dip angles indicate a 25° southerly dip to the south and a 15° northerly dip to the north, possibly indicating the location of an anticline.

Earthworks Zone	Chainage (m)	Relevant Exploratory Hole	Max. Earthworks Height	Ground Conditions
				Encountered ground conditions comprise Weathered Mudstone typically described as brown mottled grey to dark grey clayey sandy sub angular to angular mudstone gravels to >11mbgl. Groundwater seepage at 3.0m depth in BH11. Groundwater monitoring in BH101 shows groundwater levels ranging between 3.6m and 4.2m depth.
Cutting 2	2+720 to 2+950	BH09, BH10, BH11	14m	Cutting likely to be formed within the Slade and Redhill Formation with the Portfield and Haverford Mudstone Formation in part of the southern face of the cutting. Dip angles suggest the axis of an anticline lies within the earthworks zone with a 15° northerly dip to the north and a southerly dip to the south, with no angle provided. Ground conditions anticipated to typically comprise Weathered Mudstone of Slade and Redhill formation to significant depth. Weathered Mudstone typically described as dark grey sandy clays and sub-angular to angular mudstone gravels with occasional mudstone cobbles. Weathered Conglomerate and Conglomerate interpreted to be of the Portfield and Haverford Mudstone Formation encountered in BH09. Weathered Conglomerate is described as brown slightly clayey sand with occasional rounded to sub-angular gravel of mixed lithologies and rare sandstone cobbles. Conglomerate is described as very weak brown fine grained conglomerate with red brown staining and very closely spaced 45° bedding with rough planar discontinuities of variable angle. Groundwater seepage at 3.0m and 6.0m depth in BH11 and BH10 respectively. Groundwater monitoring showed water levels to range from 3.6m to 4.2m depth in BH11, however BH10 remained dry.
Embankment 5	2+950 to 3+480	BH07	24m	Limited ground investigation information available in earthworks zone. Published geology indicates bedrock comprises Slade and Redhill Formation. Dip angles indicate a 30° northerly dip. Published geology indicates an area of natural superficial Till deposits between Ch 3+020m and Ch 3+090m, however, no ground investigation has been undertaken in this area. Encountered ground conditions comprise Weathered Mudstone to 4.4m bgl described as dark brown to grey clayey mudstone gravel with occasional mudstone cobble inclusions. Mudstone

Earthworks Zone	Chainage (m)	Relevant Exploratory Hole	Max. Earthworks Height	Ground Conditions
				described as grey moderately strong mudstone with closely spaced planar smooth bedding discontinuities with occasional bands of soft grey sandy clay. Groundwater was not encountered during the ground investigation in this zone.
Cutting 3	3+480 to 3+850	TP04, TP05, BH04, BH05, BH06	21m	Geology indicated to comprise the Slade and Redhill Formation. Dip angles indicate that the cutting may be located near an anticline in the Slade and Redhill Formation, with the bedrock dipping towards the north to the north of the cutting and to the south to the south of the cutting. Encountered ground conditions comprise Weathered Mudstone, typically to 1.4m to 2.4m depth, overlying Mudstone. Weathered Mudstone typically described as brown and/or grey sandy gravel of mudstone (also described locally as sand and clay). Mudstone typically described as moderately weak becoming moderately strong with depth dark grey mudstone with very closely spaced smooth planar discontinuities at variable angle. Groundwater seepage was encountered in BH03 at 1.0m and at 3.5m depth as well as BH04 at 1.8m depth. The groundwater monitoring installation installed in BH04 remained dry.
Llanddewi Velfrey Roundabout	Beyond 3+850	TP01, TP02, TP03, BH01, BH02, BH03	15m (cutting) 12m (embankment)	The majority of the earthworks zone is underlain by Slade and Redhill Formation. Dip angles are typically towards the south, varying from 60° to 30°. At the south-western spur of the proposed roundabout, dip angles suggest the possible presence of a syncline feature, with the spur proposed to extend through cutting into the overlying Portfield and Haverford Formation (undifferentiated) and Haverford Mudstone Formation. A discrete location of Made Ground was encountered to a maximum depth of 3.1m, and was typically described as dark grey to brown sandy clay and fine to coarse mudstone gravel with mudstone cobble and boulder inclusions and pieces of metal, plastic, tile and concrete. Encountered ground conditions comprise Weathered Mudstone, typically to 2.5 to 4.4m depth, overlying Mudstone. Weathered Mudstone was typically described as orange brown to light grey soft silty sandy clayey fine to coarse sub-angular predominantly mudstone gravel with occasional sub-angular to sub-rounded sandstone and mudstone cobbles. Mudstone was typically described as moderately weak becoming moderately strong with depth dark grey mudstone with very closely spaced smooth planar discontinuities at variable angle.

Earthworks Zone	Chainage (m)	Relevant Exploratory Hole	Max. Earthworks Height	Ground Conditions
				Groundwater was struck twice in BH03, at 1.0m and 3.5m depth within the weathered mudstone. In addition, the groundwater monitoring installation in BH01 recorded groundwater levels ranging between 2.6m and 2.7m depth. A band of moderately strong Conglomerate was identified in BH03 only. The Conglomerate is interpreted to be of the Portfield and Haverford Mudstone Formation that overlies the mudstones within the Slade and Redhill Formation.

6 Ground conditions and material properties

6.1 Introduction

Overview

6.1.1 Details of the ground and groundwater conditions encountered during the ground investigation are presented in the sections below. Long sections showing the geology encountered in the exploratory holes have been produced (see Figures 4, 5 and 6) as well as cross sections through the two main cuttings and across the embankment widening (see Figures 7, 8 and 9). Cross sections at the locations of the Category 2 structures are also presented (see Figures 10 and 11).

6.1.2 A review of the log descriptions and geotechnical test results has been undertaken for the different geological rock formations. No significant clear differences between the formations have been identified, other than variations between the different rocks types and the degree of weathering. Review of the log descriptions does not indicate any specific characteristics of strength, structure or discontinuity condition of rocks from a particular formation. Review of the geotechnical test data as presented on Figures 12 to 35 indicates that the results for the rock types from the different rock formations are all within a similar range. No distinguishable trends relating to specific formations have been identified. On this basis, for the purpose of the engineering interpretation within this report, it is proposed to not distinguish between the different geological formations and to only distinguish between the different rock types. Mudstone is the most prevalent rock type within the scheme, but areas and bands of sandstone, conglomerate and siltstone have also been encountered.

6.1.3 The results of the geotechnical test results are presented graphically in Figures 12 to 35 of this report. Colour coding has been used to distinguish between different rock types and geological formations, which demonstrates that there are no significant differences between the different geological formations.

6.1.4 For the purpose of this report, weathered bedrock has been defined as bedrock that has been highly to fully weathered and has been described using soil descriptors on the exploratory hole logs. Where the rock is described using rock descriptors this has been considered as a rock, although it is likely to have experienced some degree of weathering. The weathered rock materials encountered are as follows:

a) Weathered Mudstone

b) Weathered Sandstone

c) Weathered Siltstone

d) Weathered Conglomerate

6.1.5 The rock materials encountered are as follows:

a) Mudstone

b) Sandstone

c) Siltstone

d) Conglomerate

Earthworks and structures summary sheets

6.1.6 The summary of the ground conditions and material properties presented in Section 6 has been completed on a site wide basis. Details of the localised ground conditions at earthworks zones and structures (excluding Category 0 structures) are presented in the summary sheets included in Appendices C and D respectively.

6.1.7 The summary sheets have been prepared as part of this GIR and therefore are intended to be completed and revised as required as the Key Stage 3 geotechnical design of structures and earthworks is completed. Updated summary sheets are to be included in the Key Stage 3 preliminary Geotechnical Design Report (GDR) and the Agreement In Principles (AIPs) for structures.

Limitations

6.1.8 It should be noted that the ground conditions and material properties discussed in this section only include those encountered during the ground investigation. The review of the site geology indicates that the proposed alignment crosses an area of glaciofluvial deposits between Ch. 0+430m and Ch. 0+510m, and an area of till (diamicton) between Ch. 3+020m and 3+090m. No ground investigation was undertaken in these areas.

6.1.9 Should further ground investigation be undertaken at Key Stage 6, the findings should be presented in an addendum or a revised version of the GIR.

6.2 Topsoil

6.2.1 Turf over topsoil was encountered at the ground surface in the majority of the exploratory holes. It is typically in the region of 0.3m in thickness. It is most commonly described as soft brown silt with humus and roots. No geotechnical testing was undertaken on the Topsoil.

6.3 Made Ground

Description

Made Ground was encountered in seven of the 37 exploratory holes at discrete locations throughout the scheme. A summary of the encountered Made Ground is presented in

6.3.1 Table 12 below. Manmade materials were encountered in two of these exploratory holes and included fragments of brick, metal, plastic, tile and concrete. No visual or olfactory evidence of contamination was noted on the exploratory hole logs.

Table 4 Summary of encountered Made Ground

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

6.3.2 There is limited information and test data to derive geotechnical parameters for the Made Ground. In addition, the Made Ground is likely to be heterogeneous in nature and therefore its engineering properties will vary.

Classification

6.3.3 No moisture content, Atterberg Limit or Particle Size Distribution (PSD) tests were undertaken on samples of the Made Ground.

Standard penetration test

6.3.4 Two Standard Penetration Tests (SPTs) were undertaken in the Made Ground in BH12 and recorded N values of 14 and 11 (see Figure 13). The results indicate the material is medium dense at this location.

Summary of parameters

6.3.5 Should there be a need to attribute engineering parameters to the Made Ground during design, this should be approached on a case by case basis for the specific areas under consideration.

6.4 Weathered Mudstone

Description

6.4.1 The term Weathered Mudstone has been used for fully or highly weathered bedrock which has been described using soil rather than rock descriptors on the exploratory hole logs; refer to Section 6.1.4. For the geological sections (Figures 4 to 6) and test data plots (Figures 12 to 35), colour coding has been used to distinguish between the 'Weathered Mudstone' and 'Mudstone'.

6.4.2 Weathered Mudstone was encountered in 35 of the 37 exploratory holes underlying the Topsoil or Made Ground where present. The thickness of the Weathered Mudstone is typically in the region of 2m to 4m. The degree of weathering generally reduces with depth.

6.4.3 Weathered Mudstone has been identified from all three geological formations (see Section 3.2). The description of the Weathered Mudstone is variable, however, it is most commonly described as slightly silty sandy fine to coarse sub-angular to sub-rounded gravel of mudstone. In places, the Weathered Mudstone is described as a cohesive material but generally only at relatively shallow depth below the ground surface. This is supported by the PSDs (see Figure 20) which indicate only a small number of the samples tested are cohesive in nature (fines content >35% as defined in BS5930 [18]) and all of those samples were obtained from less than around 3m below ground level. The cohesive Weathered Mudstone is typically described as firm to stiff slightly gravelly clay or silt, also locally soft near the ground surface. It should also be noted that where Weathered Mudstone has been described as cohesive, in some locations the PSDs indicate a fines content of less than 35%.

6.4.4 Based on review of the geotechnical test results, there is evidence that some of the material which has been classified as weathered on the borehole records may have broken down during drilling and as a result of undertaking Standard Penetration Tests (SPTs). This may have resulted in the description of the material suggesting a greater degree of weathering than is present in-situ. In particular, this may be the case where Weathered Mudstone was recorded to significant depths from 7.5m to >17mbgl in four boreholes. Depths over which the classification and description of the material may have been influenced by drilling induced fracturing and poor recovery of the sample are annotated on the geological long sections (see Figures 4, 5 and 6).

6.4.5 A density value of 20kN/m^3 is recommended [19] on the basis that the Weathered Mudstone is typically medium dense to dense where granular, or firm to stiff where cohesive.

Classification

6.4.6 40 natural moisture content tests were undertaken on samples of the Weathered Mudstone and the results varied from 3% to 23%, but are more commonly in the region of 8% to 21% (see Figure 14).

6.4.7 30 Atterberg Limit tests were undertaken on samples of the Weathered Mudstone and the results are shown on a Casagrande chart in Figure 16. The results indicate that the material passing the 425µm sieve is a clay of low to intermediate plasticity, with one result indicating high plasticity. The natural moisture content was generally found to be slightly above or below the plastic limit (see Figure 18).

6.4.8 22 PSD tests were undertaken on samples of the Weathered Mudstone (see Figure 20). The PSD tests support the variation in the material descriptions on the exploratory hole logs as a result of various degrees of weathering of the material. The results indicate the material varies from cobbles with some finer material, to slightly sandy slightly gravelly silty clay. The results indicate that the Weathered Mudstone will be both a Class 1 (<15% fines) and Class 2 (>15% fines) fill in accordance with the Specification for Highways Works, Series 600 Earthworks [20].

Standard penetration test

6.4.9 47 SPTs were undertaken within the Weathered Mudstone (see Figure 12). The results varied from N values of 7 to extrapolated values of 300 and above, but are most commonly in the region of 10 to 50 which equates to a medium dense to dense material [18].

6.4.10 The SPT N values from the Haverford Mudstone Formation appear to be lower than the other materials as shown on Figure 12, however, these SPTs are mostly from a single borehole (BH14) and are still within the spread of data. In addition, the characteristic SPT N value for parameter derivation has been taken as 20 and these SPT N values are generally around or above this value.

Compaction and CBR

6.4.11 Nine laboratory California Bearing Ratio (CBR) and dry density versus moisture content relationship tests were undertaken on samples of the Weathered Mudstone (see Figure 22 and 24). The samples were compacted using a 4.5kg rammer and tested at 5 moisture contents, at which the dry density and CBR were measured. The tests were only undertaken on the material passing the 20mm sieve. Based on the PSD tests (see Figure 20) this can be a significant proportion of the sample, as all coarse gravel and cobbles are removed. The test result sheets indicate the percentage of the sample removed by the sieving but this indicates that generally only a small proportion of the samples was removed (less than 10%). This does not correspond with the PSD test results and it is anticipated that this is due to some selective subsampling of the material prior to sieving.

6.4.12 The Optimum Moisture Content (OMC) varied between 7% and 10% as summarised in Table 5 below. The natural moisture content of the samples tested was found to be between 0.3% and 17% higher than the optimum moisture content, and in a similar range to the other natural moisture content tests presented in Section 6.4.6.

6.4.13 There is a wide variation in the CBR results and the zone of results which achieved a CBR less than 15% is highlighted on Figure 22. The results indicate that the material is highly sensitive to changes in moisture content, with a decrease in the CBR value from 15% to 3% as a result of an increase in moisture content in the region of 3%. The results also indicate that at the natural moisture content of the samples tested, the CBR value would typically be <5%.

6.4.14 It should be noted that for the purpose of pavement design, the long term equilibrium CBR value of materials should be used. This accounts for possible changes in the moisture content of the soil after it has been placed and compacted and potential degradation of the material with time.

6.4.15 For the Weathered Mudstone, the OMC and CBR of the material will be impacted by the degree of weathering and the grading of the material, in particular for those samples with higher fines content (greater than approximately 15%).

Table 5 Summary of optimum versus natural moisture content

Exploratory hole	**Depth (mbgl)**	**Optimum Moisture Content (%)**	**Natural Moisture Content (%)**	**Difference (%)**
BH10	1.2 to 2.0	7	10.1	+3.1
BH101	0 to 1.2	9	26.3	+17.3
BH102	1.2 to 2.0	10	25.5	+15.5
TP4	1.8 to 2.1	10	10.3	+0.3
TP19	3.0 to 3.4	9	19.1	+10.1
TP20	2.9 to 3.3	9	16.8	+7.8
TP21	3.0 to 3.4	7	16.9	+9.9
TP24	1.8 to 2.2	9	15.4	+6.4
TP29	1.9 to 2.3	7	10.8	+3.8

Strength parameters

6.4.16 No direct measurements of strength were undertaken on the Weathered Mudstone and therefore strength parameters have been derived using published correlations. Where the Weathered Mudstone is granular, the peak angle of friction has been derived using the guidance in CIRIA 143 [21] for granular soils. It should be noted that this relational typically underestimates the angle of friction and therefore this approach is considered to be conservative:

$\varphi' = 34°$ based on a characteristic SPT N value of 20.

$c' = 0$ kPa.

6.4.17 For the cohesive Weathered Mudstone, the following strength parameters have been derived:

φ'_{pk} = 29° based on Equation 8 of BS8002 [19] and assuming I_p=15% and φ'_{dil} = 2°. Although no testing was undertaken to demonstrate a precise value of dilation, is it considered reasonable to allow for a small value of dilation as the material has a high granular content and is medium dense to dense.

c' = 0 kPa

c_u = 75 kPa based on firm to stiff consistency [22].

Compressibility

6.4.18 The Young's Modulus (E') for the cohesive and granular Weathered Mudstone has been derived using the following correlations presented by Stroud [23]:

$E'=250\ c_u$ = 19,000 kN/m^2 for cohesive Weathered Mudstone based on a c_u of 75 kPa.

$E'=1500N$ = 30,000 kN/m^2 for granular Weathered Mudstone based on a characteristic SPT N value of 20.

Summary of parameters

6.4.19 A summary of the derived parameters for the Weathered Mudstone is presented in Table 6 below.

Table 6 Summary of derived parameters for Weathered Mudstone

Material	**Density** **γ' (kN/m^3)**	**Angle of friction** **φ'_{pk} (°)**	**Cohesion** **c' (kPa)**	**Undrained shear strength** **c_u (kPa)**	**Young's Modulus** **E' (kN/m^2)**
Granular	20	34	0	-	30,000
Cohesive	20	29	0	75	19,000

6.5 Mudstone

Description

6.5.1 Mudstone is the most prevalent rock type encountered during the ground investigation and was identified in nine of the 12 boreholes which identified bedrock. Mudstone was most commonly encountered beneath the Weathered Mudstone at some 2m to 4m depth. Mudstone was also encountered beneath bands of Conglomerate and Sandstone.

6.5.2 The Mudstone is typically described as moderately weak to moderately strong grey mudstone with very closely spaced planar smooth bedding discontinuities. The dip of the bedding discontinuities is variable and in the range of 10° to 70°. Widely spaced subvertical or randomly orientated planar and stepped discontinues are also indicated. Clay infill is noted in some of the discontinuities. The base of the Mudstone was not proven and was encountered to a maximum depth of 20m in BH10.

6.5.3 There are a number of publications which provide recommended values for the density of bedrock [24][25][26]. A density value of $22kN/m^3$ is recommended for the Mudstone.

Classification

6.5.4 The Total Core Recovery of the Mudstone was generally >90%, with the main exceptions to this being in BH06 and BH08 where a number of the core runs only had core recovery in the range of 35% to 60% (see Figure 26). The Solid Core Recovery was highly variable as shown on Figure 28, ranging from 0% to 97%. The Rock Quality Designation varied from 0% to 33% (see Figure 30), with one outlier of 63%.

Standard penetration test

6.5.5 SPTs were generally not undertaken within the rotary boreholes and therefore only six N values are available within the Mudstone. The results varied between 130 and 220, with one outlier of 1700 (see Figure 12).

Compaction and CBR

6.5.6 A single CBR and dry density versus moisture content relationship test was undertaken on a sample of the Mudstone from BH04 (see Figure 22 and 24). The results presented in the Factual Report [17] does not indicate any additional crushing or preparation of the sample. Based on the photographs of the rock cores included in the Factual Report [17], the bedrock was highly fractured and if disturbed may have broken down in to a medium to coarse gravel.

6.5.7 The compaction test using a 4.5kg rammer gave the optimum moisture content of the material as 4% compared to the natural moisture content of the material at 6.9%

6.5.8 CBR tests were undertaken at moisture contents varying from 1% to 9% and all returned CBR values greater than 25%.

6.5.9 The optimum moisture content and CBR of the Mudstone will be effected by the grading of the material following excavation and any subsequent crushing and sorting, as well as the initial strength of the rock.

Strength parameters

6.5.10 Due to the fracturing of the bedrock and sample recovery, no Unconfined Compressive Strength (UCS) tests was undertaken on the Mudstone. UCS of the bedrock can be correlated from the Point Load tests. There are numerous publications providing guidance on the multiplication factor for mudstones which generally are between 15 and 24. It is proposed to use a multiplication factor of 21 and the results are shown on Figure 32. The derived values of UCS vary from 1MPa to 55MPa, but are commonly in the range of 5MPa to 35MPa which equates to a weak to medium strong rock which broadly corresponds with the log descriptions. A characteristic value for the UCS of 10MPa is recommended for the Mudstone.

6.5.11 Rock mass parameters have been derived using RocLab which is based on the Hoek-Brown criterion. The rock mass parameters for the Mudstone are as follows:

$\varphi' = 28°$

$c' = 60$ kPa

6.5.12 Details of the RocLab assessment are included in Appendix E. The Geological Strength Index (GSI) value adopted are based on the review of the logs descriptions for the boreholes in the cuttings to determine the characteristic rock structure and surface condition. No variation in the rock structure or surface condition has been identified for rocks from the different formation based on review of the log descriptions.

6.5.13 The log descriptions of the surface condition for the Mudstone are summarised in Section 6.5.2. Based on this the rock structure has been assumed to be seamy/disturbed (in accordance with the classification system within RocLab) for the derivation of the GSI value. The surface condition has been assumed to be smooth, moderately to highly weathered (or fair to poor). The surface condition is described as stepped / undulation in places, however, smooth has been conservatively assumed as is most commonly described.

6.5.14 A single Los Angeles abrasion test was undertaken on the Mudstone from BH05 and returned a result of 42 (see Figure 35).

6.5.15 Five Slake Durability Tests were undertaken on samples of the Mudstone (see Figure 34). Following the first cycle the index values ranged from 86% to 98% and following the second cycle ranged from 77% to 93%. This equates to a material of medium to medium high durability based on Gamble's classification system [27].

Compressibility

6.5.16 The Young's Modulus (E') for the Mudstone has been derived using the following correlation presented by Stroud [23]:

E'=1000 N = 150,000 kN/m^2 based on a SPT N value of 150.

6.5.17 Due to the limited number of SPTs undertaken within the bedrock, a literature review of published values for E' of mudstones was undertaken. Based on the review, the value presented above is considered to be reasonable.

Discontinuities

6.5.18 Discontinuities are present in the Mudstone as described on the exploratory hole logs. The presence of discontinuities will be considered as part of the stability assessment of cuttings as the discontinuities may form preferential failure planes resulting in wedge type failures.

6.5.19 The review of the geological information (see Section 3.2) indicates significant variation in the angle (ranging from 10° to 75°) and direction of the bedding. On this basis, it is not considered feasible to confirm the likely angle of direction of the dip in the face of the cuttings based on this information.

6.5.20 A summary of the descriptions of the discontinuities from the boreholes in the cuttings are presented in Table 7 below. The condition of the bedding discontinuity set is typically described as very closely spaced planar smooth and clay infill is also noted on BH03. As per the dip angles on the geological maps, the dip angles are variable from 10° to 70°, however, they are most commonly in the range of 10° to 30°. The descriptions also indicate a secondary joint set in some strata, the description of which is variable.

6.5.21 A review of published information relating to the strength parameters of discontinuities has been undertaken. This indicates that an angle of friction in the region of 30° is typical for mudstones and there may be some cohesion [28][29][30]. The stability of the cuttings and the potential for wedge failures will be considered as part of the earthworks design and presented in the preliminary GDR. The proposed angle of cuttings is anticipated to be 1V:2H and wedge failures will only occur if the direction of the discontinuities is unfavourable and daylights in the face of the cutting. Based on the anticipated strength parameters for the discontinuities, wedge failures are not anticipated to be of significant concern.

Table 7 Summary of discontinuity descriptions in Mudstone

Borehole	**Top depth (mbgl)**	**Base depth (mbgl)**	**Description**
BH03	4.5	15	Very closely spaced 10-30° planar smooth bedding discontinuities, very close random fractures and widely spaced 70° planar and stepped discontinuities, all with red brown staining and clay infill
BH04	1.8	14.8	Very closely spaced 70° and randomly orientated planar and undulating smooth discontinuities, dark red brown stained
BH04	14.8	18	Very closely spaced 10-30° planar smooth bedding discontinuities
BH05	1.4	7.4	Very closely spaced 10° bedding discontinuities and random planar smooth discontinuities, red brown and black stained
BH05	7.4	17.5	Very closely spaced 30° and random planar smooth discontinuities, red brown staining
BH06	2.4	4.7	Very closely spaced irregular planar and undulating bedding discontinuities, red brown and black staining
BH06	4.7	10.3	Very closely spaced 10-20° bedding discontinuities and very close 45-60° discontinuities, all planar smooth with red brown staining
BH06	10.3	17.7	Very closely spaced 10-20° planar smooth bedding discontinuities
BH07	4.4	10.5	Very closely spaced planar smooth sub horizontal to 45° bedding discontinuities and sub vertical discontinuities
BH101	1.8	3.9	Very closely spaced 45° planar smooth bedding discontinuities, red brown and black staining

Summary of parameters

A summary of the derived parameters for the Mudstone is presented in Table 8 below:

Table 8 Summary of derived parameters for Mudstone

Density γ' (kN/m^3)	**UCS** σ_c (MPa)	**Angle of friction** φ (°)	**Cohesion** c' (kPa)	**Young's Modulus** E' (kN/m^2)
22	10	28	60	150,000

6.6 Weathered Siltstone and Siltstone

Description

6.6.1 Weathered Siltstone and Siltstone was only encountered in BH15 throughout the full depth of the borehole and is interpreted to be of the Portfield and Haverford Mudstone Formation. Weathered Siltstone was encountered to 6.2m depth and is described as brown clayey sandy silt with fine to coarse subangular gravel and cobbles of siltstone. Siltstone was encountered from 6.2m depth to the base of the hole at 14.5m. It is typically described as strong grey siltstone with very closely spaced subhoriztonal (20°) planar smooth bedding discontinuities. Subvertical planar smooth discontinuities are also noted.

6.6.2 A density value of 20kN/m^3 is recommended [19] on the basis the Weathered Siltstone is typically medium dense to dense gravel.

6.6.3 There are numerous publications which provide recommended values for the density of bedrock. A density value of 22kN/m^3 is recommended for the Siltstone.

Classification

6.6.4 No classification testing was undertaken on the Weathered Siltstone.

6.6.5 The Total Core Recovery of the Siltstone was variable and ranged from 30% to 100% (see Figure 27). The Solid Core Recovery was highly variable as shown on Figure 29, ranging from 0% to 83%. The Rock Quality Designation varied from 0% to 53% (see Figure 31).

Standard penetration test

6.6.6 Three SPTs were undertaken within the Weathered Siltstone and recorded N values of 14, 15 and 19 (see Figure 13) which equates to a medium dense material.

6.6.7 A single SPT was undertaken on the horizon of the Siltstone and returned an extrapolated N value of 260.

Compaction and CBR

6.6.8 No compaction or CBR testing was undertaken on samples of the Weathered Siltstone.

Strength parameters

6.6.9 No direct measurements of strength were undertaken on the Weathered Siltstone and therefore strength parameters have been derived using published correlations of SPT data. The peak angle of friction has been derived using the guidance in CIRIA 143 [21] for granular soils. It should be noted that this relational typically underestimates the angle of friction and therefore this approach is considered to be conservative. Furthermore, only a limited SPT dataset is available for the weathered siltstone as it was only encountered in one specific location. Should additional areas of this material be identified in future ground investigation the derived value should be reassessed:

φ' = 31° based on a characteristic SPT N value of 14.

c’ = 0 kPa.

6.6.10 A single UCS was undertaken on the Siltstone and returned a result of 180MPa which equates to a very strong rock. Two results from Point Load tests are shown on Figure 33 using a multiplication factor of 21 to the Point Load Index (Is50) to calculate UCS. The values of UCS are 75MPa and 85Mpa which equates to a strong rock as per the log description. A characteristic value of 75MPa is recommended.

6.6.11 Rock mass parameters have been derived using RocLab which is based on the Hoek-Brown criterion. The rock mass parameters for the Siltstone are as follows:

φ’ = 55°

c’ = 400 kPa

6.6.12 Details of the RocLab assessment are included in Appendix E. The Geological Strength Index (GSI) value adopted are based on the review of the logs descriptions in BH15. Based on this the rock structure has been assumed to be blocky (in accordance with the classification system within RocLab). The surface condition has been assumed to be smooth, moderately to slightly weathered (or good to fair). The surface condition of some of the discontinuities is described as undulation, however, smooth has been conservatively assumed.

Compressibility

6.6.13 Siltstone was only encountered in BH15 which is at the proposed location of an underpass beneath the mainline which is at grade at this location. On this basis, consideration of compressibility characteristics is not required.

Summary of parameters

6.6.14 A summary of the derived parameters for the Weathered siltstone and Siltstone are presented in Table 9 below.

Table 9 Summary of parameters for Weathered Siltstone and Siltstone

Material	**Density** γ **(kN/m^3)**	**UCS** σ_c **(MPa)**	**Angle of friction** φ'_{pk} **(°)**	**Cohesion** **c' (kPa)**	**Young's Modulus** **E' (kN/m^2)**
Weathered Siltstone	20	-	34	0	NA
Siltstone	22	75	55	400	NA

6.7 Weathered Sandstone and Sandstone

Description

6.7.1 Weathered Sandstone and Sandstone was encountered in 4 of the exploratory holes as summarised in Table 10 below.

Table 10 Summary of encountered Weathered Sandstone and Sandstone

Exploratory hole	Depth present	Description
TP03	3.1 to >4.1mbgl	Brown slightly clayey sandy gravel or gravelly sand. Gravel is fine to coarse subangular to subrounded
BH12	6.9 to >8mbgl	Strong dark grey medium grained sandstone
BH14	6.5 to 7.5mbgl	Brown very clayey sand/silt with cobbles of sandstone
	8.5 to >14.5mbgl	Very stiff grey very sandy clay with many fine to coarse sub-rounded to sub-angular gravel of mixed lithologies and occasional cobbles and boulders of sandstone
BH101	3.9 to 6.5mbgl	Strong grey coarse grained sandstone with very closely spaced 45° and 70° planar rough black stained discontinuities

Classification

6.7.2 No classification testing was undertaken on samples of the Weathered Sandstone.

6.7.3 The Total Core Recovery of Sandstone was variable and ranged from 20% to 100% (see Figure 27). The Solid Core Recovery ranged from 0% to 17% (see Figure 29). The Rock Quality Designation of the Sandstone was 0% (see Figure 31).

Standard penetration test

6.7.4 Seven SPTs were undertaken in the Weathered Sandstone in BH14 and returned N values ranging from 60 to 185 which equates to a very dense material.

6.7.5 No SPTs were undertaken in the Sandstone.

Compaction and CBR

6.7.6 A single CBR and dry density versus moisture content relationship test was undertaken on a sample of the Weathered Sandstone from TP03 (see Figure 23 and 25). The optimum moisture content of the material was 10% and the natural moisture content of the material was 27%

6.7.7 In regards to the CBR values, the results indicate that for a CBR of 15% the moisture content of the material would need to be in the region of

14% and that for a CBR of 3% the moisture content of the material would need to be in the region of 23%.

Strength parameters

6.7.8 No direct measurements of strength was undertaken on the Weathered Sandstone and there is limited information to derive strength parameters using published correlations. Based on the log descriptions and SPT N values, it is considered reasonable to adopt the same parameters as the granular Weathered Mudstone as the material is likely to exhibit comparable or greater engineering characteristics. In addition, due to the heavily folded nature of the bedrock and spacing of the exploratory holes there is little evidence to suggest the bands of sandstone will be present consistently through sections of the scheme and therefore this approach will not have a significant impact on the geotechnical design.

6.7.9 No UCS or PLI tests were undertaken on the Sandstone and therefore it is proposed to adopt the same strength parameters as the Mudstone. This is considered to be conservative as the Sandstone is likely to exhibit greater strength characteristics than the Mudstone, however, as the Sandstone is typically relatively thin bands within the Mudstone this approach is considered to be reasonable.

Compressibility

6.7.10 As per Section 6.7.8 above, it is proposed to adopt the Young's Modulus values for the Weathered Mudstone and Mudstone for the Weathered Sandstone and Sandstone respectively.

Summary of parameters

6.7.11 A summary of the derived parameters for the Weathered Sandstone and Sandstone is presented in Table 11 below.

Table 11 Summary of parameters for Weathered Sandstone and Sandstone

Material	**Density** γ **(kN/m^3)**	**UCS** σ_c **(MPa)**	**Angle of friction** φ'_{pk} **(°)**	**Cohesion c' (kPa)**	**Young's Modulus E' (kN/m^2)**
Weathered Sandstone	20	-	34	0	30,000
Sandstone	22	10	28	60	150,000

6.8 Weathered Conglomerate and Conglomerate

Description

Weathered Conglomerate and Conglomerate was encountered in four of the 37 exploratory holes as summarised in

6.8.1 Table 12 below. Conglomerate is a coarse-grained sedimentary rock composed of fragments of rocks of various lithologies embedded in a matrix of cementing material.

6.8.2 Based on the review of the geological information (see Section 3.2) it anticipated that all of the conglomerate encountered is of the Portfield and Haverford Mudstone Formation. The descriptions of the material indicate that the Weathered Conglomerate and Conglomerate is highly variable, with the descriptions indicating the Weathered Conglomerate is a gravel and clay, and the strength the Conglomerate varies from weak to strong. It is anticipated that this is as a result of variation in the degree of weathering.

Table 12 Summary of encountered Weathered Conglomerate and Conglomerate

Exploratory hole	Depth present	Description
BH16	0 to 3.2mbgl	Firm orange brown very sandy silt/clay with many fine to coarse subangular to subrounded gravel of sandstone and mudstone
	3.2 to >8mbgl	Firm to stiff dark grey brown silty clay with many fine to coarse subangular gravel of sandstone and mudstone
BH101	6.5 to >8.5mbgl	Strong brown fine grained conglomerate with very closely spaced 45° bedding discontinuities and 70° planar rough discontinuities
BH09	0 to 3.5mbgl	Brown occasionally grey slightly clayey fine to coarse sand with occasional fine to coarse rounded to subangular gravel of mixed lithologies and rare cobbles of sandstone
	3.5 to 9.5	Very weak brown fine grained conglomerate with very closely spaced 45° bedding and very closely spaced 45° to 80° planar rough discontinuities
BH03	3.4 to 4.5mbgl	Moderately strong fine grained conglomerate

6.8.3 Due to the variability of the material and that it has only been identified in discrete locations, it is not considered appropriate to characterise the Weathered Conglomerate and Conglomerate and determine its engineering properties on a site wide basis. A summary of the scheme proposals at the locations where Weathered Conglomerate and Conglomerate has been identified and the required engineering parameters is provided in Table 13 below. The derivation of the parameters are presented in Appendix H and the parameters stated in the relevant earthworks and structures summary sheets. Due to the limited test data to inform the derivation of these parameters, further investigation is likely to be required during Key Stage 6.

Table 13 Scheme proposals at locations of Weathered Conglomerate and Conglomerate

Exploratory hole	**Location**	**Required parameters**
BH16	Eastern end of Embankment 1. Embankment height of 5m to 2.5m in area of conglomerate.	E' for settlement analysis φ' c' c_u for slope stability assessment
BH101	Cutting 1. Cutting height up to 6m.	φ' c' for rock stability assessment
BH09	Cutting 2 and Overbridge 1 (SBR-0285). Cutting height up to 15m.	φ' c' of Weathered Conglomerate and Conglomerate for stability assessment
BH03	Llanddewi Velfrey Roundabout, southern spur. Cutting height up 15m.	φ' c' for rock stability assessment

Classification

6.8.4 Two natural moisture content tests were undertaken on samples of the Weathered Conglomerate and returned results of 10% and 18% in BH16 and BH09 respectively (see Figure 15).

6.8.5 Atterberg Limits tests were undertaken on the same two samples and the results are shown on a Casagrande chart in Figure 17. The results indicate that the material passing the 425µm sieve is a clay of low plasticity from BH16 and intermediate plasticity from BH09. The natural moisture content of the samples was below the plastic limit (see Figure 19).

6.8.6 PSD tests were undertaken on the same two samples (see Figure 21). The results indicate the material from BH16 is slightly sandy slightly gravelly clay and the sample from BH09 is a slightly silty very sandy gravel which broadly corresponds with the log descriptions.

6.8.7 The Total Core Recovery of the Conglomerate was variable and ranged from 30% to 100% (see Figure 27). The Solid Core Recovery ranged from 0% to 50% (see Figure 29). The Rock Quality Designation of the Conglomerate varied from 0% to 24% (see Figure 31).

Standard penetration test

6.8.8 Five SPTs were undertaken within the Weathered Conglomerate and the results varied between N values of 8 and 46 (see Figure 13). This equates to a loose to dense material. A single SPT was undertaken within the Conglomerate and returned an extrapolated N value of 240.

Compaction and CBR

6.8.9 No compaction or CBR testing was undertaken on samples of the Weathered Conglomerate.

Strength parameters

6.8.10 No direct measurements of strength were undertaken on samples of the Weathered Conglomerate or Conglomerate.

6.8.11 Reference should be made to Appendix H for the derivation of location specific parameters. For the derivation of rock mass parameters for the Conglomerate, RocLab has been used. As location specific parameters have been derived, the adopted GSI value is based on the logs description of the rock structure and surface condition at each location. The assumed rock structure and surface condition is stated in Appendix H.

Compressibility

6.8.12 Reference should be made to Appendix H for the derivation of location specific parameters.

Summary of parameters

6.8.13 Reference should be made to Appendix H for the derivation of location specific strength parameters.

6.9 Groundwater / chemistry

Groundwater strikes

6.9.1 Groundwater was encountered in 10 boreholes; BH03, BH04, BH09, BH10, BH11, BH14, BH16, BH17, BH101, BH102, as shown in Appendix E. In addition, water was observed in the base of the excavation in the photographs of TP19 and TP29 which are included in the Factual Report [17], however, the presence of groundwater was not recorded on the exploratory hole logs.

6.9.2 Groundwater seepage depths varied across the scheme ranging from 1.0m and 6m and with corresponding levels ranging from 77.4mAOD and 127.6mAOD. The groundwater seepages were recorded in various strata as shown in Appendix E.

Groundwater monitoring

6.9.3 During the investigation, slotted 50mm groundwater standpipes were installed in eight boreholes; BH01, BH04, BH08, BH10, BH11, BH12, BH17 and BH102. Groundwater monitoring was undertaken during three visits on 19th May, 1st and 7th June 2016. The results of the groundwater monitoring are presented in Appendix E and the Factual Report [17].

6.9.4 Groundwater monitoring recorded depths ranging from 0.2m to 4.4m and elevations ranging from 65.9mAOD and 95.9mAOD in BH01, BH08, BH11 and BH17. In each borehole, the installation response zone was within the Slade and Redhill Formation. Groundwater levels increased by typically 0.35m over the three week monitoring period, with the exception of BH01 where it decreased by 0.15m. BH01, BH08 and BH11 were all located near watercourses which coincide with low points in the topography. BH17 was not located near a watercourse but was located at a low point in the topography.

6.9.5 BH04, BH10, BH12 and BH102 remained dry during the three visits. With the exception of BH12, these boreholes were located at higher points in the topography and therefore it is anticipated the response zone of the installation may not have been within the main groundwater body.

6.9.6 Seepages were recorded when boring BH04, BH10 and BH102 although the installations in these boreholes remained dry during the monitoring period. There are also a number of springs located on hillsides at higher points in the topography as indicated on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008. It is anticipated that these seepages and springs are associated with groundwater flows through more permeable bands in the bedrock and are not necessarily associated with the main groundwater body. The proposed cuttings in the scheme may intercept these groundwater flows through permeable bands in the bedrock and any persistent flows will need to be dealt with using appropriate drainage measurers.

6.9.7 The results of groundwater seepages and groundwater monitoring relevant to individual earthworks zones and structures are presented in the summary sheets in Appendix C and D respectively.

Chemistry

6.9.8 No chemical testing was undertaken on samples of the groundwater.

6.10 CBR testing

6.10.1 Nine in situ CBR tests were taken at the location shown on Drawings A40LVP-ARP-VGT-SWI-DR-C-0006, 0007 and 0008. The results of the CBR tests are summarised in Table 14. This includes a description of the soil, however, it does not include an indication of the material type or the lithology. It is anticipated that the tests will generally have been undertaken on the surface of the weathered bedrock, but they also may have been undertaken on any superficial deposits if present at the test location.

Table 14 Summary of in situ CBR test results

Location	Test Depth (m)	Soil Description	Moisture Content (%)	CBR Value (%)
CBR1	0.5	Firm light brown sandy gravelly clay	35.7	1.9
CBR2	0.6	Light brown very clayey sandy fine to coarse gravel	11.4	5.7
CBR3	0.65	Light brown slightly clayey sandy fine to coarse gravel	16.6	8.9
CBR4	0.65	Light brown very clayey sandy fine to coarse gravel	17.8	4.5
CBR5	0.8	Firm light brown sandy gravelly clay	22.2	4.2
CBR6	0.6	Firm light brown slightly sandy slightly gravelly clay	19.5	4.5
CBR7	0.7	Firm light brown slightly sandy slightly gravelly clay	14.7	3.4
CBR8	0.6	Firm light brown slightly sandy slightly gravelly clay	14.7	3.6
CBR9	0.9	Red brown highly weathered shale	21.3	15.3

6.11 Concrete aggressivity

6.11.1 Various samples of soil taken during the groundwater investigation were tested for pH and sulfate in accordance with BRE Special Digest 1 [31]. As there is a potential for presence of pyrite in the mudstone, the amount of oxidisable sulfides has been calculated from the total potential sulfate content and the acid-soluble sulfates.

6.11.2 The results indicate that pyrite is unlikely to be present. Design sulfate classes and associated ACEC classes have been derived for each of the geological formations as presented in Table 15 below. The Design Sulfate Class and ACEC Class for all materials is DS-1 and AC-1 respectively. It should be noted that there was no testing available for geological formations and rock types. Full results are provided in the Factual Report [17].

Table 15 Results of Concrete Aggressivity Testing and BRE Assessment

Formation	**Characteristic value**					**Design Sulfate Class**	**ACEC Class**
	Aqueous Extract Sulfate (mg/l)	**pH**	**Oxidisable sulfides (%)**	**Total potential sulfate (%)**	**No. of samples**		
Made Ground	<10	7.52	0	0.03	1	DS-1	AC-1
Weathered mudstone - Portfield and Haverford Mudstone Formation	10	5.58	0	0.09	1	DS-1	AC-1
Weathered mudstone - Haverford Mudstone Formation	10	7.29	0	0.09	3	DS-1	AC-1
Weathered mudstone - Slade & Redhill Formation	20	7.39	0.06	0.06	3	DS-1	AC-1
Mudstone - Portfield and Haverford Mudstone Formation	No testing				0	N/A	N/A
Mudstone - Slade & Redhill Formation	20	7.34	0	0.09	6	DS-1	AC-1
Siltstone - Haverford Mudstone Formation	10	7.41	0	<0.03	2	DS-1	AC-1
Sandstone - Portfield and Haverford Mudstone Formation	No testing				0	N/A	N/A
Sandstone - Haverford Mudstone Formaiton	No testing				0	N/A	N/A
Conglomerate - Portfield and Haverford Mudstone Formation	No testing				0	N/A	N/A

6.12 Contamination of soil and groundwater

6.12.1 Made Ground materials were encountered in seven exploratory holes located across the scheme alignment, as detailed in Section 6.3. The encountered made ground is likely to be associated with:

a) agricultural activities (TP20 and BH14)

b) construction of the existing road network (TP01, BH01 and BH102), or

c) infilled historical quarries (BH12 and TP03).

6.12.2 No evidence of contamination (visual or olfactory) with hydrocarbons or asbestos was observed during the field works. The encountered Made Ground materials in majority of the cases comprised reworked natural materials. However, unidentified isolated areas of hydrocarbon contamination, resulting from with the use of the existing road network e.g. accidental spillages and leakages of fuel, may be present.

6.12.3 Five soil samples were subjected to laboratory testing for the presence of contaminants. The samples were obtained from the Made Ground encountered in five exploratory holes (TP01, TP03, BH12, TP20 and BH102). The results are presented in the factual report (see Section 4.3.3). Groundwater level monitoring was undertaken as part of the investigation, however, no chemical laboratory testing was undertaken on samples of groundwater.

7 Geotechnical risk register

7.1.1 The geotechnical risk register is included in Appendix F.

7.1.2 This risk register is an extract of the live combined risk register for the project filtered on the geotechnical risks on 18th May 2017. The register will be developed as the design progresses and an updated extract will be provided as part of the GDR.

8 References

[1] DMRB Standard HD22/08, Volume 4, Section 1, Part 2, Managing Geotechnical Risk. August 2008.

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[3] Statement of Intent, Mott MacDonald. Revision A, 7th March 2016.

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[9] BGS Geology of Britain online viewer. Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html. [Accessed on 28th March 2017]

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[11] The biostratigraphy of the upper Ordovician and lower Silurian of south-west Dyfed, with comments on the Hirnantia fauna, L. R. M. Cocks and D. Price. 21 January 1975.

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[31] BRE (2005) Special Digest 1, Concrete in aggressive ground, 3rd Edition.

.

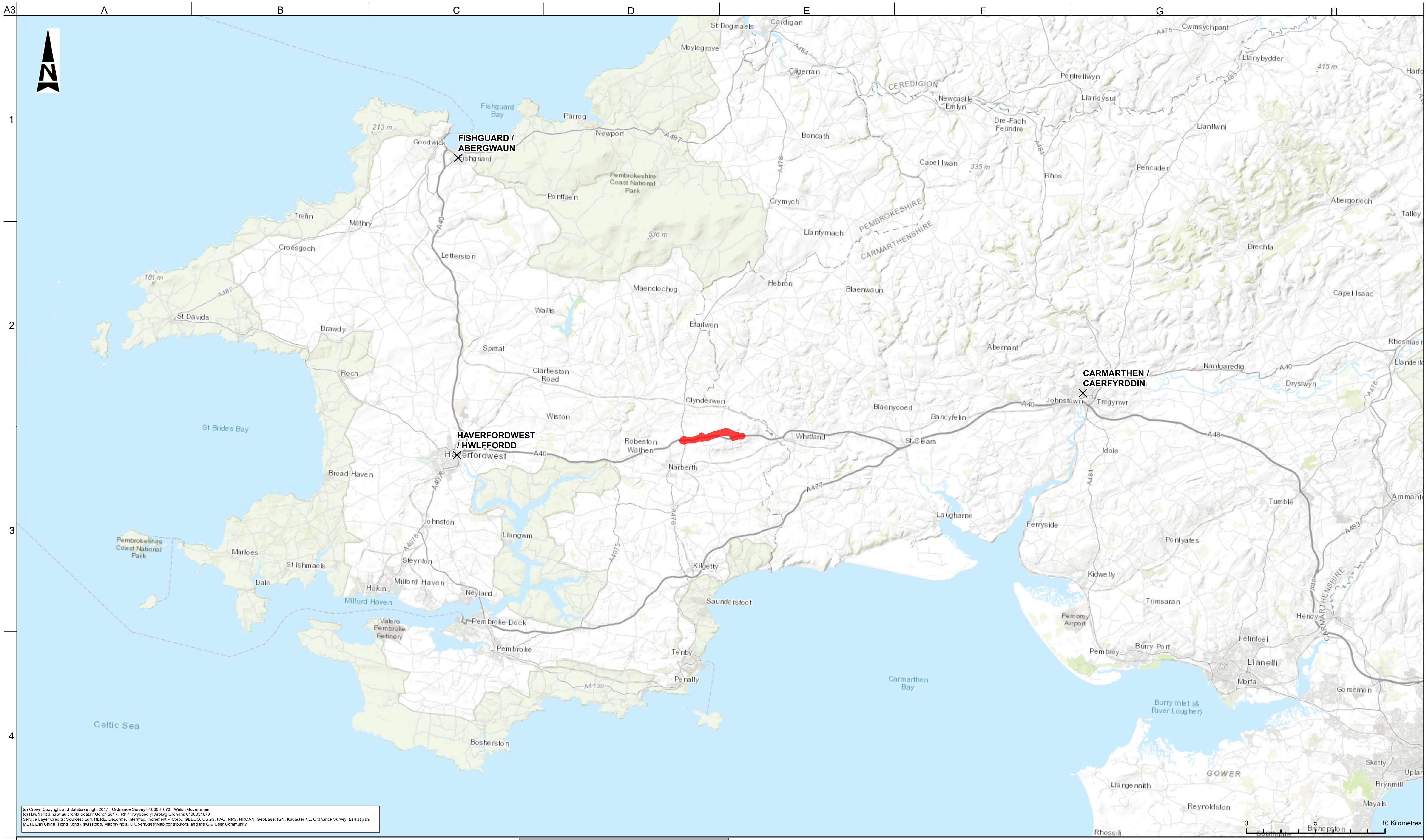
Drawings

A40LVP-ARP-VGT-SWI-DR-C-0005 - Site Location Plan,

A40LVP-ARP-VGT-SWI-DR-C-0006 - Constraints and Features Plan (Sheet 1 of 3),

A40LVP-ARP-VGT-SWI-DR-C-0007 - Constraints and Features Plan (Sheet 2 of 3),

A40LVP-ARP-VGT-SWI-DR-C- 0008 - Constraints and Features Plan (Sheet 3 of 3),



LEGEND

🟥 SCHEME LOCATION

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	21/11/18	REMOVED COMPANY LOGO	HC	DR	TE	GD
P01	15/05/17	FIRST ISSUE	EB	AP	TE	-

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

ARCADIS
MOTT MACDONALD

Delivery Team
ARUP
RICHARDS MOOREHEAD & LAING LTD
PLANNING | LANDSCAPE | ENVIRONMENT

Drawing Title
A40 CONTEXT

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A3 1:250,000

Rev	By	Chkd	Appd	Auth
P02	HC	DR	TE	GD
	Date 21/11/18	Date 21/11/18	Date 21/11/18	Date --

Name
A40LVP - ARP - VGT - SWI - DR - C - 0005
Project | Originator | Volume | Location | Type | Role | Number

Highway model updated May 2017

Geology base on British Geological Survey Free WMS Service with amendments added in line with the 6 inch county maps.

LEGEND

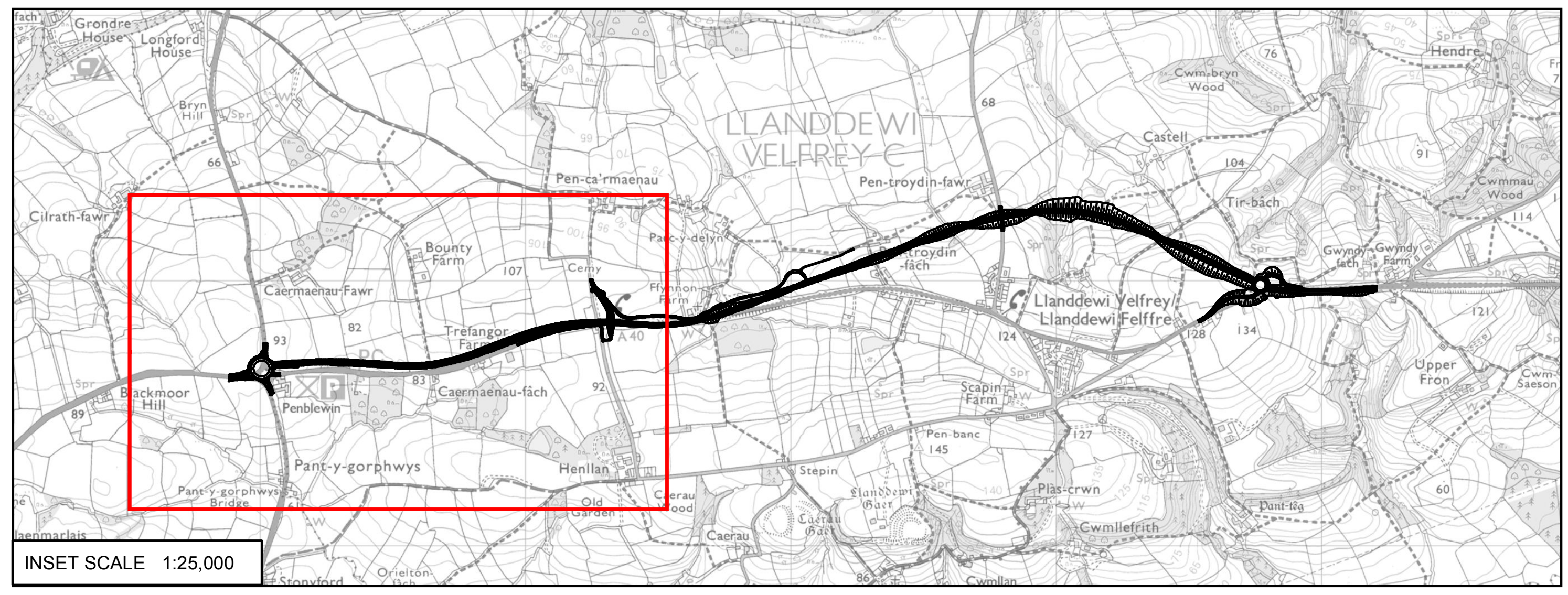
☁	MEDIUM OR HIGH FLOODING RISK FROM SURFACE WATER
—	PRELIMINARY HIGHWAY DESIGN
▨	WATER FEATURE
text	SITE WALKOVER OBSERVATION

GEOLOGY

🟩	PORTFIELD & HAVERFORD FORMATION
▨	SLADE & REDHILL FORMATION
▨	TILL DIAMICTON
▨	HAVERFORD MUDSTONE FORMATION
▨	GLACIOFLUVIAL DEPOSITS

EXPLORATORY HOLES

◉	CBR
⊕	BOREHOLE
▣	TRIAL PIT
△	SPRING
- —	FAULT
↑	DIP and ANGLE
⇕	ANTICLINE, LONG BAR INDICATES LINE OF AXIS
⇕	SYNCLINE, LONG BAR INDICATES LINE OF AXIS



INSET SCALE 1:25,000

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd
P03	13/09/18	TO REMOVE REFERENCES TO CARILLION	IM	AP	TE
P02	07/07/17	FINAL DRAFT	JL	AP	TE
P01	15/05/17	FIRST DRAFT	EB	AP	TE

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

ARCADIS Design & Consultancy for natural and built assets
MOTT MACDONALD

Delivery Team
ARUP
RICHARDS MOOREHEAD & LAING LTD
PLANNING | LANDSCAPE | ENVIRONMENT

Drawing Title
FEATURES AND CONSTRAINTS PLAN
SHEET 1 OF 3

Suitability
S2 SUITABLE FOR INFORMATION

Scale at A1 1:2,500

Rev	By	Chkd	Appd
P03	IM	AP	TE
	Date 13/09/18	Date 13/09/18	Date 13/09/18

Name
A40LVP - ARP - VGT - SWI - DR - C - 0006
Project | Originator | Volume | Location | Type | Role | Number

Highway model updated May 2017

Geology base on British Geological Survey Free WMS Service with amendments added in line with the 6 inch county maps.

LEGEND

- MEDIUM OR HIGH FLOODING RISK FROM SURFACE WATER
- PRELIMINARY HIGHWAY DESIGN
- ▨ WATER FEATURE
- text SITE WALKOVER OBSERVATION

GEOLOGY

- 🟩 PORTFIELD & HAVERFORD FORMATION
- SLADE & REDHILL FORMATION
- TILL DIAMICTON
- HAVERFORD MUDSTONE FORMATION
- GLACIOFLUVIAL DEPOSITS

EXPLORATORY HOLES

- ▲ SPRING
- CBR
- FAULT with DOWNTHROW
- DIP and ANGLE
- BOREHOLE
- ANTICLINE, LONG BAR INDICATES LINE OF AXIS
- TRIAL PIT
- SYNCLINE, LONG BAR INDICATES LINE OF AXIS


INSET SCALE 1:25,000

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd
P03	13/09/18	TO REMOVE REFERENCES TO CARILLION	IM	AP	TE
P02	07/07/17	FINAL DRAFT	JL	AP	TE
P01	15/05/17	FIRST DRAFT	EB	AP	TE

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

ARCADIS Design & Consultancy for natural and built assets
MOTT MACDONALD

Delivery Team
ARUP
RICHARDS MOOREHEAD & LAING LTD PLANNING | LANDSCAPE | ENVIRONMENT

Drawing Title
FEATURES AND CONSTRAINTS PLAN
SHEET 2 OF 3

Suitability
S2 SUITABLE FOR INFORMATION

Scale at A1 1:2,500

Rev	By	Chkd	Appd
P03	IM	AP	TE
	Date 13/09/18	Date 13/09/18	Date 13/09/18

Name
A40LVP - ARP - VGT - SWI - DR - C - 0007
Project | Originator | Volume | Location | Type | Role | Number

Highway model updated May 2017

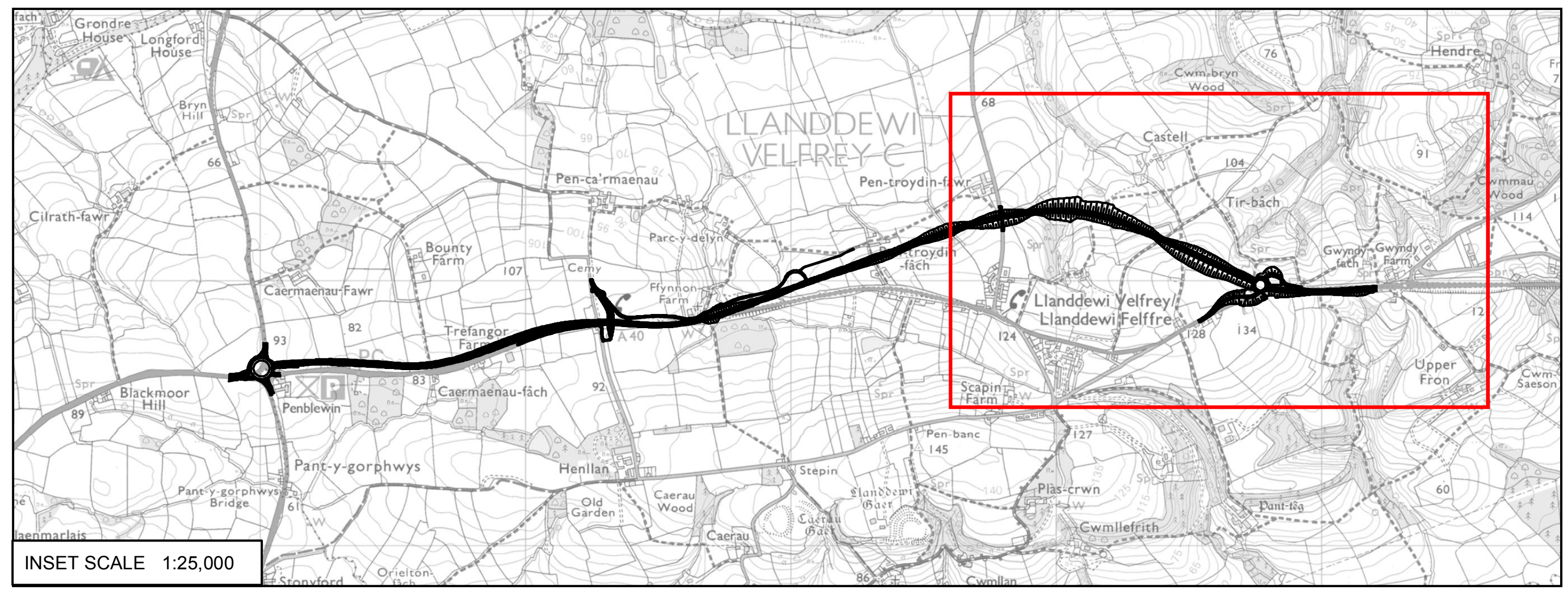
Geology base on British Geological Survey Free WMS Service with amendments added in line with the 6 inch county maps.

LEGEND

- MEDIUM OR HIGH FLOODING RISK FROM SURFACE WATER
- PRELIMINARY HIGHWAY DESIGN
- ▨ WATER FEATURE
- text SITE WALKOVER OBSERVATION

GEOLOGY
- 🟩 PORTFIELD & HAVERFORD FORMATION
- 🟦 SLADE & REDHILL FORMATION
- ☐ TILL DIAMICTON
- 🟧 HAVERFORD MUDSTONE FORMATION
- 🟪 GLACIOFLUVIAL DEPOSITS

EXPLORATORY HOLES
- ▲ SPRING
- ◉ CBR
- FAULT
- DIP and ANGLE
- BOREHOLE
- ANTICLINE, LONG BAR INDICATES LINE OF AXIS
- SYNCLINE, LONG BAR INDICATES LINE OF AXIS
- TRIAL PIT



INSET SCALE 1:25,000

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd
P03	13/09/18	TO REMOVE REFERENCES TO CARILLION	IM	AP	TE
P02	07/07/17	FINAL DRAFT	JL	AP	TE
P01	15/05/17	FIRST DRAFT	EB	AP	TE

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

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PLANNING | LANDSCAPE | ENVIRONMENT

Drawing Title
FEATURES AND CONSTRAINTS PLAN
SHEET 3 OF 3

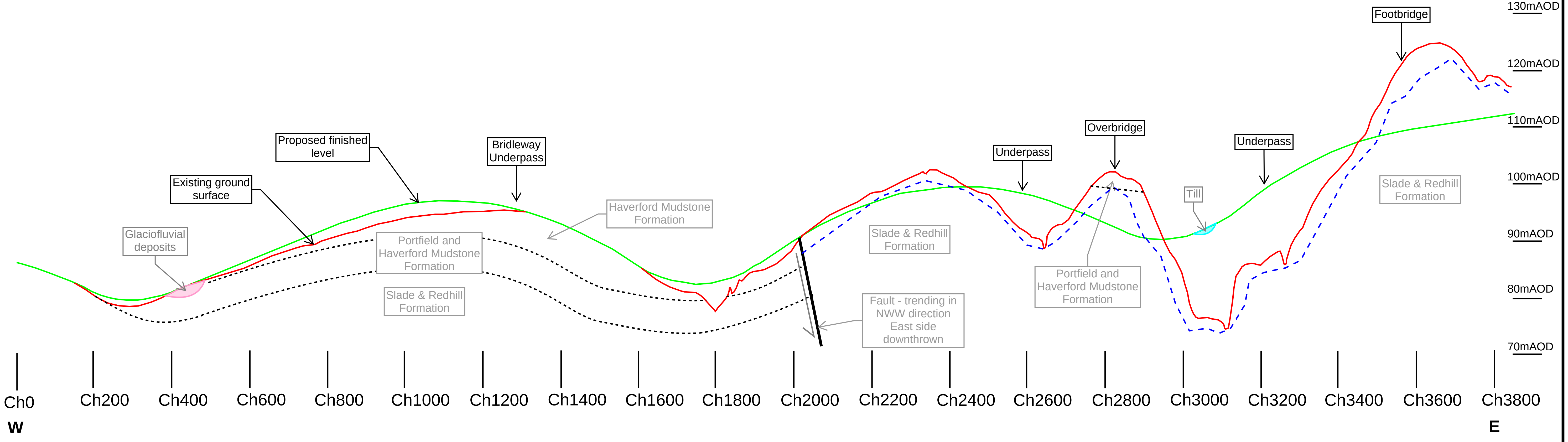
Suitability
S2 SUITABLE FOR INFORMATION

Scale at A1 1:2,500

Rev	By	Chkd	Appd
P03	IM	AP	TE
	Date 13/09/18	Date 13/09/18	Date 13/09/18

Name
A40LVP - ARP - VGT - SWI - DR - C - 0008
Project | Originator | Volume | Location | Type | Role | Number

Figures



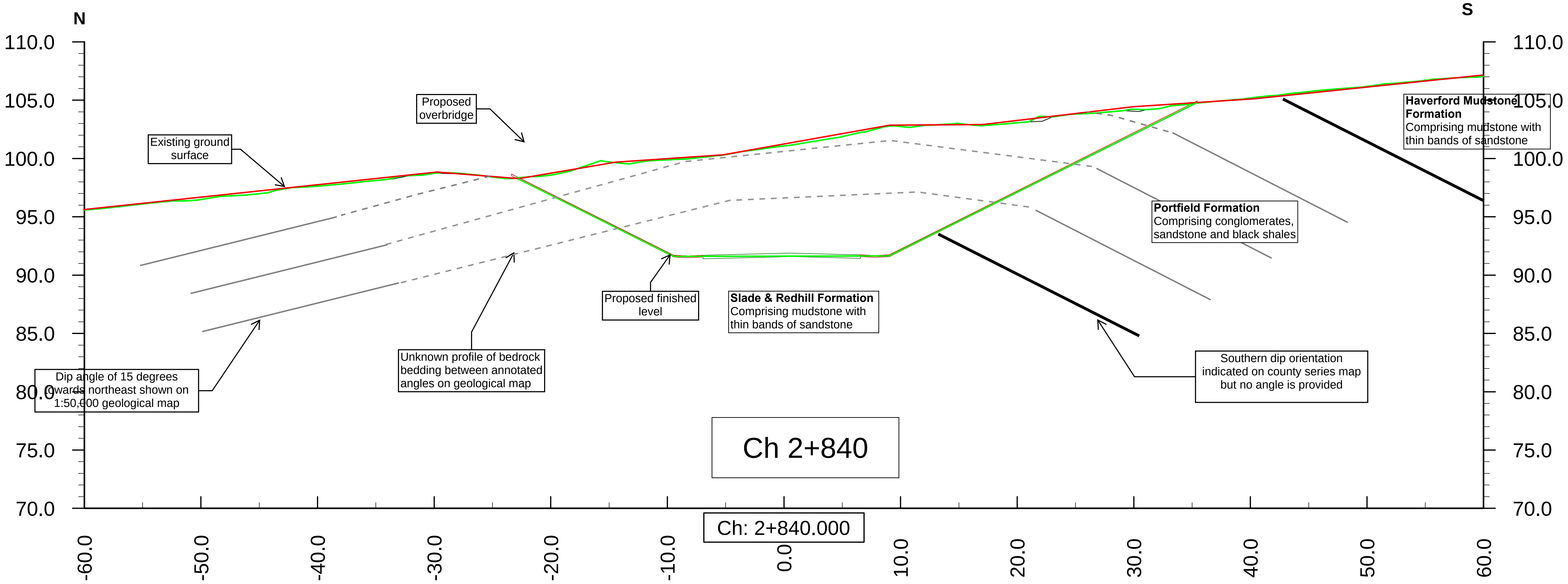
Note: Formation boundaries are based on geological plans. Formation thicknesses and elevations are indicative only.

Conceptual geological model - Long section

NTS

A40LVP-ARP-VGT-SWI-SK-C-0001, P01.1

FIGURE 01

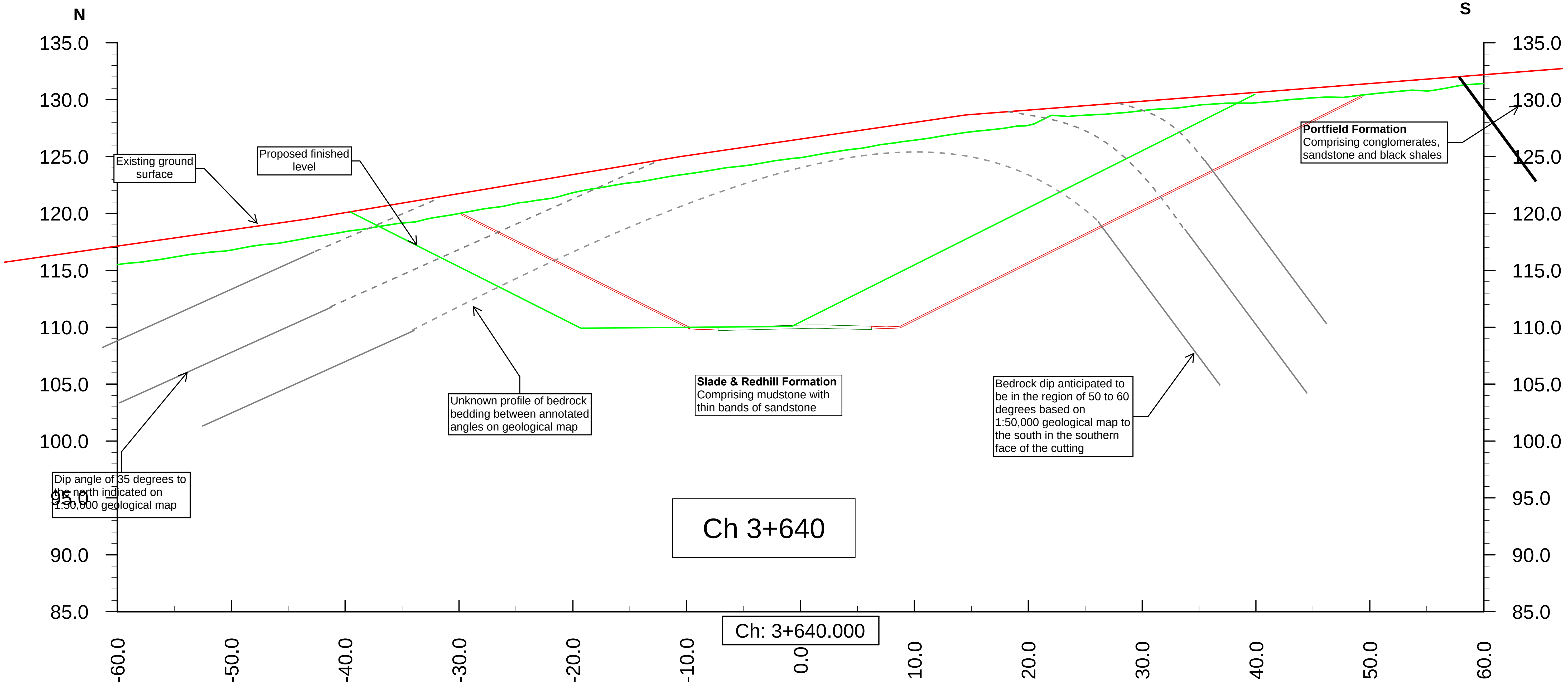


Conceptual geological model - Cutting 2 cross section

NTS

A40LVP-ARP-VGT-0285-SK-C-0001, P01.1

FIGURE 02



Conceptual geological model - Cutting 3 cross section

NTS

A40LVP-ARP-VGT-M01-SK-C-0001, P01.1

FIGURE 03

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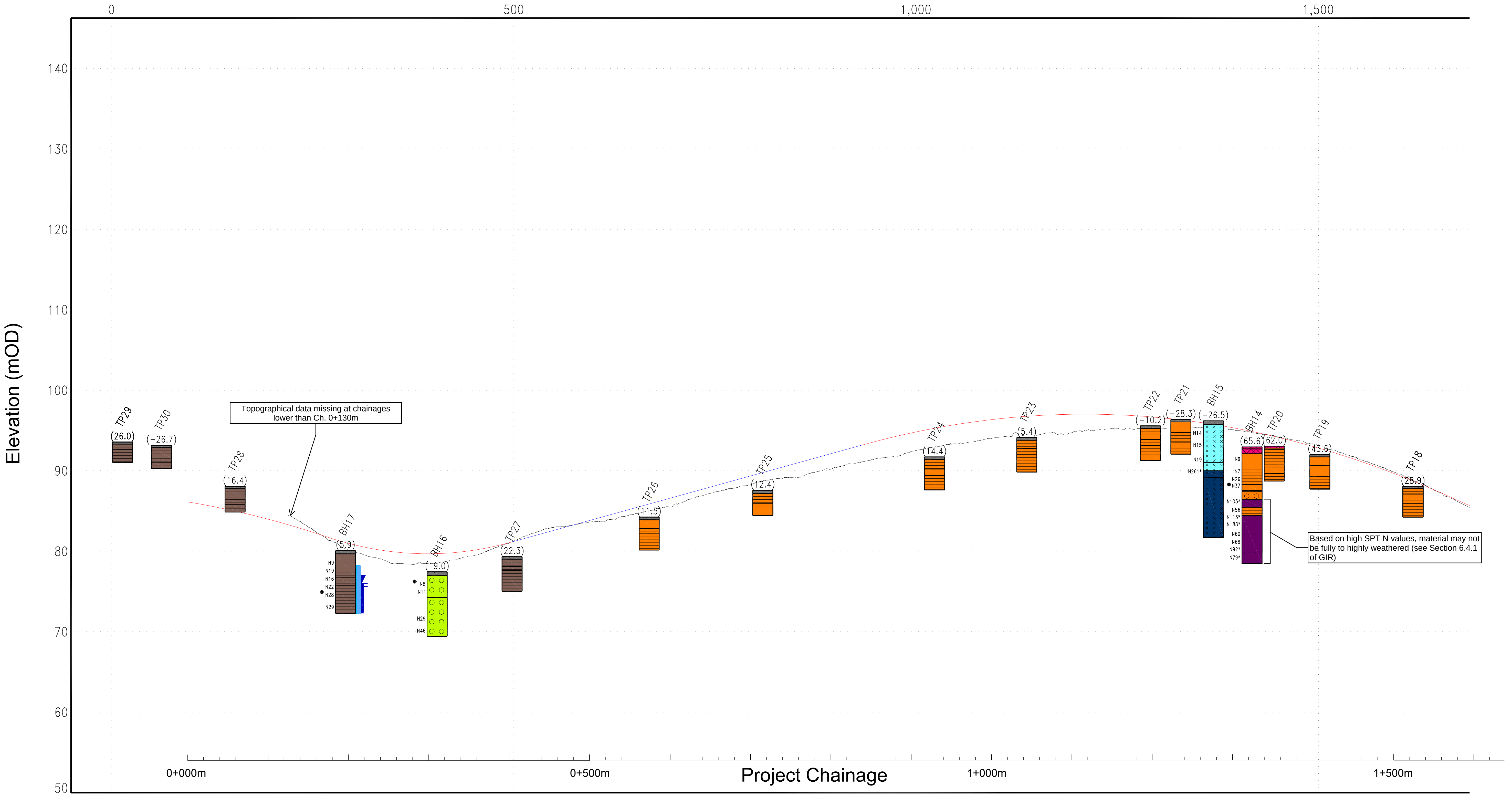
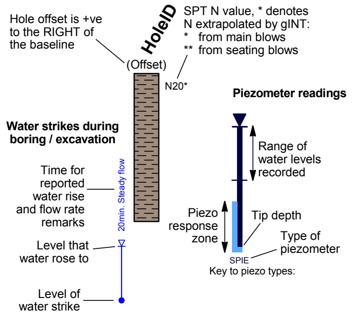


LEGEND



COLOUR LEGEND

■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

MATERIALS

⁙	TOPSOIL
▩	Fill (MADE GROUND)
▤	Gravelly CLAY
▤	Clayey sandy COBBLES
☰	MUDSTONE
⊠	SILTSTONE
⁙	SANDSTONE
○	CONGLOMERATE

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

— EXISTING GROUND LEVEL

— PROPOSED EARTHWORK

Long Section
Sheet 1 of 3

A40LVP-ARP-VGT-SWI-SK-C-0002, P02.1

FIGURE 04

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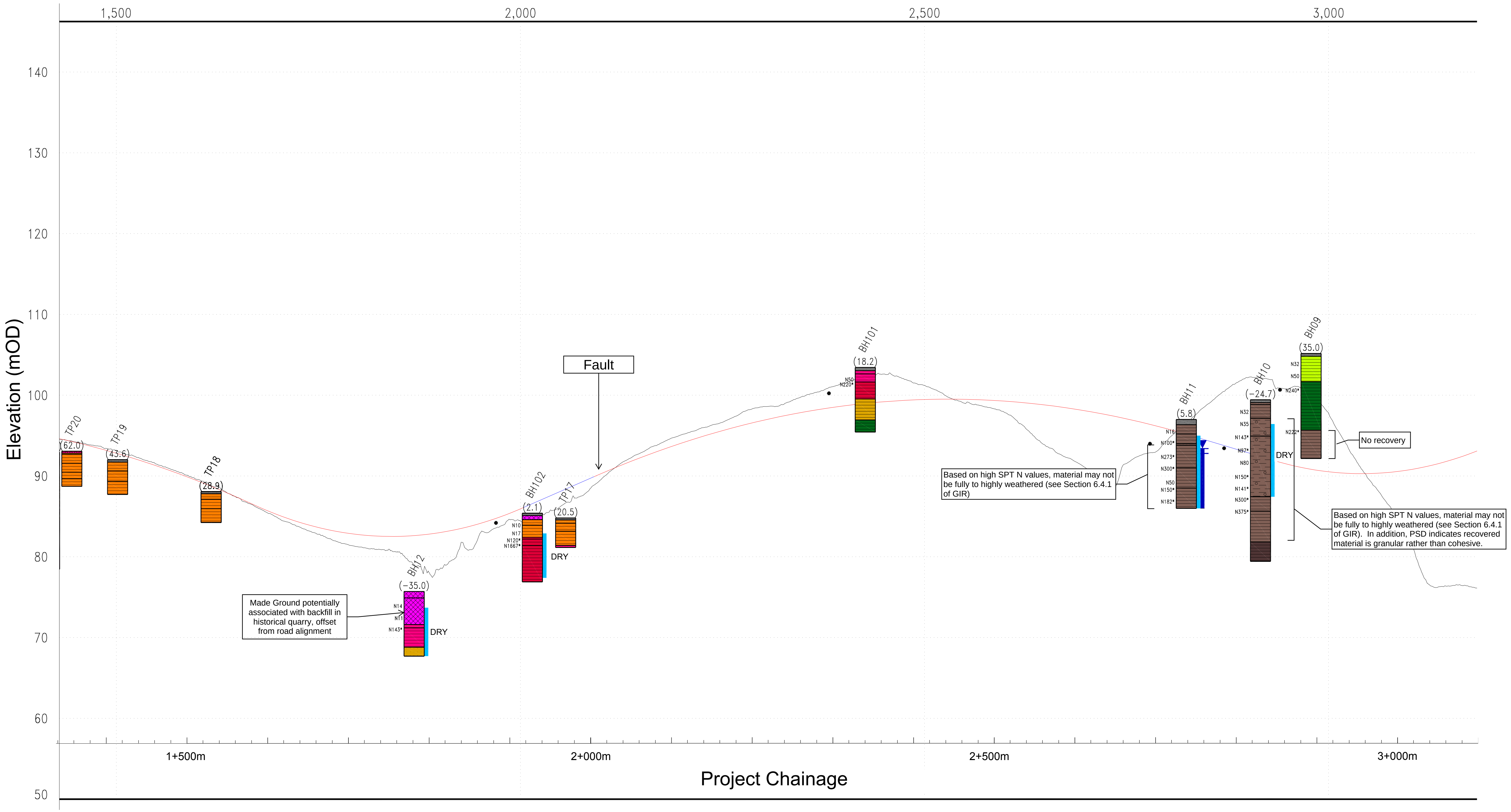
Filter: None



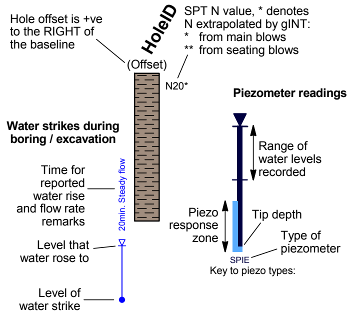
Made Ground potentially associated with backfill in historical quarry, offset from road alignment

Based on high SPT N values, material may not be fully to highly weathered (see Section 6.4.1 of GIR)

No recovery

Based on high SPT N values, material may not be fully to highly weathered (see Section 6.4.1 of GIR). In addition, PSD indicates recovered material is granular rather than cohesive.

LEGEND



COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟨	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

MATERIALS

⁘	TOPSOIL
▩	Fill (MADE GROUND)
▤	Gravelly CLAY
○	Clayey sandy COBBLES
▤	MUDSTONE
☒	SILTSTONE
⁘	SANDSTONE
○	CONGLOMERATE

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

—— EXISTING GROUND LEVEL

—— PROPOSED EARTHWORK

Long Section
Sheet 2 of 3

A40LVP-ARP-VGT-SWI-SK-C-0003, P02.1

FIGURE 05

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Database check status: Full check (A) = 0% Partial/selective check (B) = 0% Minimum check (C) = 0% Unchecked (U) = 0% of holes
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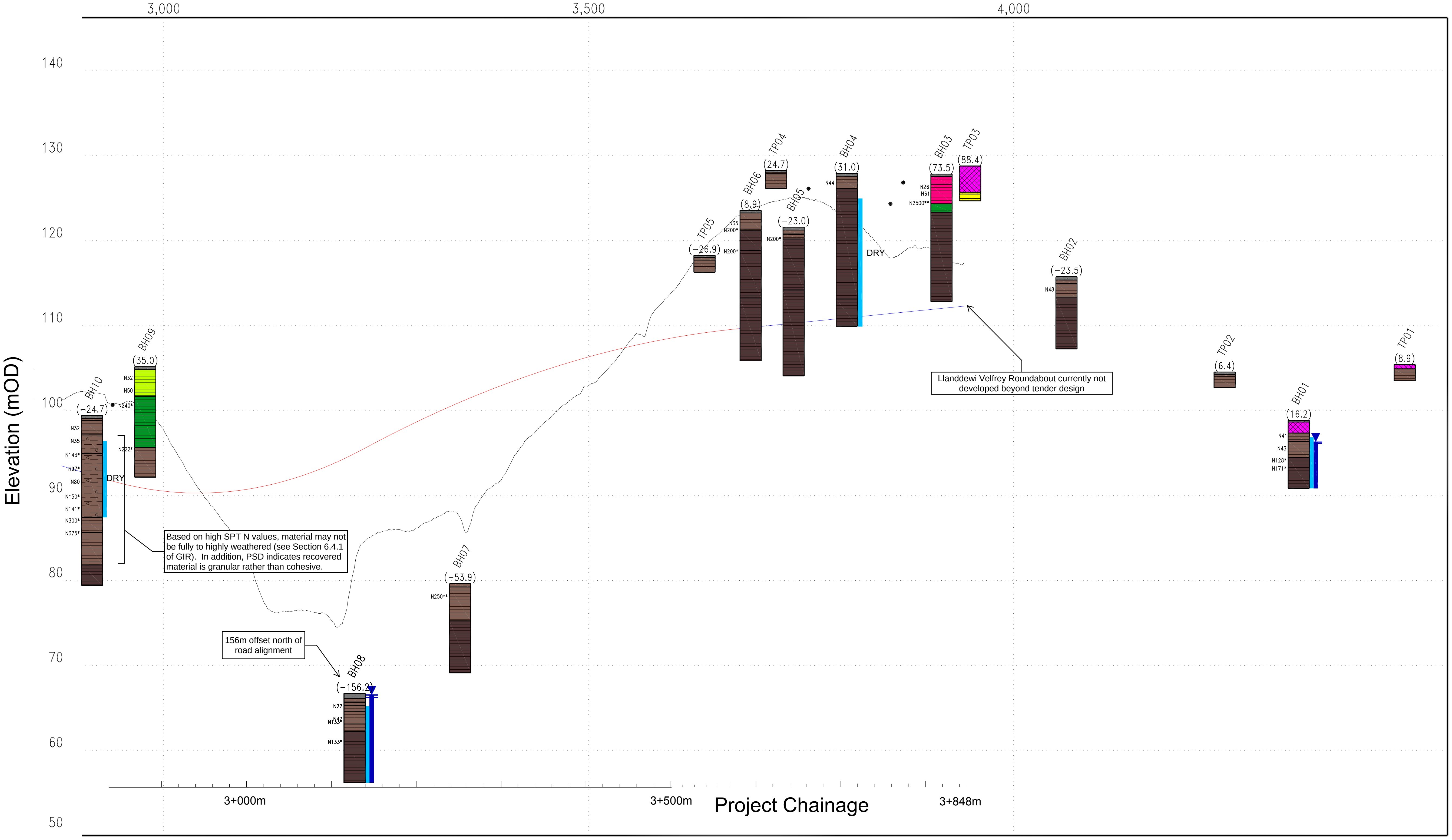
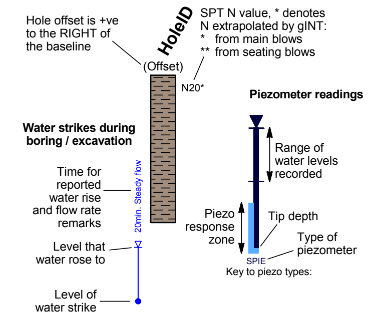


Based on high SPT N values, material may not be fully to highly weathered (see Section 6.4.1 of GIR). In addition, PSD indicates recovered material is granular rather than cohesive.

156m offset north of road alignment

Llandewi Velfrey Roundabout currently not developed beyond tender design

LEGEND



COLOUR LEGEND

■ Topsoil
■ Made Ground
■ Weathered mudstone - Haverford Mudstone Formation
■ Siltstone - Haverford Mudstone Formation
■ Weathered sandstone - Haverford Mudstone Formation
■ Weathered mudstone - Portfield and Haverford Mudstone Formation
■ Mudstone - Portfield and Haverford Mudstone Formation
■ Weathered siltstone - Portfield and Haverford Mudstone Formation
■ Weathered sandstone - Portfield and Haverford Mudstone Formation
■ Sandstone - Portfield and Haverford Mudstone Formation
■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
■ Conglomerate - Portfield and Haverford Mudstone Formation
■ Weathered mudstone - Slade & Redhill Formation
■ Mudstone - Slade & Redhill Formation

MATERIALS

⬚ TOPSOIL
▩ Fill (MADE GROUND)
⬚ Gravelly CLAY
⬚ Clayey sandy COBBLES
☰ MUDSTONE
☒ SILTSTONE
⬚ SANDSTONE
○ CONGLOMERATE

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

— EXISTING GROUND LEVEL

— PROPOSED EARTHWORK

Long Section
Sheet 3 of 3

A40LVP-ARP-VGT-SWI-SK-C-0004, P02.1

FIGURE 06

```
Library: arup_uklib_4-0-001. Report: 2.1.01 SECTION WITH WATER & SPT (A3)
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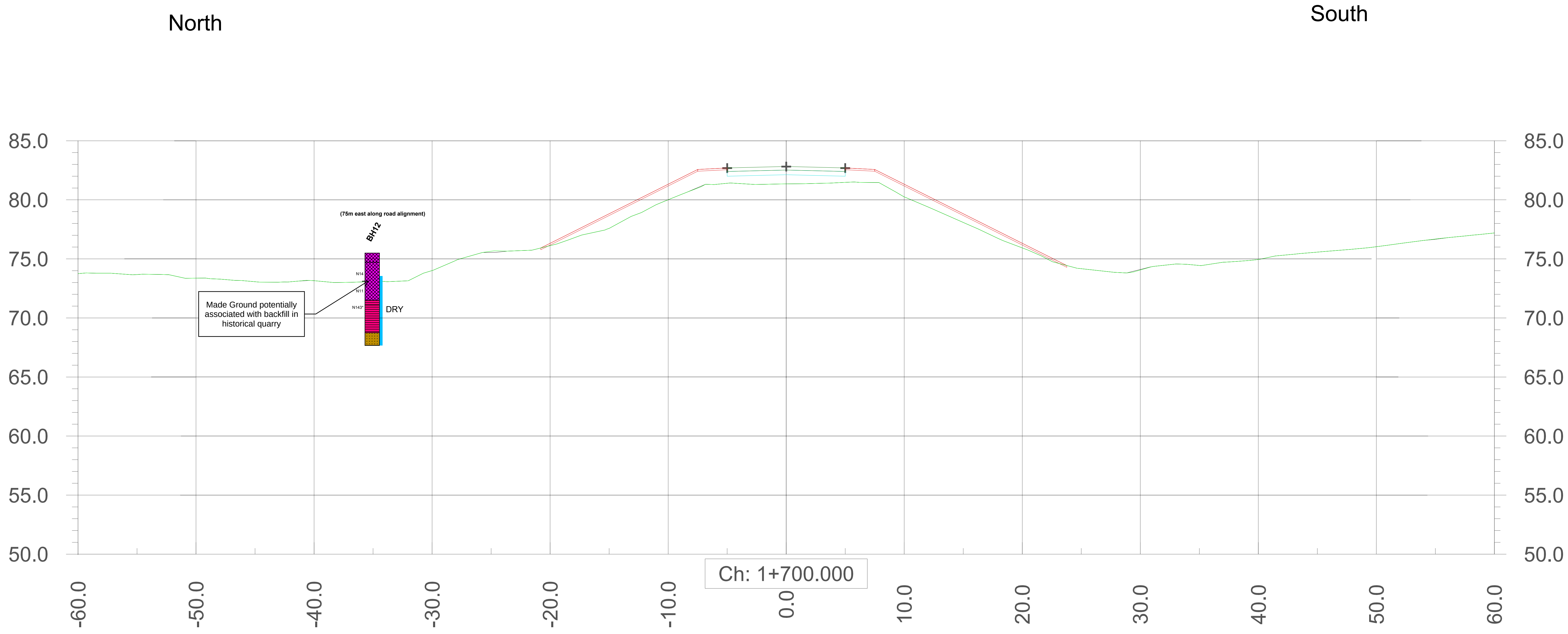

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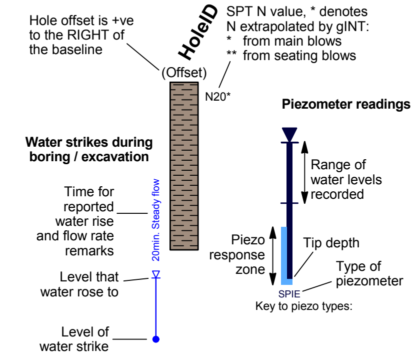

COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

MATERIALS

⁘	TOPSOIL
▩	Fill (MADE GROUND)
○	Gravelly CLAY
○	Clayey sandy COBBLES
▤	MUDSTONE
☒	SILTSTONE
⁘	SANDSTONE
○	CONGLOMERATE

🟩	EXISTING GROUND LEVEL
🟥	PROPOSED EARTHWORK

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

Cross section at Ch. 1+700m Embankment 3

A40LVP-ARP-VGT-M01-SK-C-0002, P02.1

FIGURE **07**

Library: arup_uklib_4-0-001. Report: 2.1.01 SECTION WITH WATER & SPT (A3)
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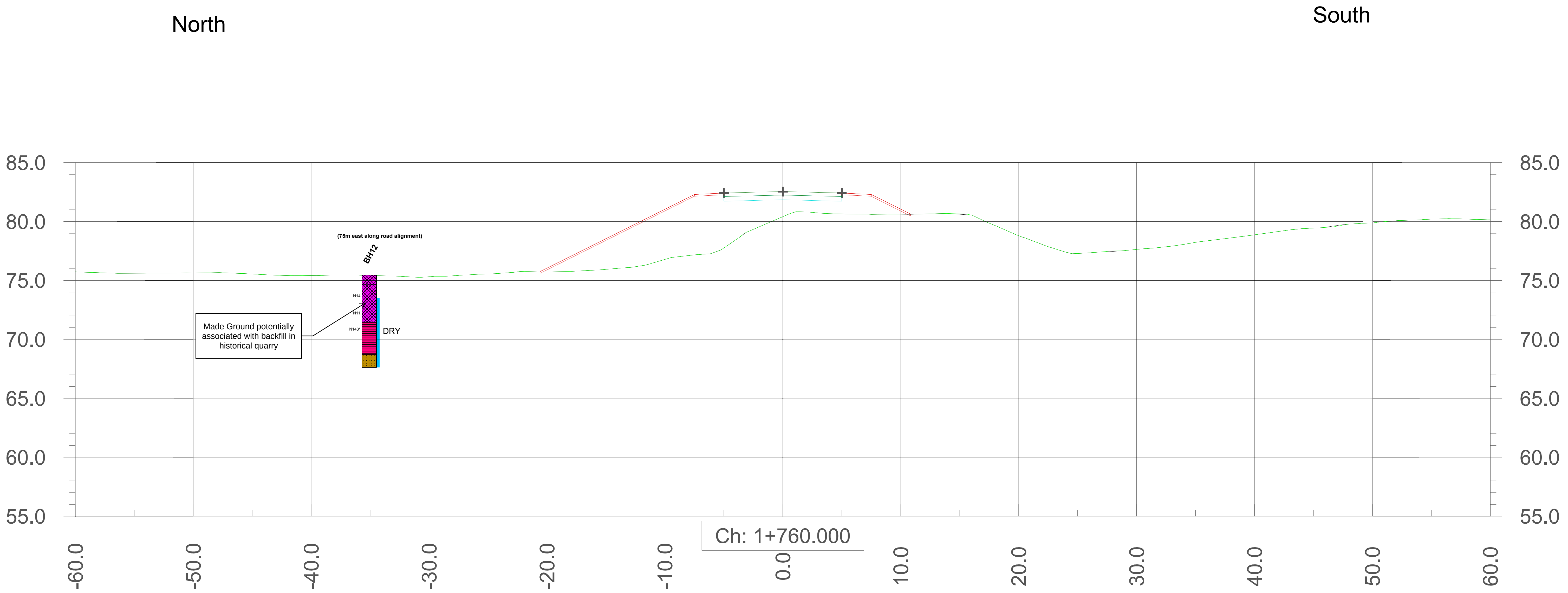

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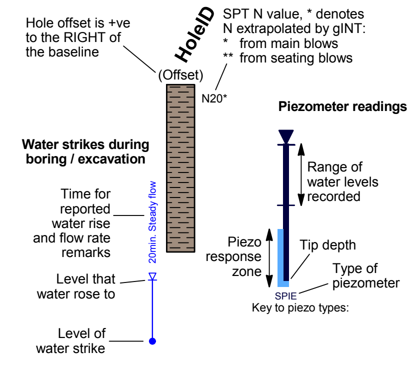

COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

MATERIALS

⬚	TOPSOIL
▩	Fill (MADE GROUND)
⬚	Gravelly CLAY
⬚	Clayey sandy COBBLES
▤	MUDSTONE
⬚	SILTSTONE
⬚	SANDSTONE
⬚	CONGLOMERATE

―	EXISTING GROUND LEVEL
―	PROPOSED EARTHWORK

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

Cross section at
Ch. 1+760m
Embankment 3

A40LVP-ARP-VGT-M
01-SK-C-0003, P02.1

FIGURE 08

Library: arup_uklib_4-0-001. Report: 2.1.01 SECTION WITH WATER & SPT (A3)
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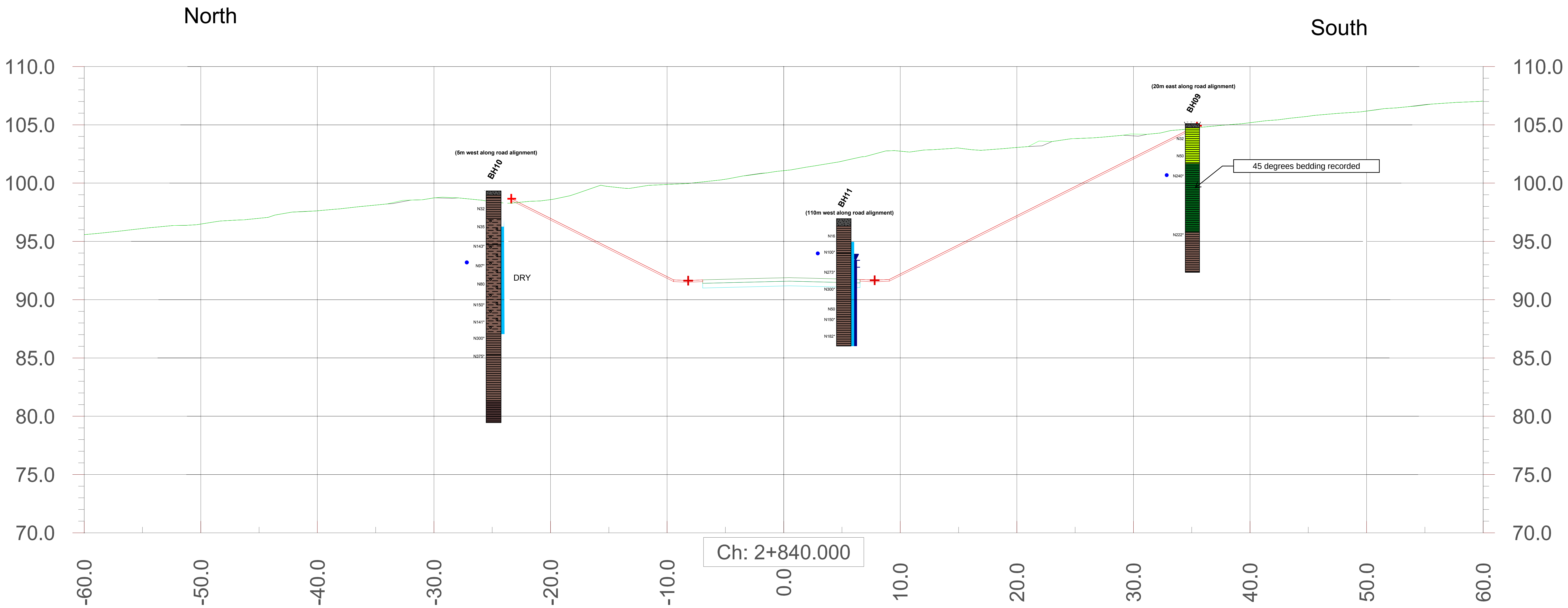

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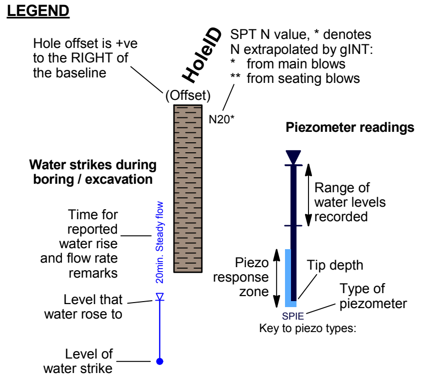

COLOUR LEGEND

- ⬛ Topsoil
- 🟪 Made Ground
- 🟧 Weathered mudstone - Haverford Mudstone Formation
- 🟦 Siltstone - Haverford Mudstone Formation
- 🟪 Weathered sandstone - Haverford Mudstone Formation
- 🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation
- 🟥 Mudstone - Portfield and Haverford Mudstone Formation
- 🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation
- 🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation
- 🟫 Sandstone - Portfield and Haverford Mudstone Formation
- 🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation
- 🟩 Conglomerate - Portfield and Haverford Mudstone Formation
- 🟫 Weathered mudstone - Slade & Redhill Formation
- 🟫 Mudstone - Slade & Redhill Formation

MATERIALS

- ▨ TOPSOIL
- ▨ Fill (MADE GROUND)
- ▨ Gravelly CLAY
- ▨ Clayey sandy COBBLES
- ▤ MUDSTONE
- ▨ SILTSTONE
- ▨ SANDSTONE
- ○ CONGLOMERATE

—— EXISTING GROUND LEVEL

—— PROPOSED EARTHWORK

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

Cross section at
Ch. 2+840
Cutting 2

A40LVP-ARP-VGT-02
85-SK-C-0002, P02.1

FIGURE 09

Library: arup_uklib_4-0-001. Report: 2.1.01 SECTION WITH WATER & SPT (A3)
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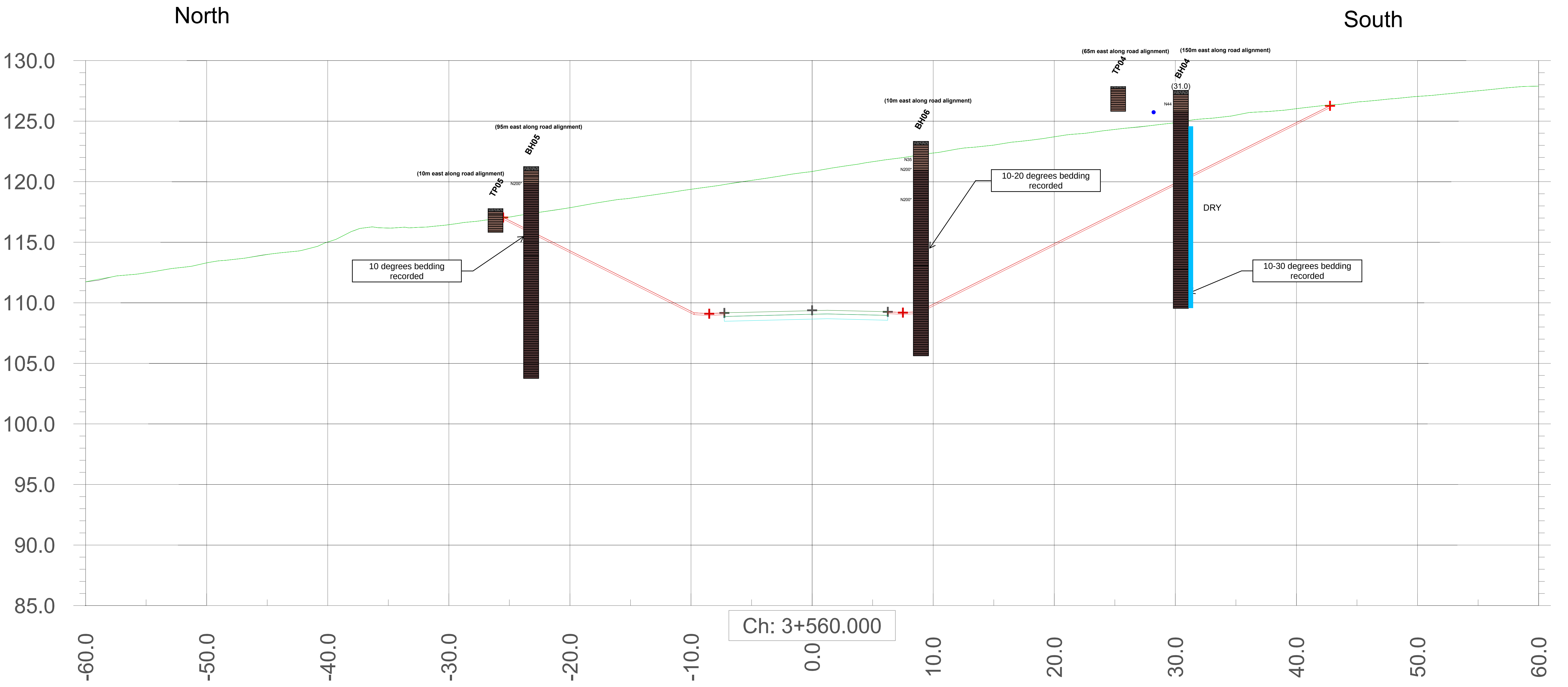
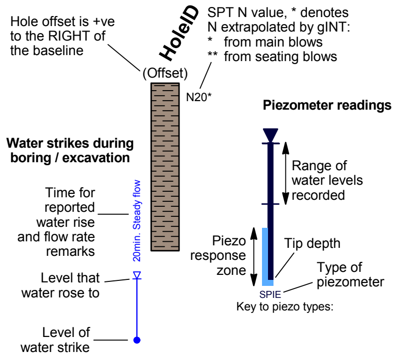


LEGEND



COLOUR LEGEND

■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

MATERIALS

⛶	TOPSOIL
▩	Fill (MADE GROUND)
▭	Gravelly CLAY
▭	Clayey sandy COBBLES
▤	MUDSTONE
☒	SILTSTONE
⛶	SANDSTONE
○	CONGLOMERATE

—	EXISTING GROUND LEVEL
—	PROPOSED EARTHWORK

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

Cross section at
Ch. 3+560m
Cutting 3

A40LVP-ARP-VGT-M
01-SK-C-0004, P02.1

FIGURE 10

Library: arup_uklib_4-0-001. Report: 2.1.01 SECTION WITH WATER & SPT (A3)
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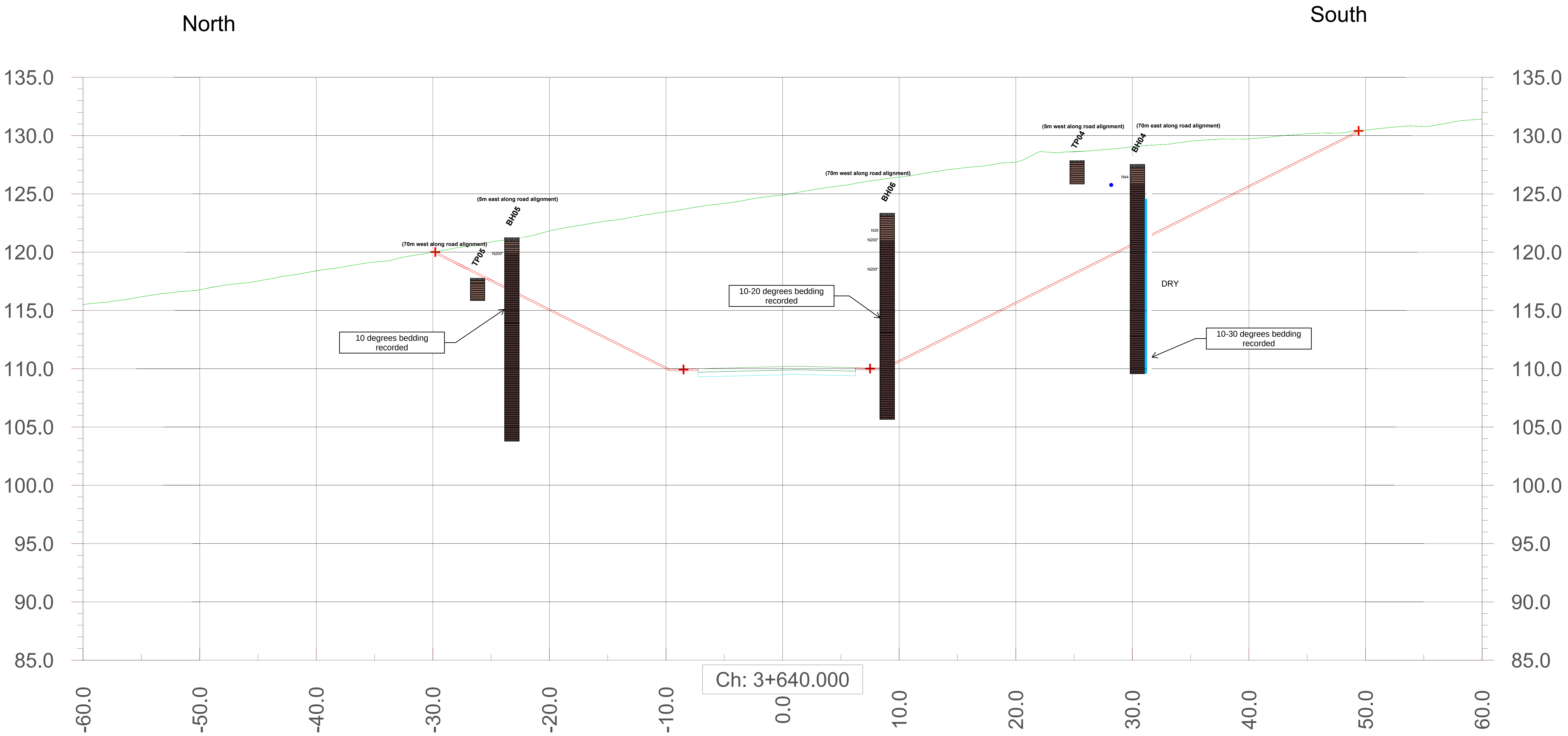

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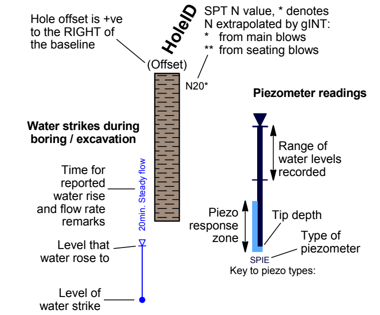


COLOUR LEGEND

■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

MATERIALS

▨	TOPSOIL
▨	Fill (MADE GROUND)
▨	Gravelly CLAY
▨	Clayey sandy COBBLES
▨	MUDSTONE
▨	SILTSTONE
▨	SANDSTONE
▨	CONGLOMERATE

—	EXISTING GROUND LEVEL
—	PROPOSED EARTHWORK

Notes:

1.“Weathered” bedrock is defined as bedrock which has been described using soil descriptors on the exploratory hole logs. See Section 6.1.1 of the GIR for further details.

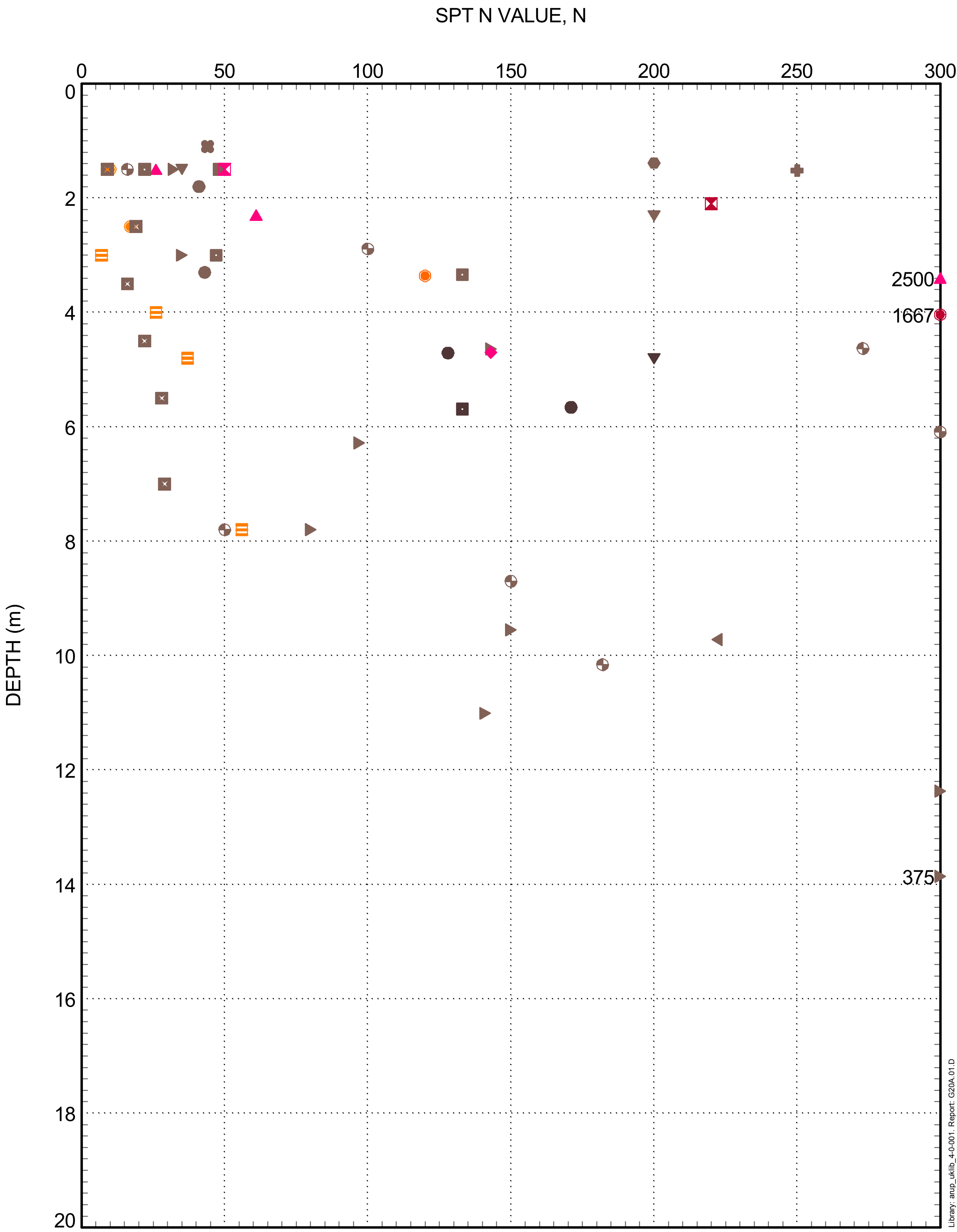
2.The rock formations are typically as per the Ground Investigation Factual Report, however, some reinterpretation of the rock formations has been undertaken by Arup following review of the geological information.

3.The material types are as per the Ground Investigation Factual Report.

Cross section at
Ch. 3+640m
Cutting 3

A40LVP-ARP-VGT-M
01-SK-C-0005, P02.1

FIGURE **11**



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- ● BH01
- ■ BH02
- ▲ BH03
- ✖ BH04
- ⬣ BH05
- ▼ BH06
- ✚ BH07
- ▣ BH08
- ◀ BH09
- ▶ BH10
- ⧗ BH101
- ◉ BH102
- ◐ BH11
- ◆ BH12
- ☰ BH14
- ☒ BH17

COLOUR LEGEND

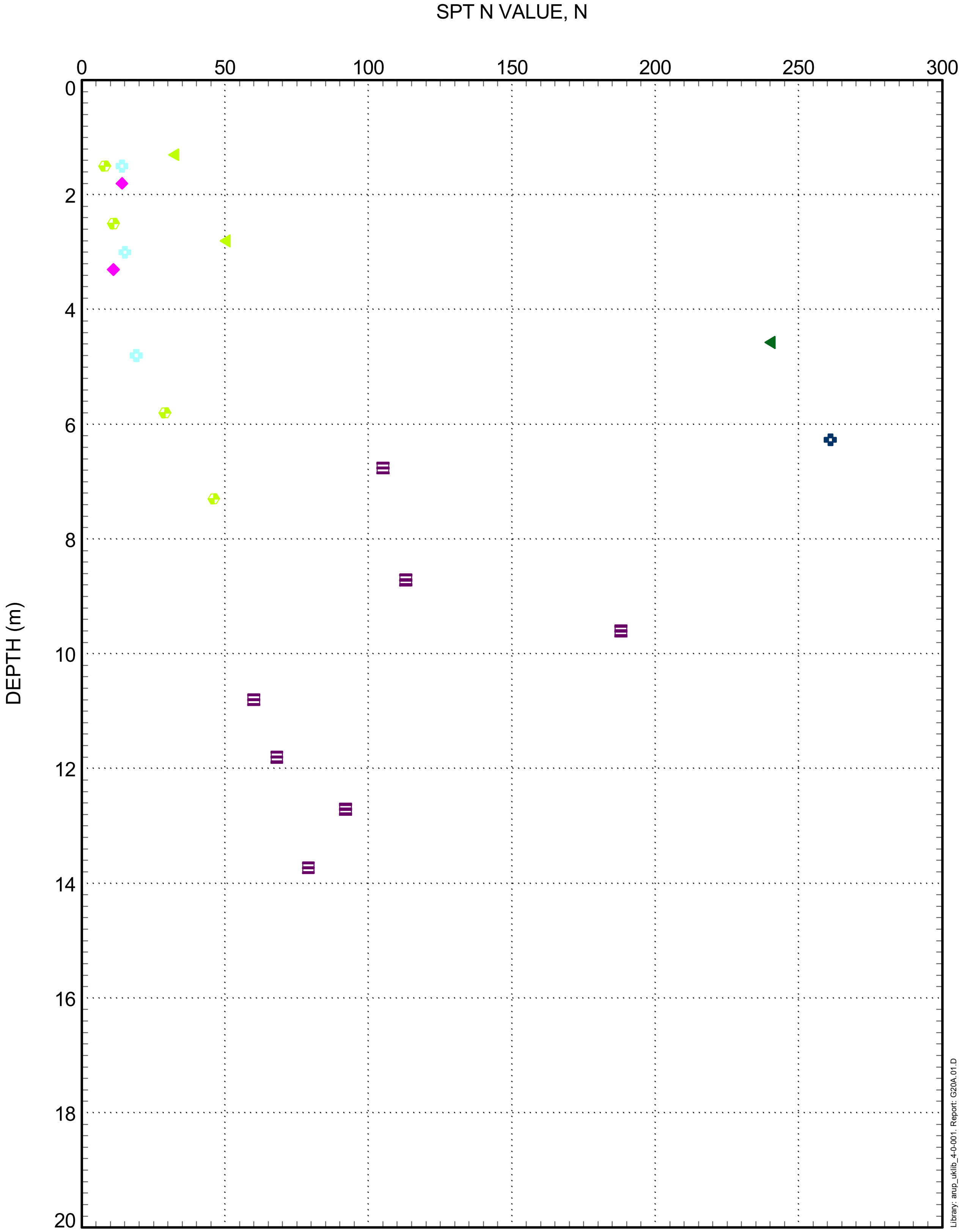
⬛	Topsoil	⬜	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Standard Penetration Tests
Mudstone and Weathered Mudstone

253875

FIGURE 12



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◀ BH09
◆ BH12
☰ BH14
✚ BH15
⬢ BH16

COLOUR LEGEND

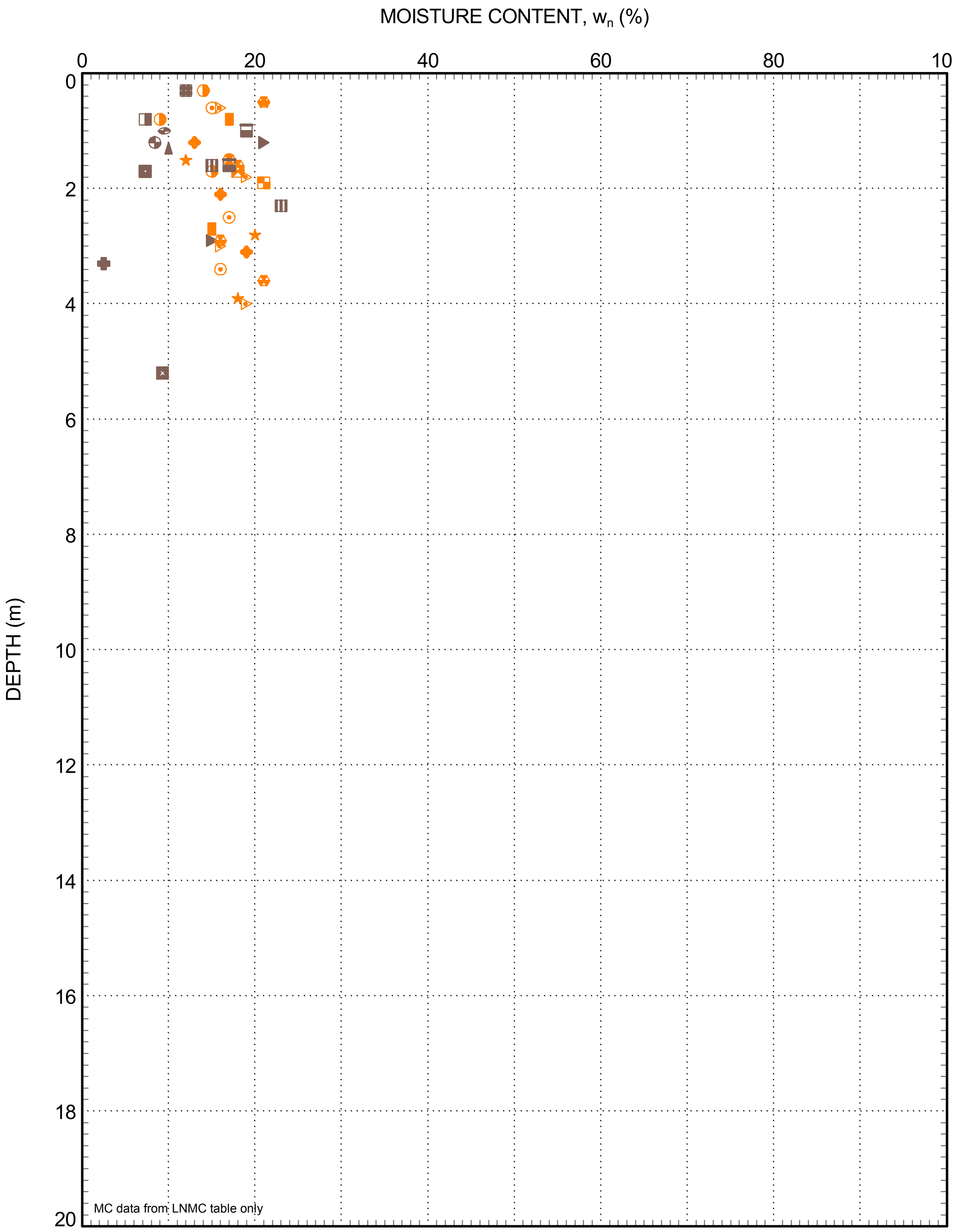
⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Standard Penetration Tests

All other materials

253875 **FIGURE 13**



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- ✚ BH07
- ■ BH08
- ▶ BH10
- ◕ BH11
- ☒ BH17
- ◨ TP04
- ▦ TP05
- ◑ TP17
- ◆ TP18
- ⧗ TP19
- ⬢ TP20
- ⊳ TP21
- ▮ TP22
- ★ TP23
- ⊙ TP24
- ▚ TP25
- ⊗ TP26
- ▲ TP27
- ▥ TP28
- ◒ TP29
- ▤ TP30

COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

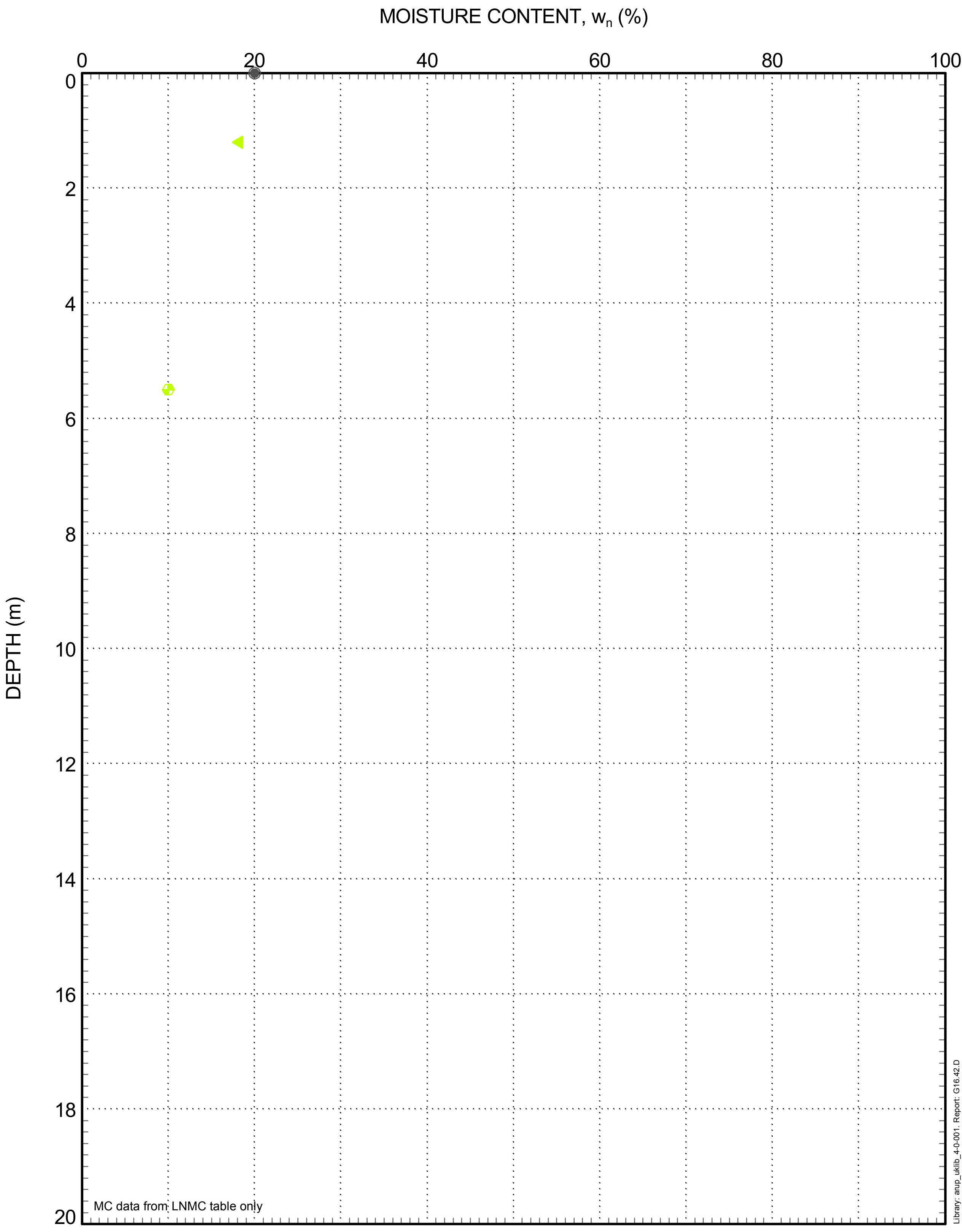
ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Moisture Content vs Depth

Mudstone and Weathered Mudstone

253875

FIGURE **14**



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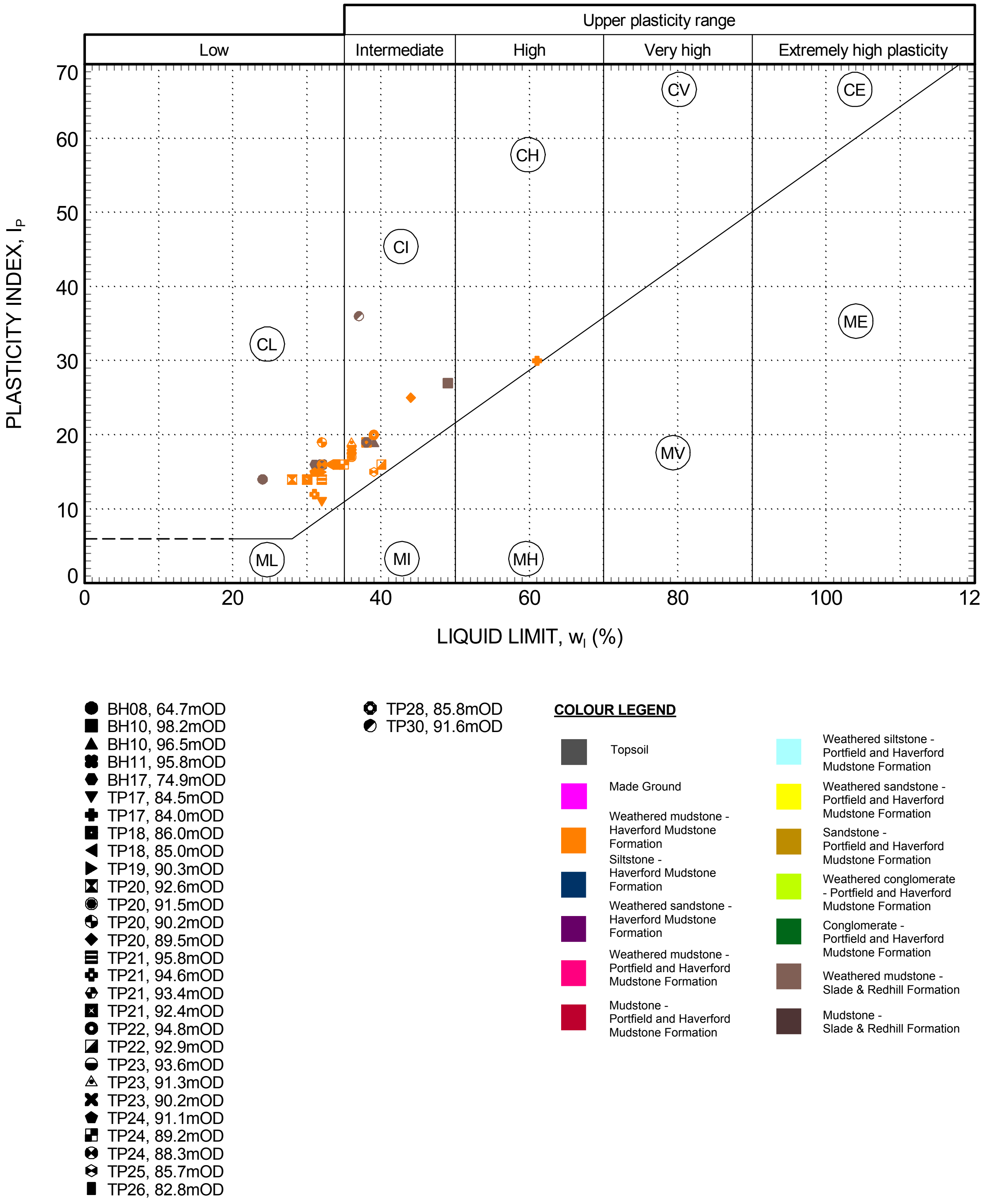
ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Moisture Content vs Depth
All other materials

253875

FIGURE **15**



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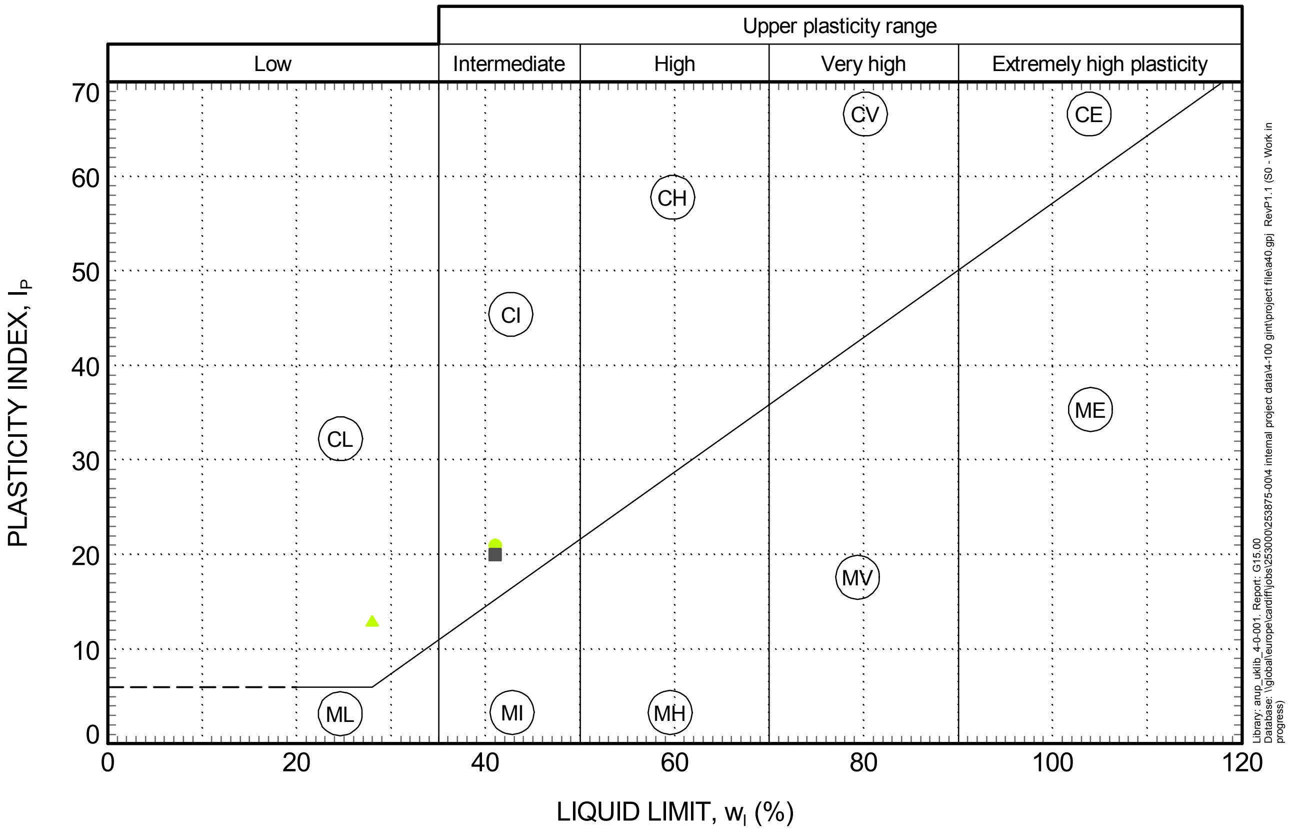
ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Plasticity Index vs Liquid Limit

Mudstone and Weathered Mudstone

253875

FIGURE **16**



● BH09, 104.0mOD
■ BH102, 85.4mOD
▲ BH16, 71.9mOD

COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

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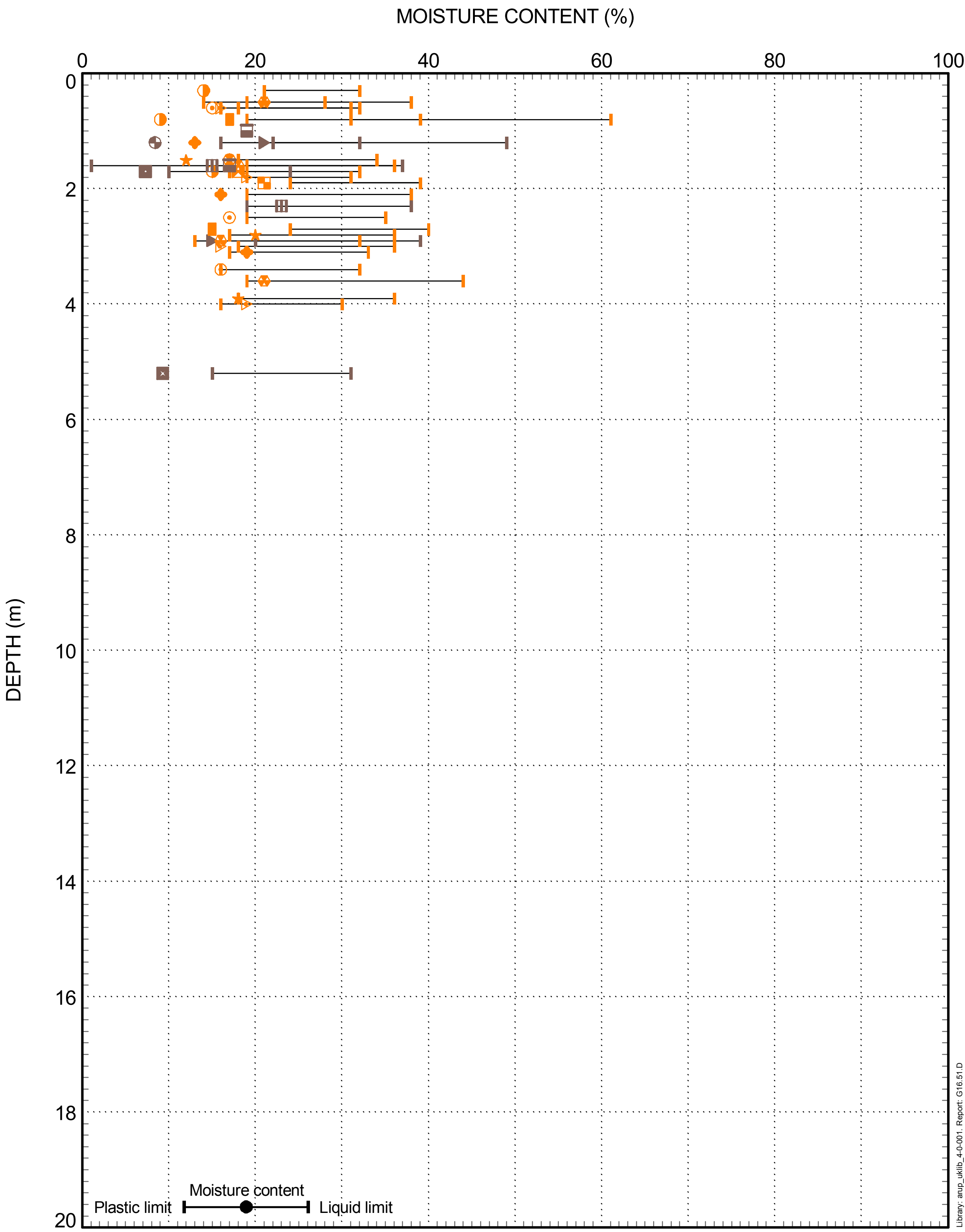
ARUP, gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Moisture Content vs Depth

All other materials

253875

FIGURE 17



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COLOUR LEGEND

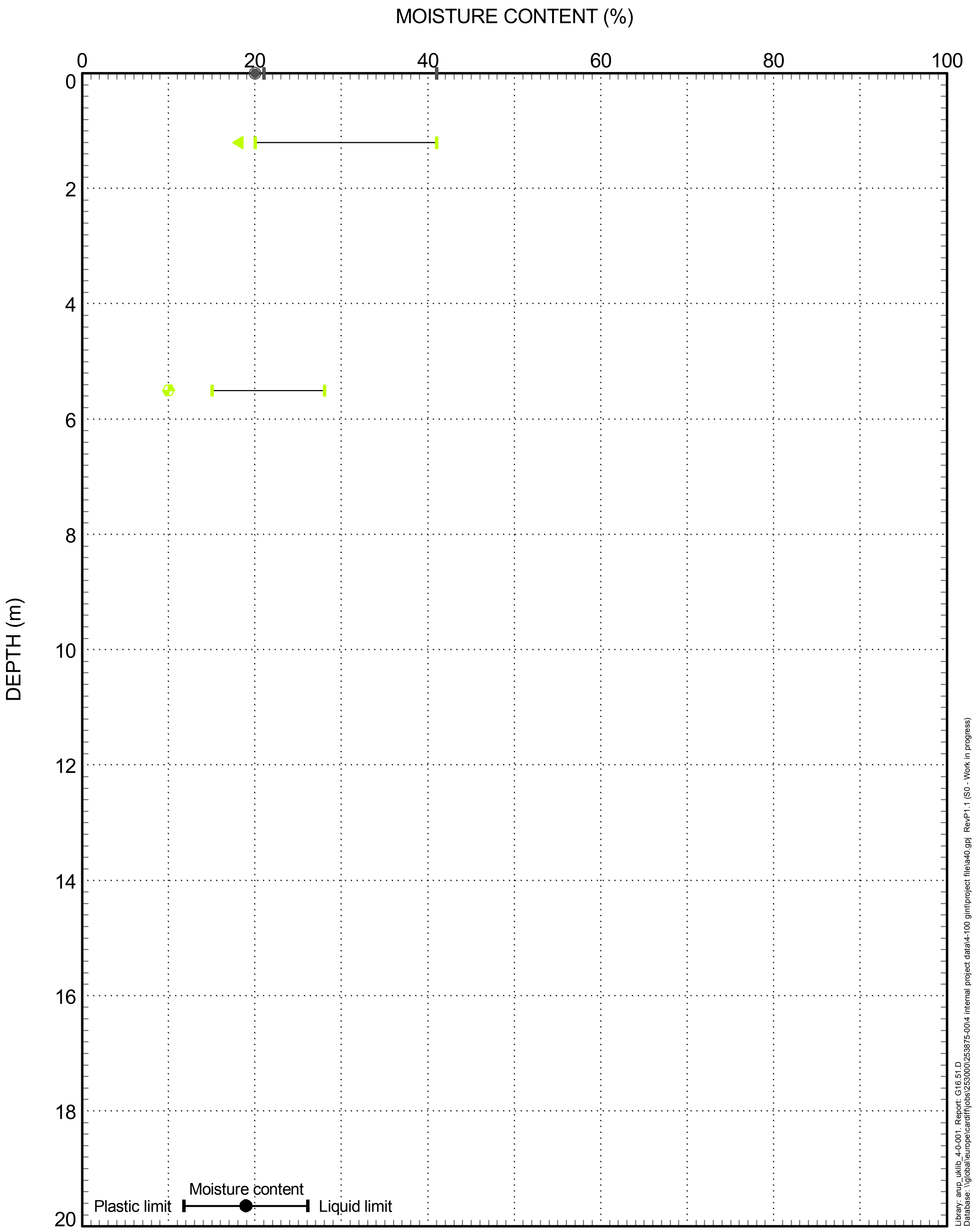
- ▪ BH08
- ▶ BH10
- ◕ BH11
- ☒ BH17
- ◑ TP17
- ✚ TP18
- ⧗ TP19
- ✪ TP20
- ⊳ TP21
- ▮ TP22
- ★ TP23
- ⊙ TP24
- ▚ TP25
- ❂ TP26
- Ⅲ TP28
- ▤ TP30

- ■ Topsoil
- ■ Made Ground
- ■ Weathered mudstone - Haverford Mudstone Formation
- ■ Siltstone - Haverford Mudstone Formation
- ■ Weathered sandstone - Haverford Mudstone Formation
- ■ Weathered mudstone - Portfield and Haverford Mudstone Formation
- ■ Mudstone - Portfield and Haverford Mudstone Formation
- ■ Weathered siltstone - Portfield and Haverford Mudstone Formation
- ■ Weathered sandstone - Portfield and Haverford Mudstone Formation
- ■ Sandstone - Portfield and Haverford Mudstone Formation
- ■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
- ■ Conglomerate - Portfield and Haverford Mudstone Formation
- ■ Weathered mudstone - Slade & Redhill Formation
- ■ Mudstone - Slade & Redhill Formation

ARUP, gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Atterberg Limits and Moisture Content
Mudstone and Weathered Mudstone

253875 FIGURE **18**



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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

◀ BH09
● BH102
⯃ BH16

COLOUR LEGEND

- ■ Topsoil
- ■ Made Ground
- ■ Weathered mudstone - Haverford Mudstone Formation
- ■ Siltstone - Haverford Mudstone Formation
- ■ Weathered sandstone - Haverford Mudstone Formation
- ■ Weathered mudstone - Portfield and Haverford Mudstone Formation
- ■ Mudstone - Portfield and Haverford Mudstone Formation
- ■ Weathered siltstone - Portfield and Haverford Mudstone Formation
- ■ Weathered sandstone - Portfield and Haverford Mudstone Formation
- ■ Sandstone - Portfield and Haverford Mudstone Formation
- ■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
- ■ Conglomerate - Portfield and Haverford Mudstone Formation
- ■ Weathered mudstone - Slade & Redhill Formation
- ■ Mudstone - Slade & Redhill Formation

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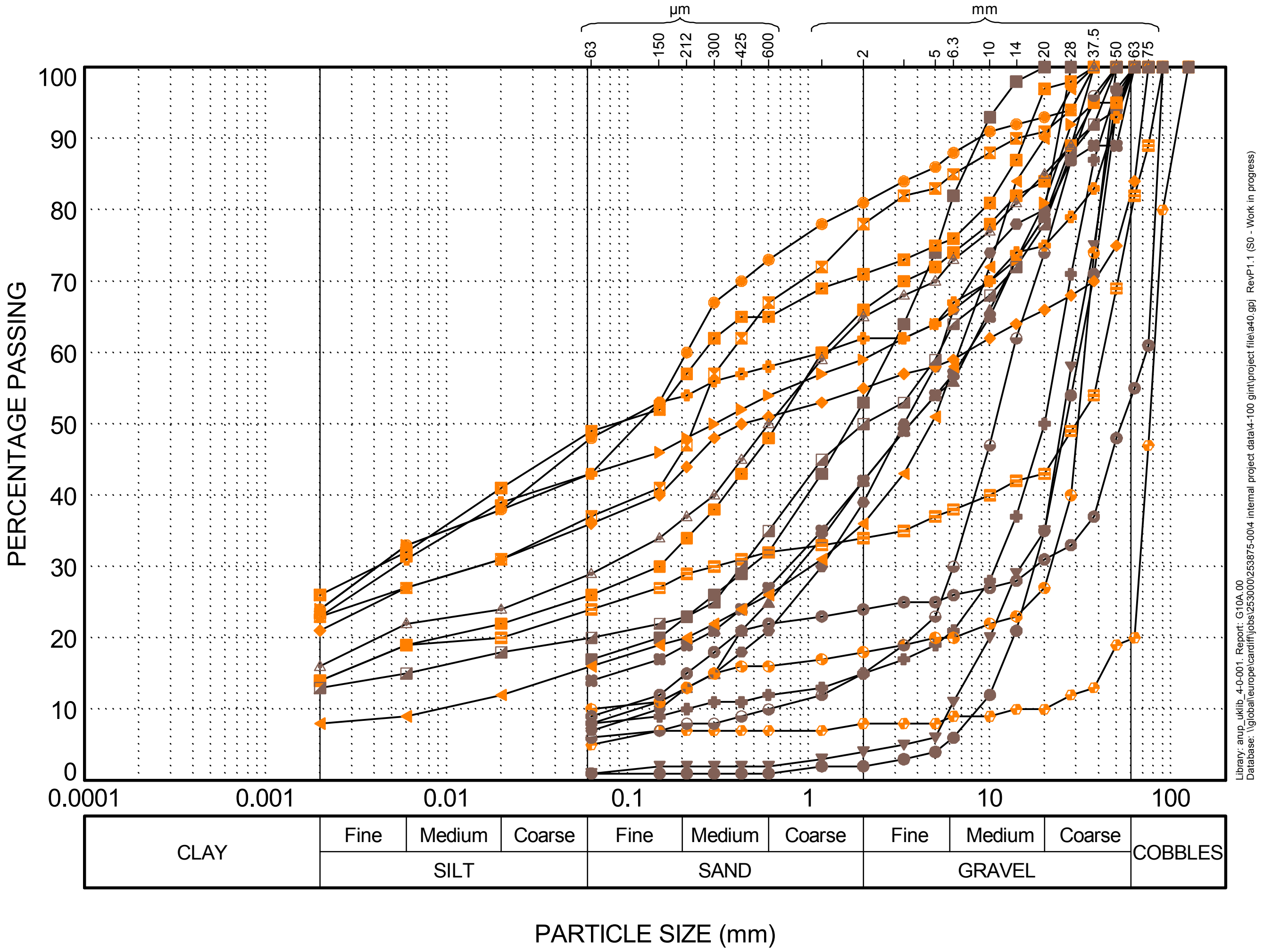
Atterberg Limits and Moisture Content
All other materials

253875 **FIGURE 19**



● BH07, 76.0mOD
■ BH08, 64.7mOD
▲ BH10, 96.5mOD
✤ BH11, 95.8mOD
⬢ BH17, 74.9mOD
▼ TP04, 125.9mOD
✚ TP05, 116.9mOD
▣ TP17, 82.8mOD
◀ TP17, 81.8mOD
▶ TP18, 86.1mOD
⧗ TP19, 90.0mOD
◉ TP20, 91.1mOD
◕ TP21, 94.4mOD
◆ TP22, 92.6mOD
☰ TP23, 92.1mOD
✚ TP24, 90.7mOD
⬢ TP25, 85.6mOD
☒ TP26, 82.3mOD
○ TP27, 77.3mOD
◪ TP28, 86.1mOD
◓ TP29, 91.3mOD
△ TP30, 91.2mOD

COLOUR LEGEND

■ Topsoil
■ Made Ground
■ Weathered mudstone - Haverford Mudstone Formation
■ Siltstone - Haverford Mudstone Formation
■ Weathered sandstone - Haverford Mudstone Formation
■ Weathered mudstone - Portfield and Haverford Mudstone Formation
■ Mudstone - Portfield and Haverford Mudstone Formation
■ Weathered siltstone - Portfield and Haverford Mudstone Formation
■ Weathered sandstone - Portfield and Haverford Mudstone Formation
■ Sandstone - Portfield and Haverford Mudstone Formation
■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
■ Conglomerate - Portfield and Haverford Mudstone Formation
■ Weathered mudstone - Slade & Redhill Formation
■ Mudstone - Slade & Redhill Formation

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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

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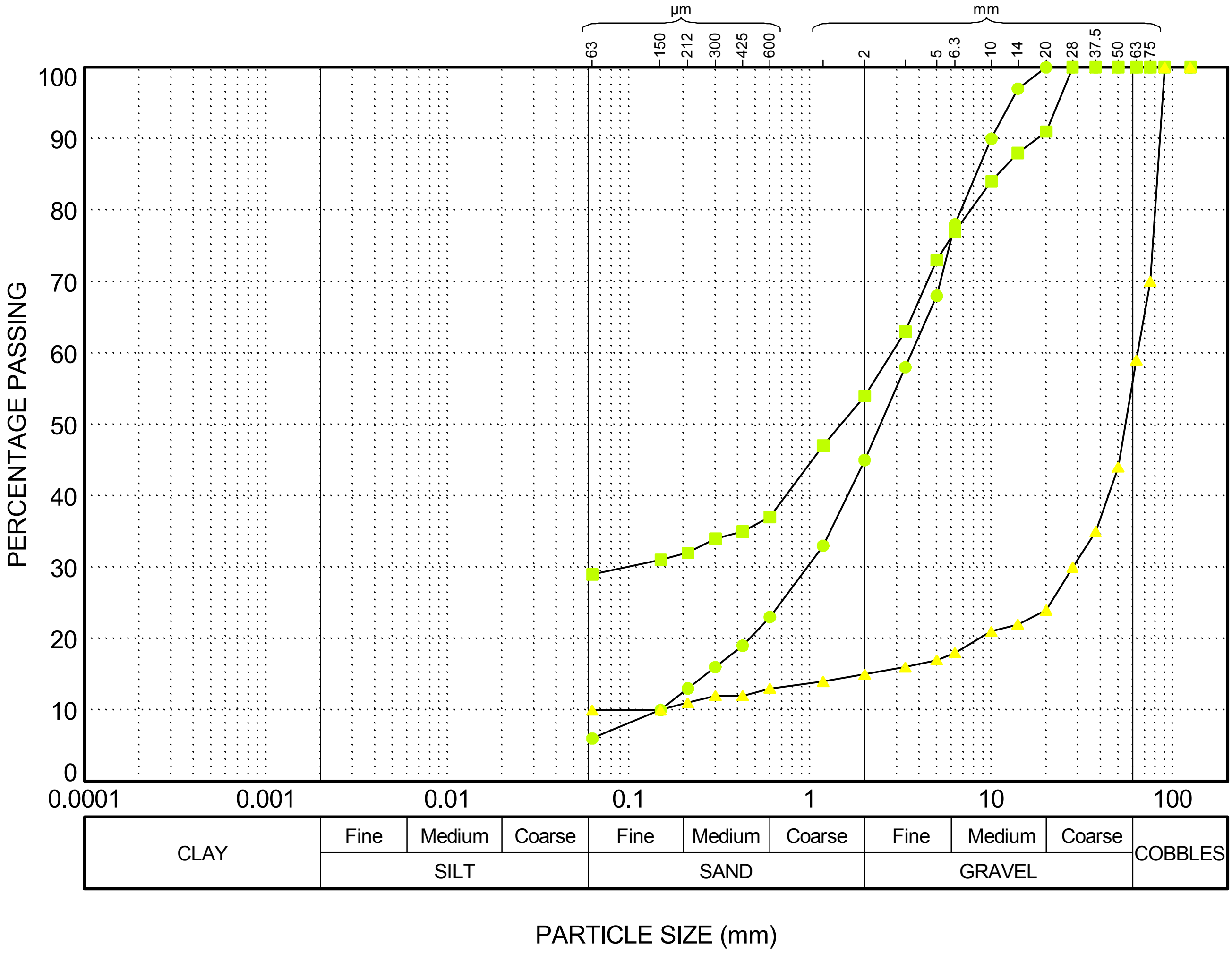
Particle Size Distribution
Mudstone and Weathered Mudstone

253875 **FIGURE 20**



● BH09, 104.0mOD
■ BH16, 71.9mOD
▲ TP03, 125.1mOD

COLOUR LEGEND

■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

Library: arup_uklib_4-0-001. Report: G10A.00
Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

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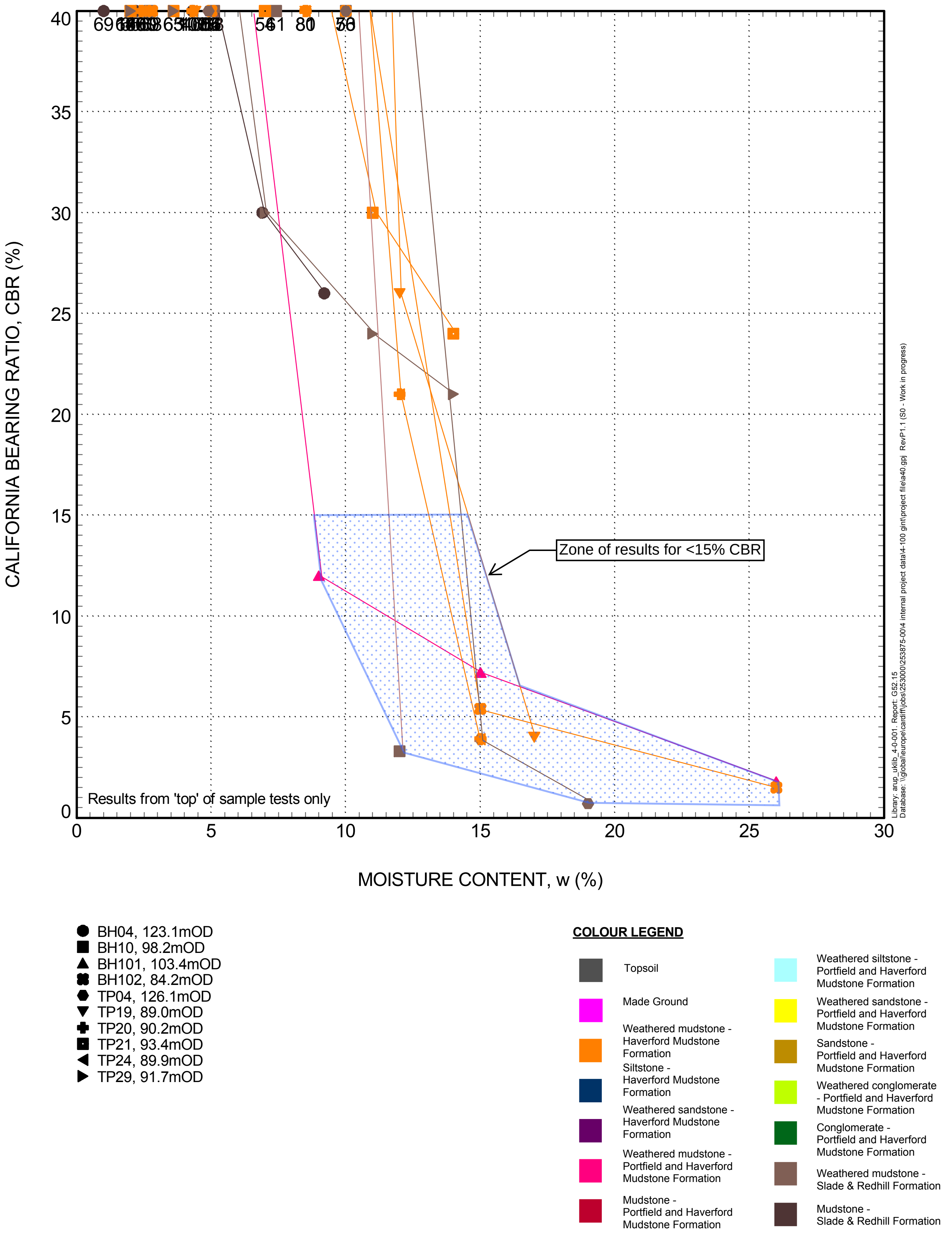
Particle Size Distribution

All other materials

253875

FIGURE **21**



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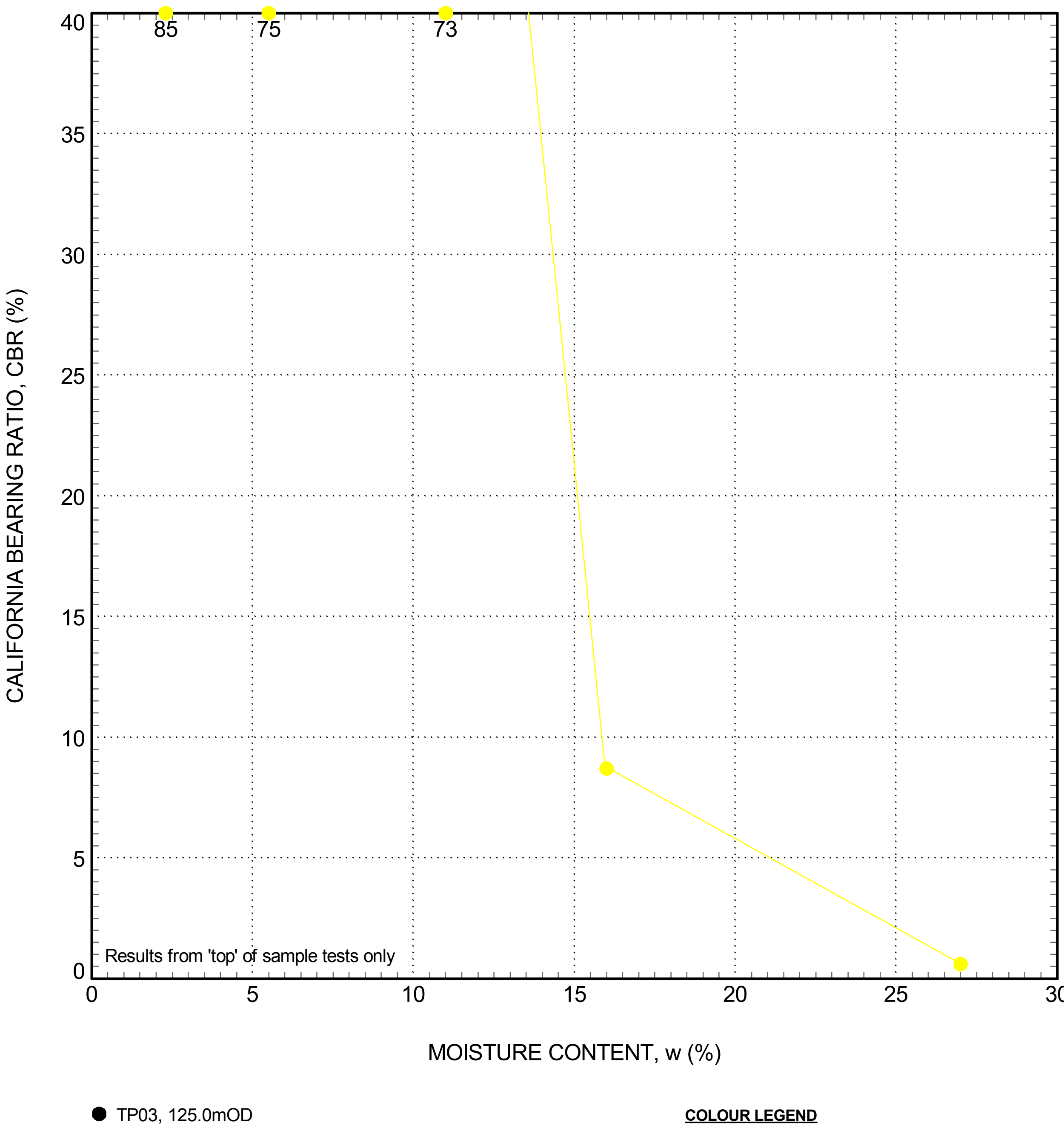
ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

California Bearing Ratio

Mudstone and Weathered Mudstone

253875

FIGURE 22



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COLOUR LEGEND

⬛ Topsoil

🟪 Made Ground

🟧 Weathered mudstone - Haverford Mudstone Formation

🟦 Siltstone - Haverford Mudstone Formation

🟪 Weathered sandstone - Haverford Mudstone Formation

🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation

🟥 Mudstone - Portfield and Haverford Mudstone Formation

🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation

🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation

🟫 Sandstone - Portfield and Haverford Mudstone Formation

🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation

🟩 Conglomerate - Portfield and Haverford Mudstone Formation

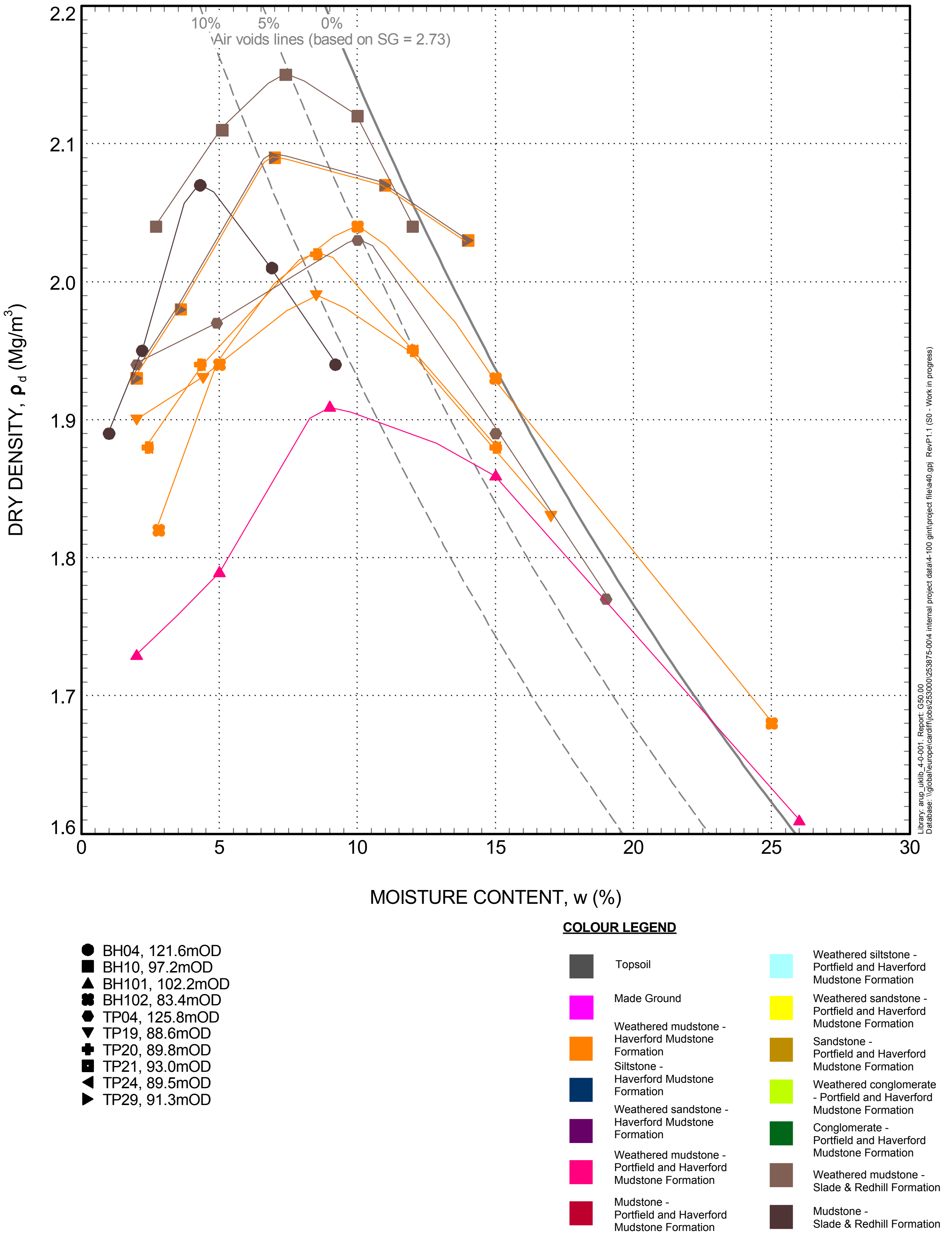
🟫 Weathered mudstone - Slade & Redhill Formation

🟫 Mudstone - Slade & Redhill Formation

ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

California Bearing Ratio
All other materials

253875 FIGURE 23



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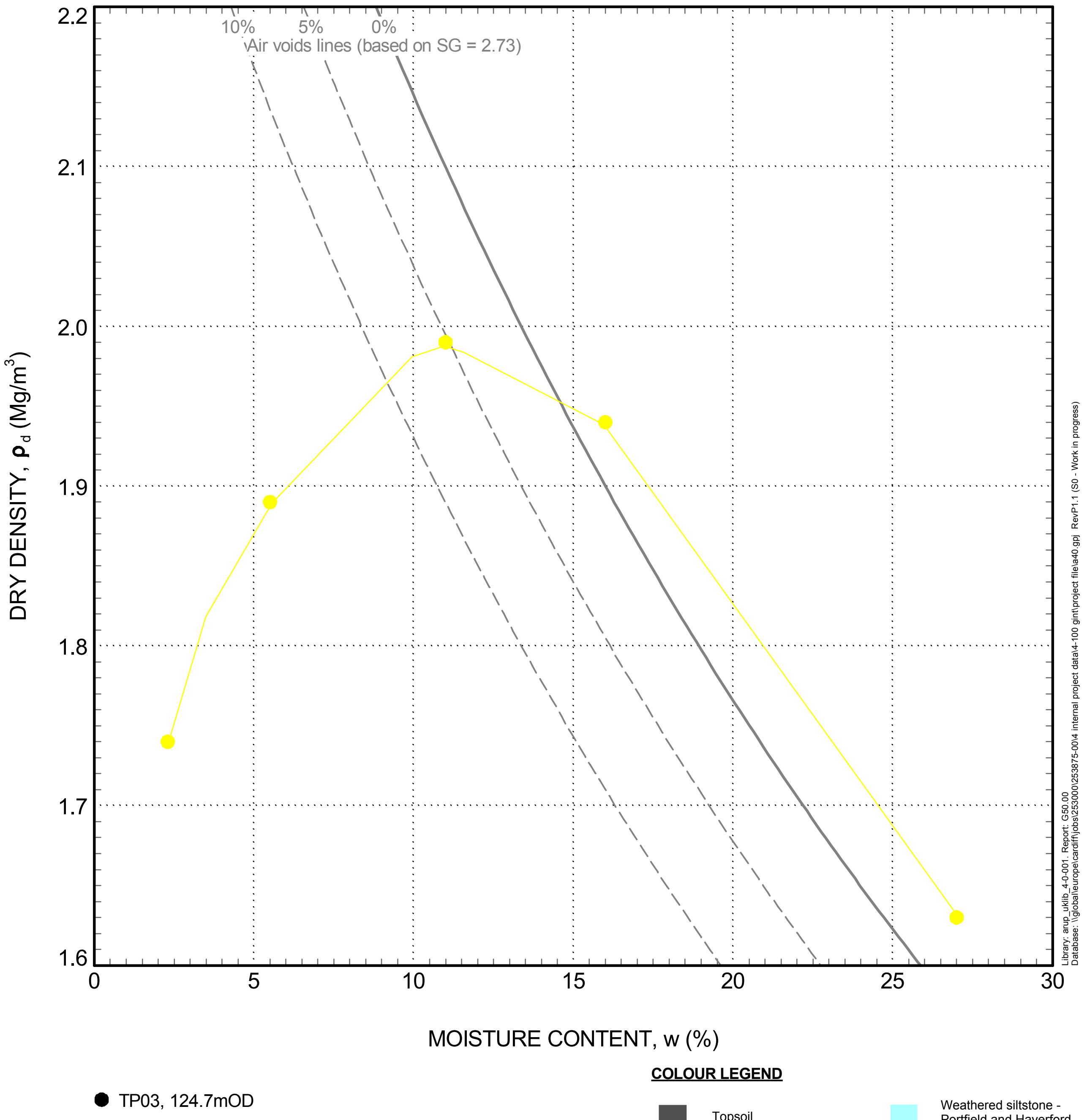
ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Compaction
Mudstone and Weathered Mudstone

253875 **FIGURE 24**



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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

COLOUR LEGEND

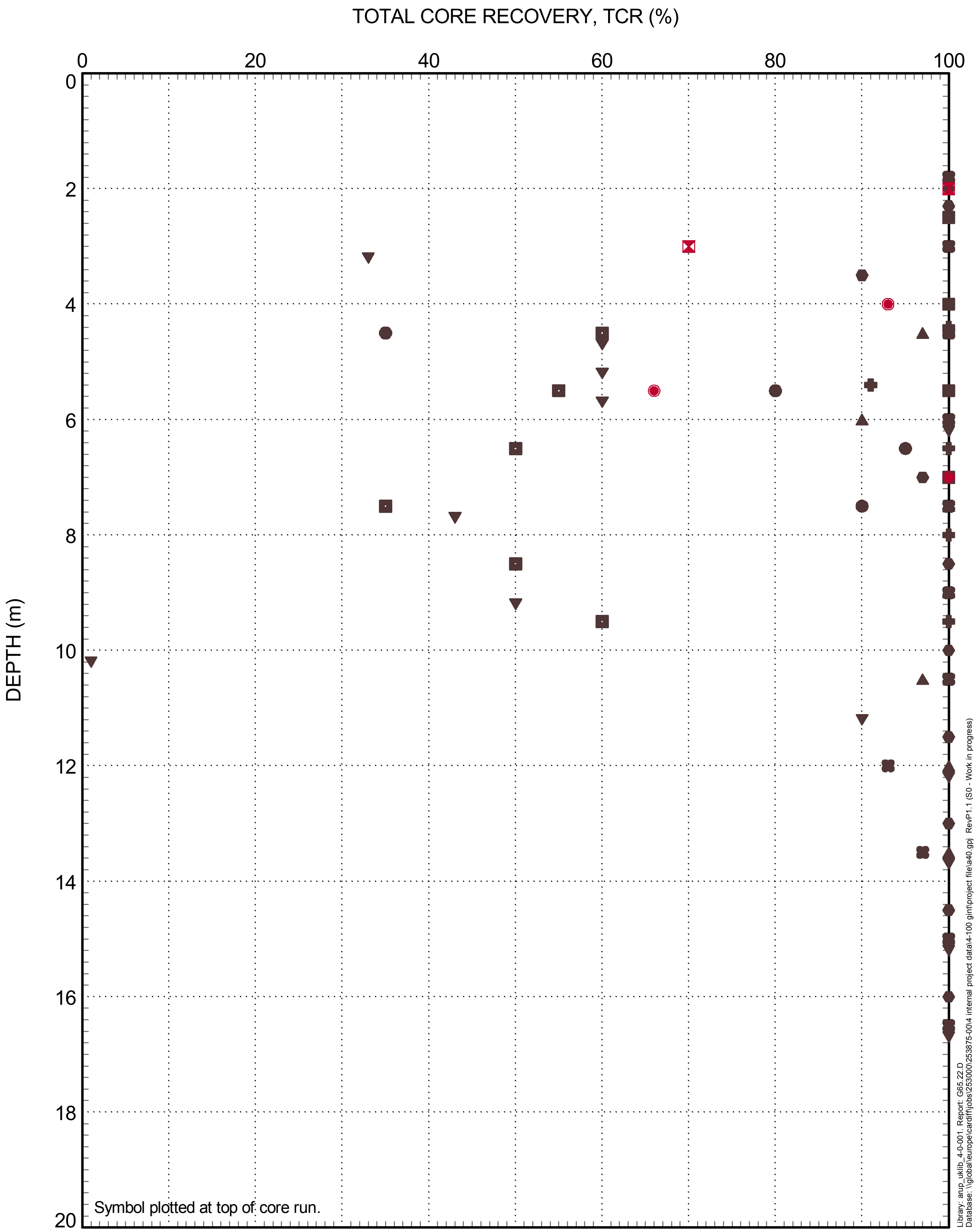
■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

ARUP_gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Compaction
All other materials

253875

FIGURE **25**



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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

● BH01
■ BH02
▲ BH03
✖ BH04
⬢ BH05
▼ BH06
✚ BH07
⊡ BH08
⧗ BH101
◉ BH102

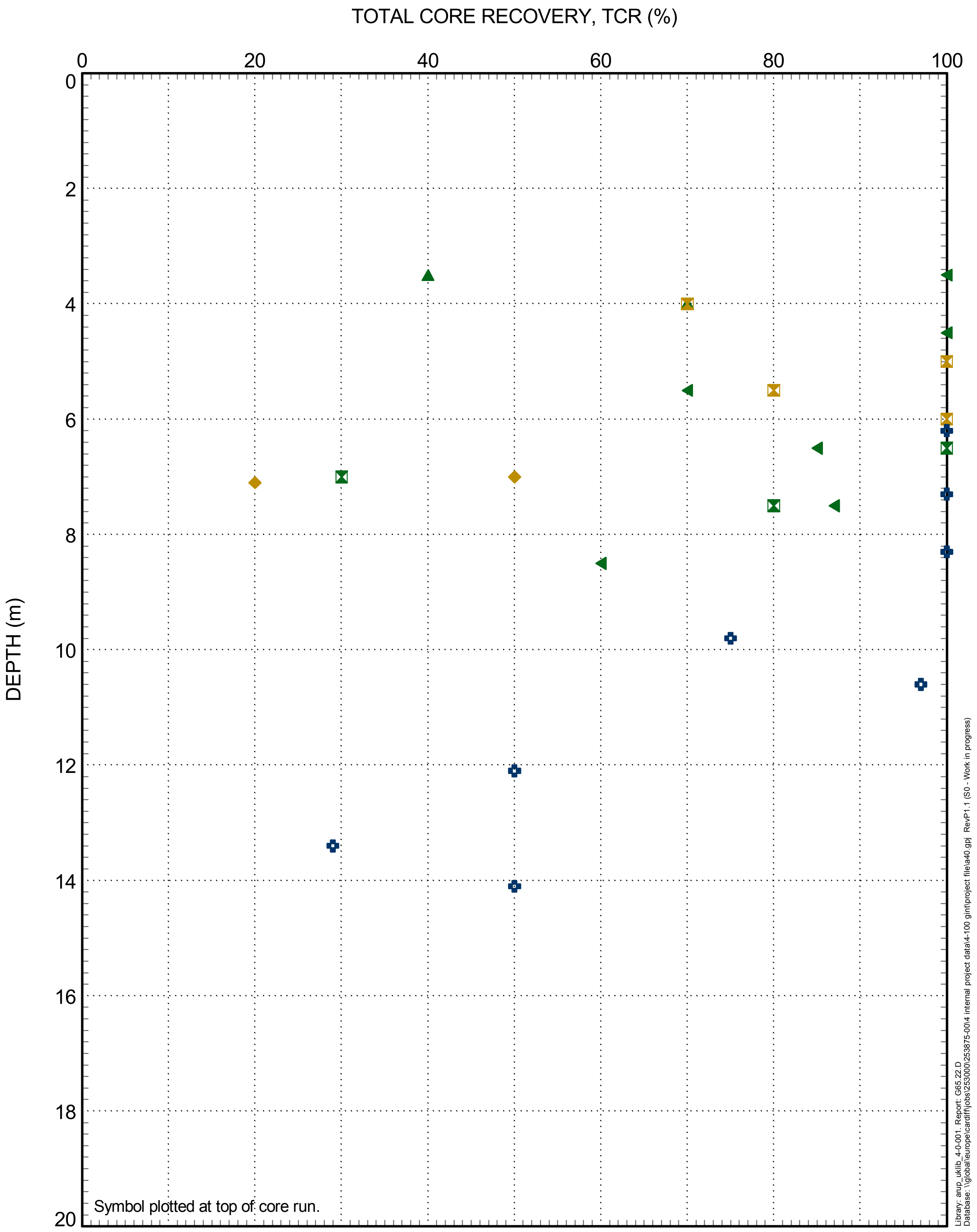
COLOUR LEGEND

⬛ Topsoil
🟪 Made Ground
🟧 Weathered mudstone - Haverford Mudstone Formation
🟦 Siltstone - Haverford Mudstone Formation
🟪 Weathered sandstone - Haverford Mudstone Formation
🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation
🟥 Mudstone - Portfield and Haverford Mudstone Formation
🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation
🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation
🟫 Sandstone - Portfield and Haverford Mudstone Formation
🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟩 Conglomerate - Portfield and Haverford Mudstone Formation
🟫 Weathered mudstone - Slade & Redhill Formation
🟫 Mudstone - Slade & Redhill Formation

ARUP gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Total Core Recovery
Mudstone

253875 FIGURE 26



- ● BH01
- ▲ BH03
- ◀ BH09
- ☒ BH101
- ◆ BH12
- ✚ BH15

COLOUR LEGEND

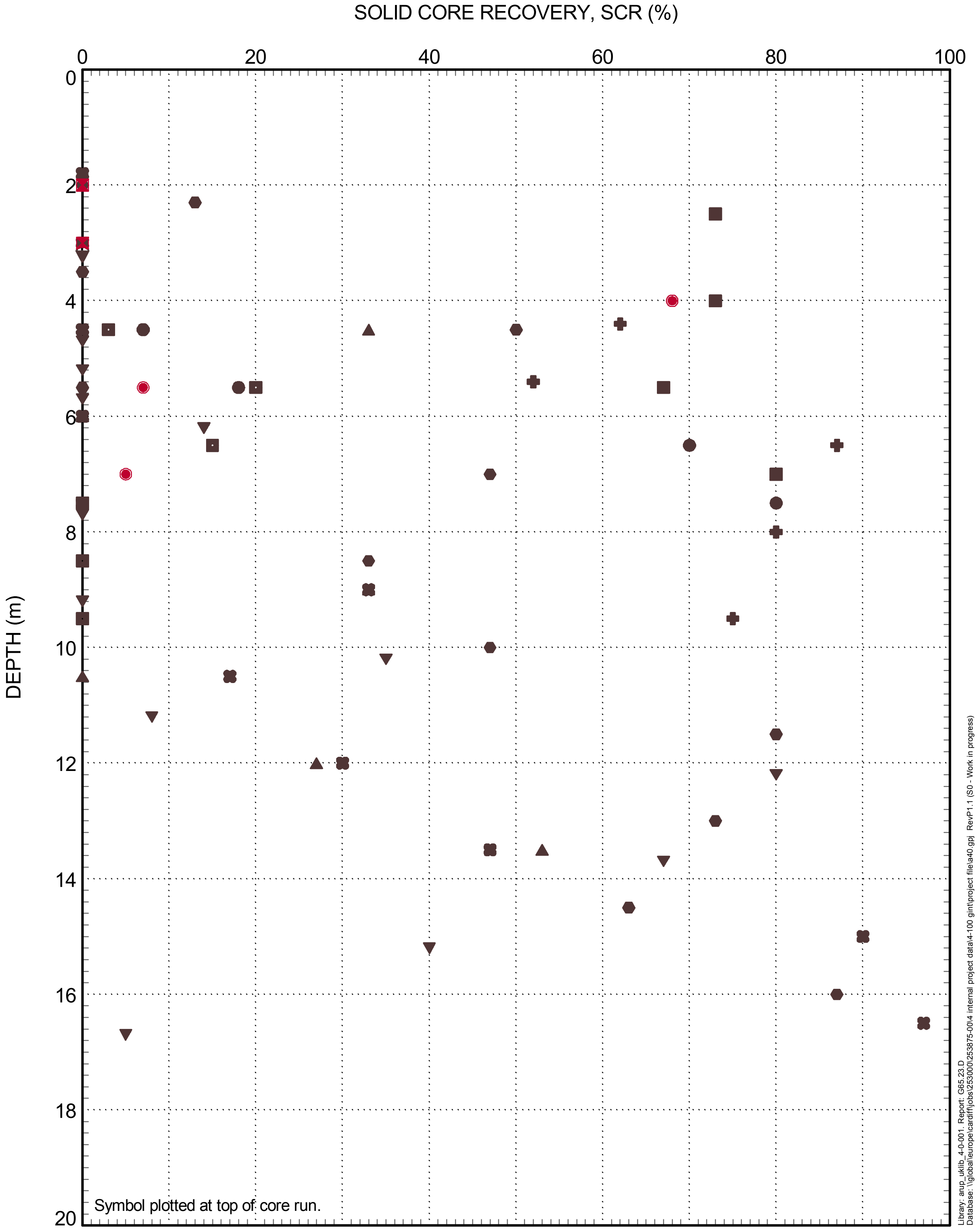
⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

Total Core Recovery
All other materials

253875 FIGURE **27**

Library: arup_uklib_4-0-001, Report: G65.22.D
Database: \\global\europe\cardiff\jobs\253000\253875-004 internal project data\4-100 gint\project files\a40.gpj RevP1.1 (S0 - Work in progress)

ARUP_gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17



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Database: \\global\europe\cardiff\jobs\253000\253875-004 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

- ● BH01
- ■ BH02
- ▲ BH03
- ✖ BH04
- ⬢ BH05
- ▼ BH06
- ✚ BH07
- ▣ BH08
- ⧗ BH101
- ◉ BH102

COLOUR LEGEND

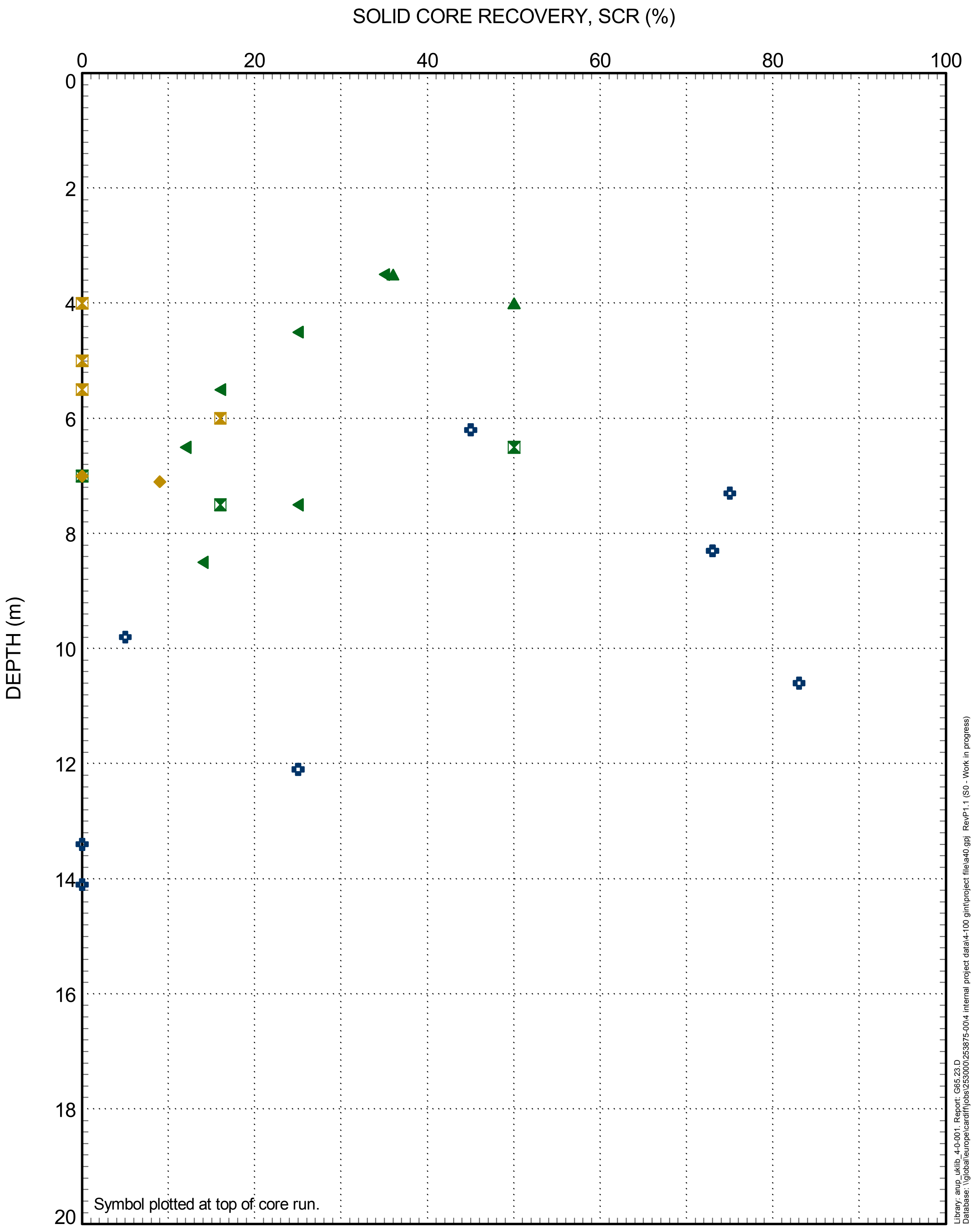
⬛	Topsoil
🟪	Made Ground
🟧	Weathered mudstone - Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation
🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟫	Weathered mudstone - Slade & Redhill Formation
🟫	Mudstone - Slade & Redhill Formation

ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Solid Core Recovery
Mudstone and Weathered Mudstone

253875

FIGURE **28**



Symbol plotted at top of core run.

- ● BH01
- ▲ BH03
- ◀ BH09
- ☒ BH101
- ◆ BH12
- ✚ BH15

COLOUR LEGEND

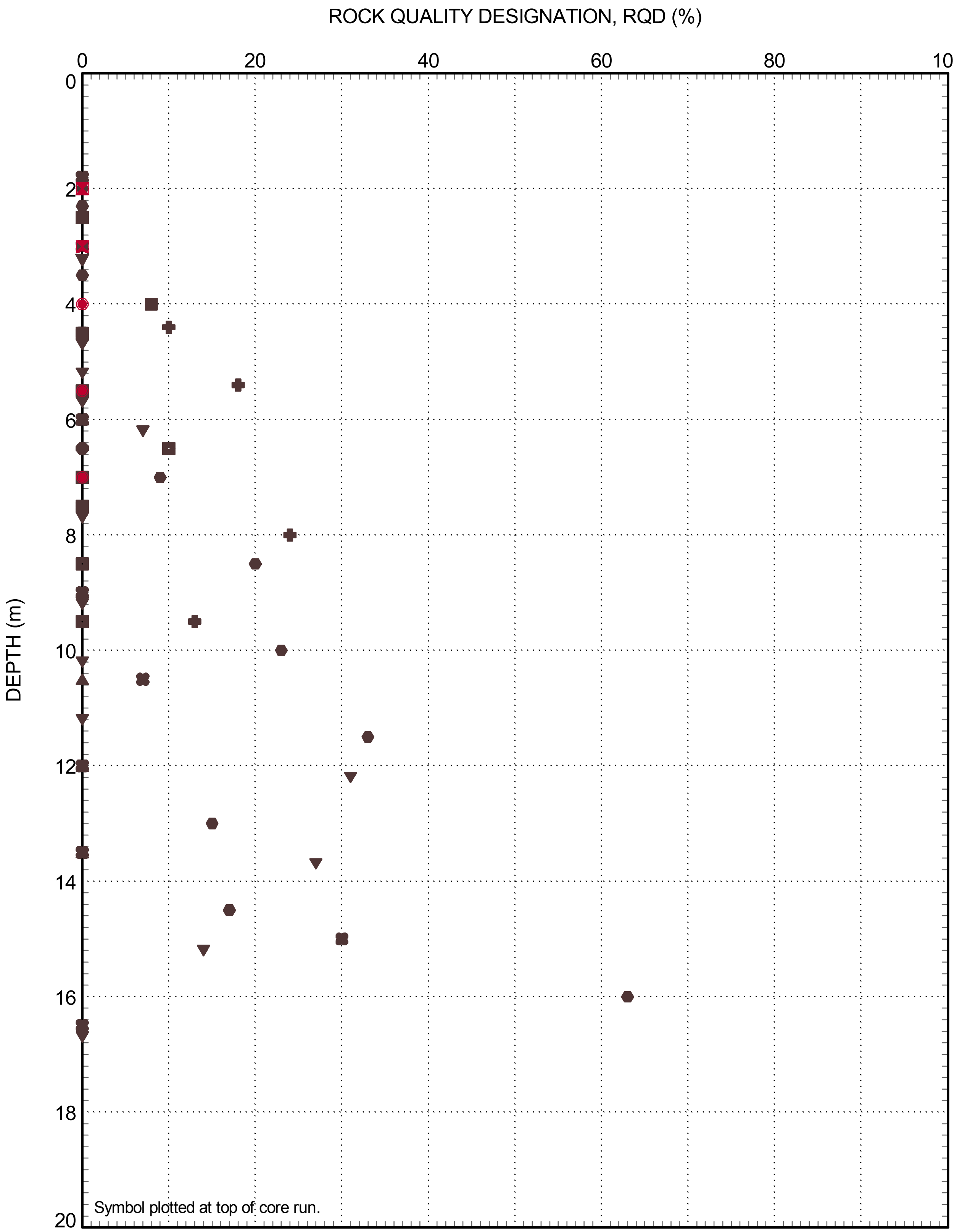
- ⬛ Topsoil
- 🟪 Made Ground
- 🟧 Weathered mudstone - Haverford Mudstone Formation
- 🟦 Siltstone - Haverford Mudstone Formation
- 🟪 Weathered sandstone - Haverford Mudstone Formation
- 🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation
- 🟥 Mudstone - Portfield and Haverford Mudstone Formation
- 🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation
- 🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation
- 🟫 Sandstone - Portfield and Haverford Mudstone Formation
- 🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation
- 🟩 Conglomerate - Portfield and Haverford Mudstone Formation
- 🟫 Weathered mudstone - Slade & Redhill Formation
- 🟫 Mudstone - Slade & Redhill Formation

Solid Core Recovery
All other materials

253875 FIGURE **29**

Library: arup_uklib_4-0-001, Report: G65.23.D
Database: \\global\europe\cardiff\jobs\253000\253875-004 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

ARUP, gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17



- ● BH01
- ■ BH02
- ▲ BH03
- ✖ BH04
- ⬢ BH05
- ▼ BH06
- ✚ BH07
- ▣ BH08
- ⧗ BH101
- ◉ BH102

COLOUR LEGEND

■	Topsoil	■	Weathered siltstone - Portfield and Haverford Mudstone Formation
■	Made Ground	■	Weathered sandstone - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Haverford Mudstone Formation	■	Sandstone - Portfield and Haverford Mudstone Formation
■	Siltstone - Haverford Mudstone Formation	■	Weathered conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered sandstone - Haverford Mudstone Formation	■	Conglomerate - Portfield and Haverford Mudstone Formation
■	Weathered mudstone - Portfield and Haverford Mudstone Formation	■	Weathered mudstone - Slade & Redhill Formation
■	Mudstone - Portfield and Haverford Mudstone Formation	■	Mudstone - Slade & Redhill Formation

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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

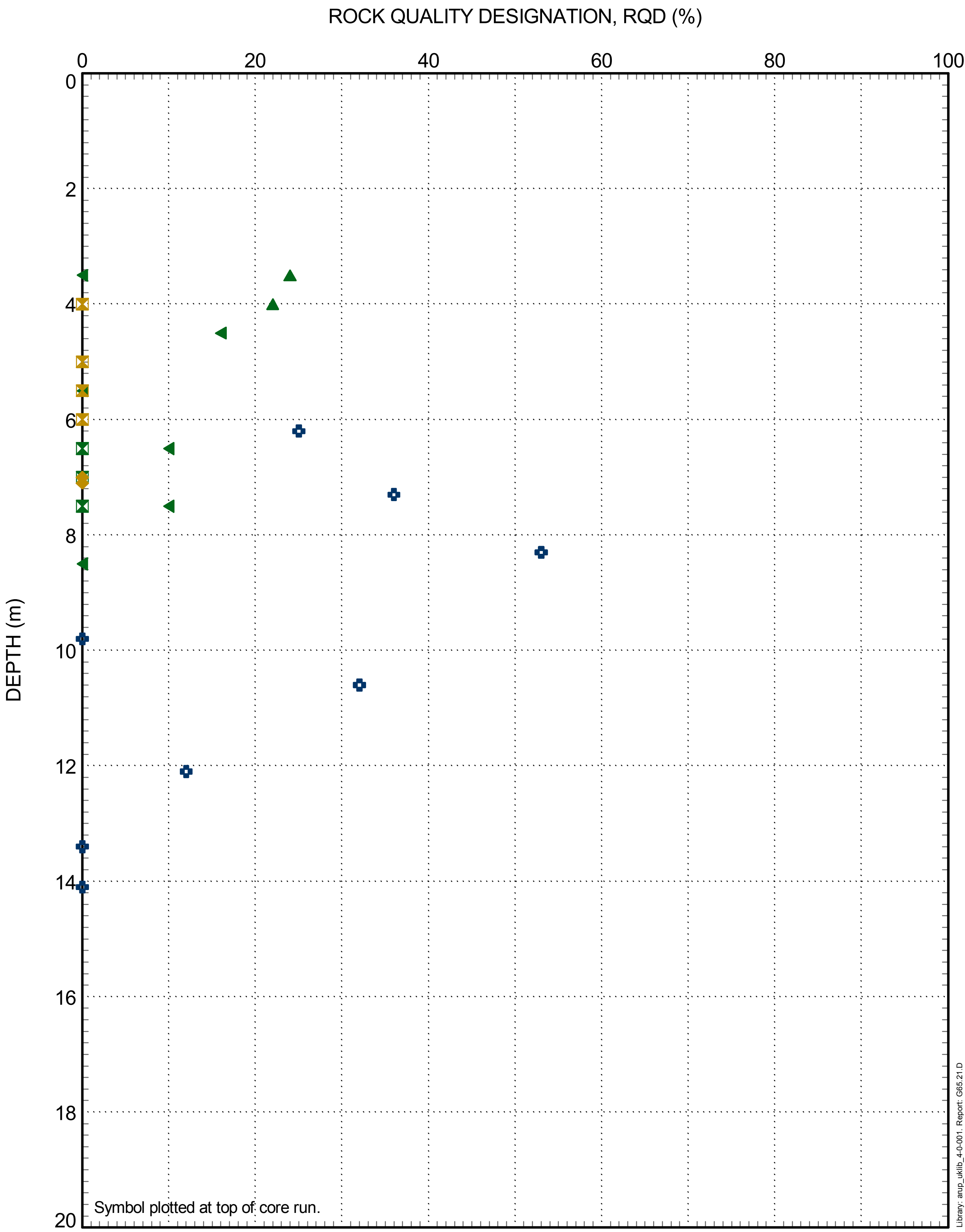
ARUP, gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Rock Quality Designation

Mudstone and Weathered Mudstone

253875

FIGURE **30**



● BH01
▲ BH03
◀ BH09
⊠ BH101
◆ BH12
✚ BH15

COLOUR LEGEND

■ Topsoil
■ Made Ground
🟧 Weathered mudstone - Haverford Mudstone Formation
🟦 Siltstone - Haverford Mudstone Formation
🟪 Weathered sandstone - Haverford Mudstone Formation
■ Weathered mudstone - Portfield and Haverford Mudstone Formation
🟥 Mudstone - Portfield and Haverford Mudstone Formation
■ Weathered siltstone - Portfield and Haverford Mudstone Formation
🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation
■ Sandstone - Portfield and Haverford Mudstone Formation
■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟩 Conglomerate - Portfield and Haverford Mudstone Formation
🟫 Weathered mudstone - Slade & Redhill Formation
🟫 Mudstone - Slade & Redhill Formation

Library: arup_uklib_4-0-001. Report: G65.21.D
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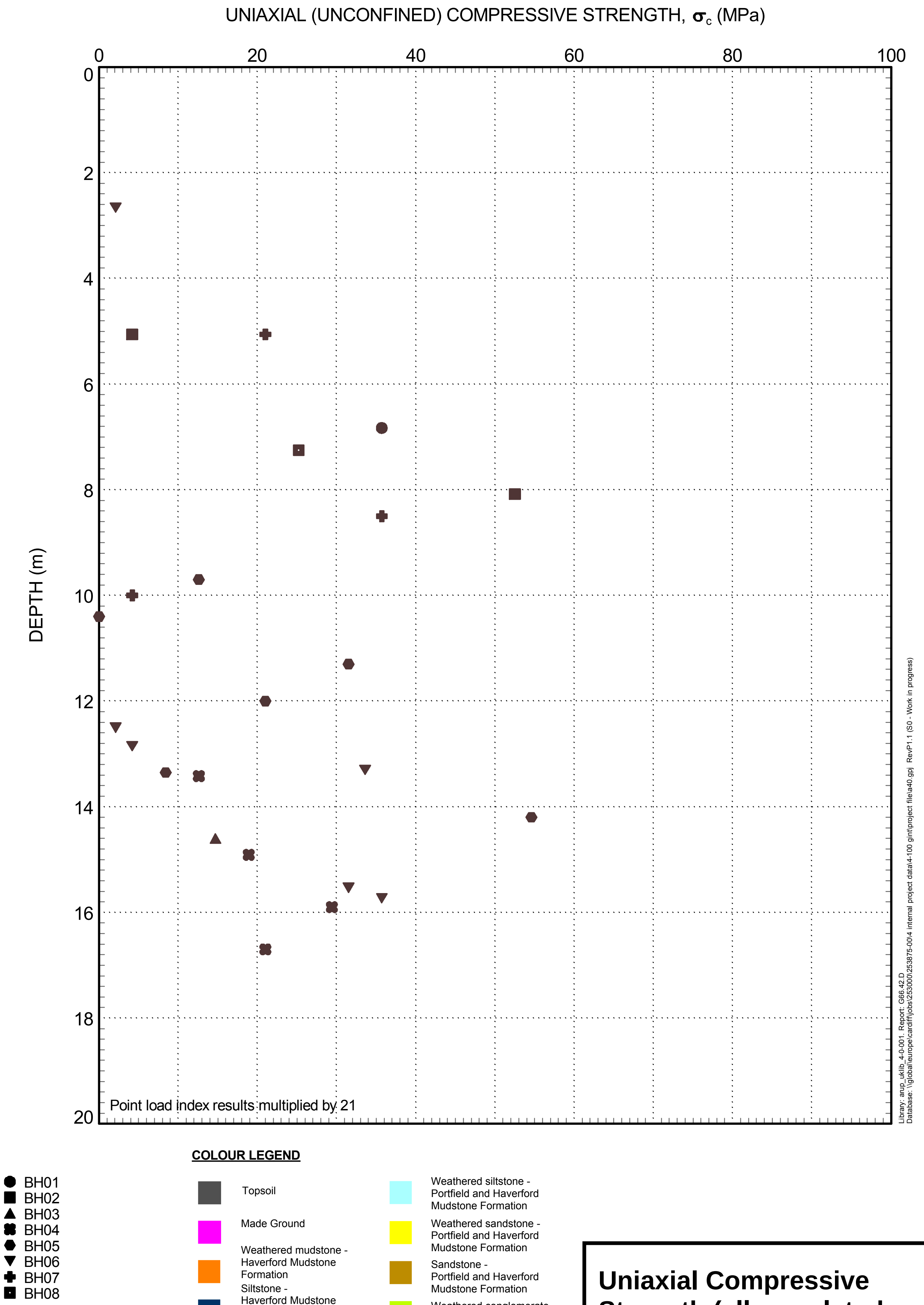
Rock Quality Designation
All other materials

253875 **FIGURE 31**



COLOUR LEGEND

- ■ Topsoil
- ■ Made Ground
- ■ Weathered mudstone - Haverford Mudstone Formation
- ■ Siltstone - Haverford Mudstone Formation
- ■ Weathered sandstone - Haverford Mudstone Formation
- ■ Weathered mudstone - Portfield and Haverford Mudstone Formation
- ■ Mudstone - Portfield and Haverford Mudstone Formation
- ■ Weathered siltstone - Portfield and Haverford Mudstone Formation
- ■ Weathered sandstone - Portfield and Haverford Mudstone Formation
- ■ Sandstone - Portfield and Haverford Mudstone Formation
- ■ Weathered conglomerate - Portfield and Haverford Mudstone Formation
- ■ Conglomerate - Portfield and Haverford Mudstone Formation
- ■ Weathered mudstone - Slade & Redhill Formation
- ■ Mudstone - Slade & Redhill Formation

Library: arup_uklib_4-0-001. Report: G66.42.D
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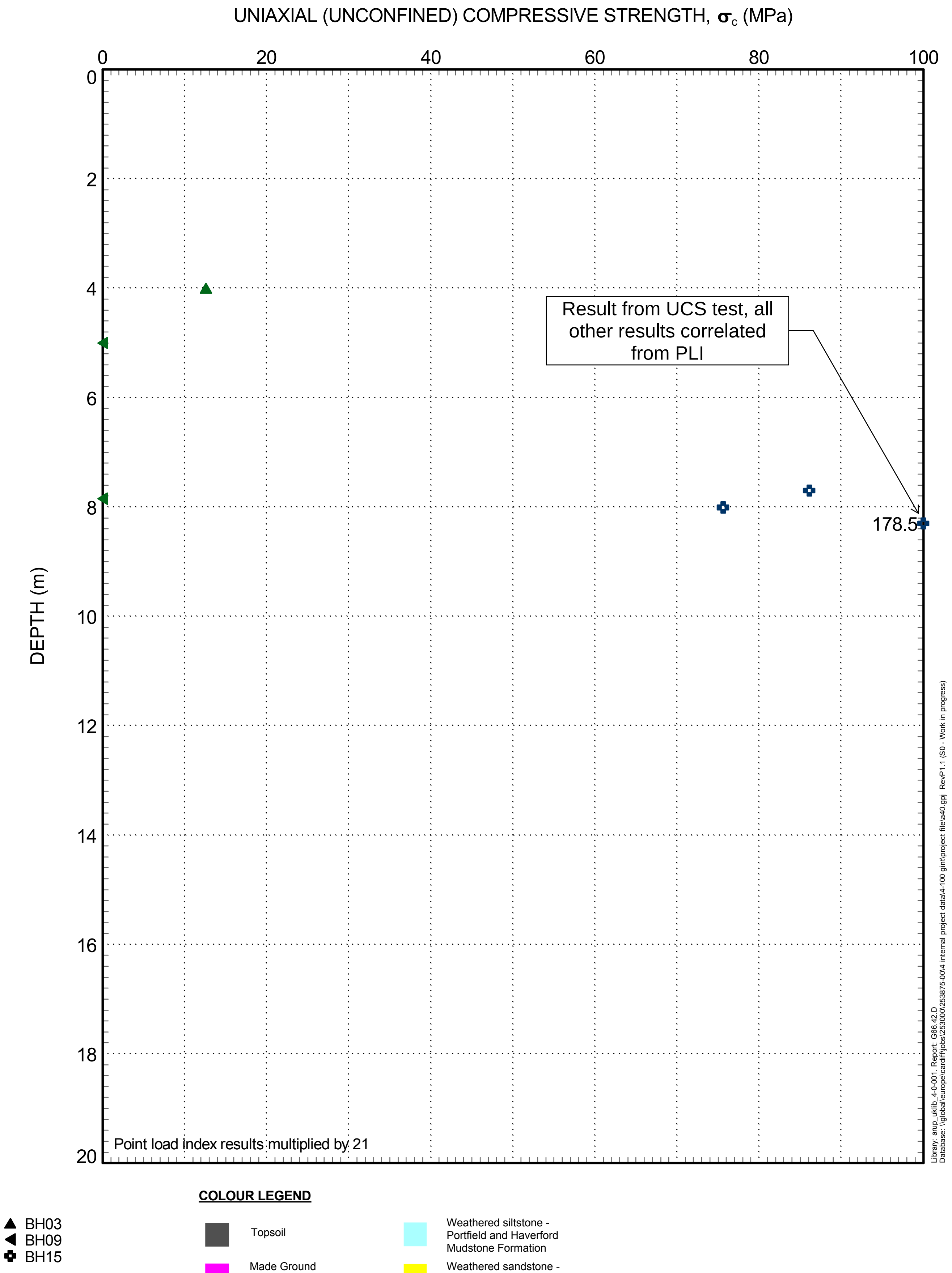
Made by Aodhan Teague on 4-Jul-17

Uniaxial Compressive Strength (all correlated from PLI)

Mudstone and Weathered Mudstone

253875 FIGURE **32**



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Database: \\global\europe\cardiff\jobs\253000\253875-00\4 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

COLOUR LEGEND

⬛ Topsoil

🟪 Made Ground

🟧 Weathered mudstone - Haverford Mudstone Formation

🟦 Siltstone - Haverford Mudstone Formation

🟪 Weathered sandstone - Haverford Mudstone Formation

🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation

🟥 Mudstone - Portfield and Haverford Mudstone Formation

🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation

🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation

🟫 Sandstone - Portfield and Haverford Mudstone Formation

🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation

🟩 Conglomerate - Portfield and Haverford Mudstone Formation

🟫 Weathered mudstone - Slade & Redhill Formation

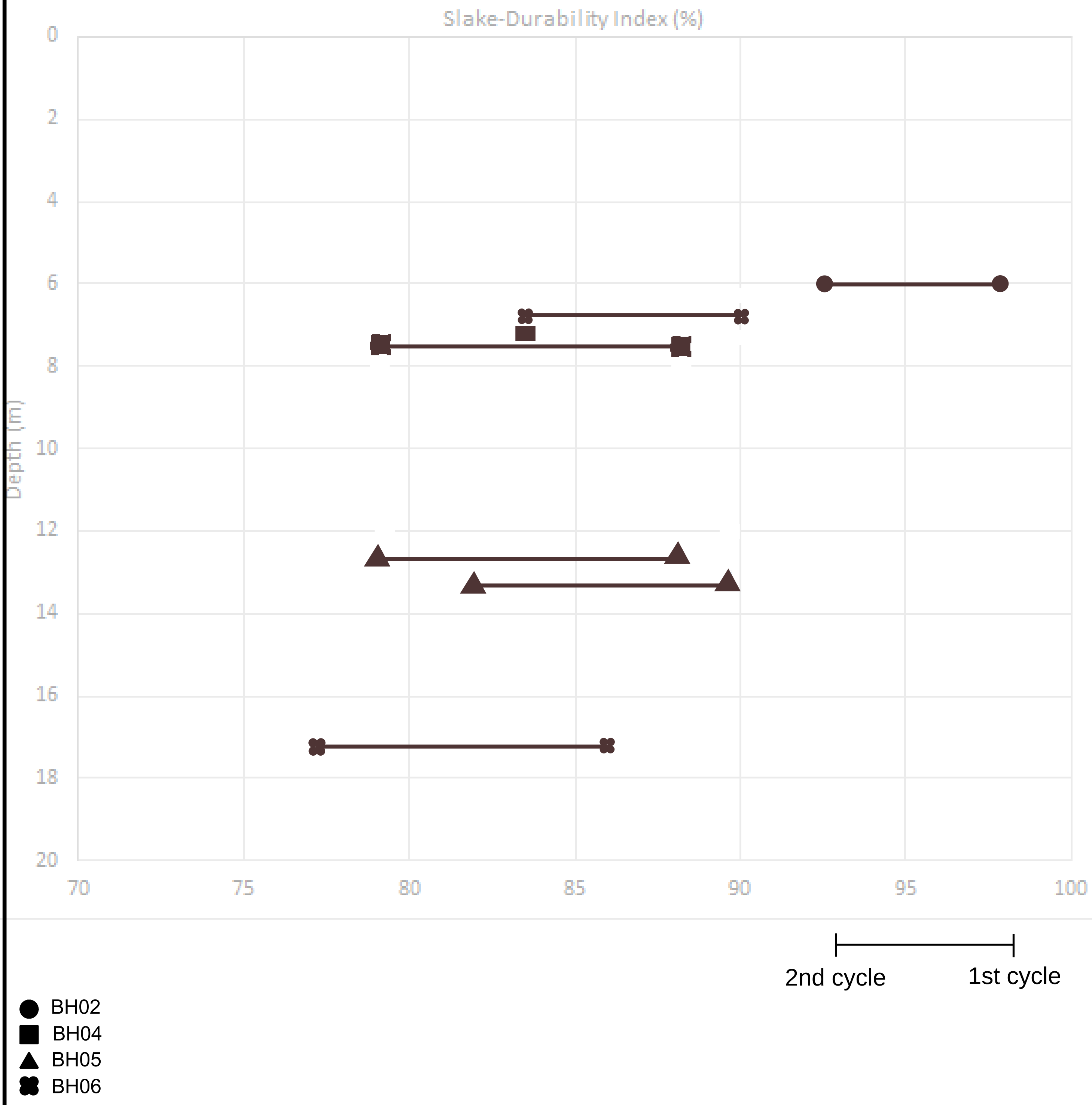
🟫 Mudstone - Slade & Redhill Formation

ARUP. gINT v8.30.004
Made by Aodhan Teague on 4-Jul-17

Uniaxial Compressive Strength (including correlated from PLI)

All other materials

253875 **FIGURE 33**



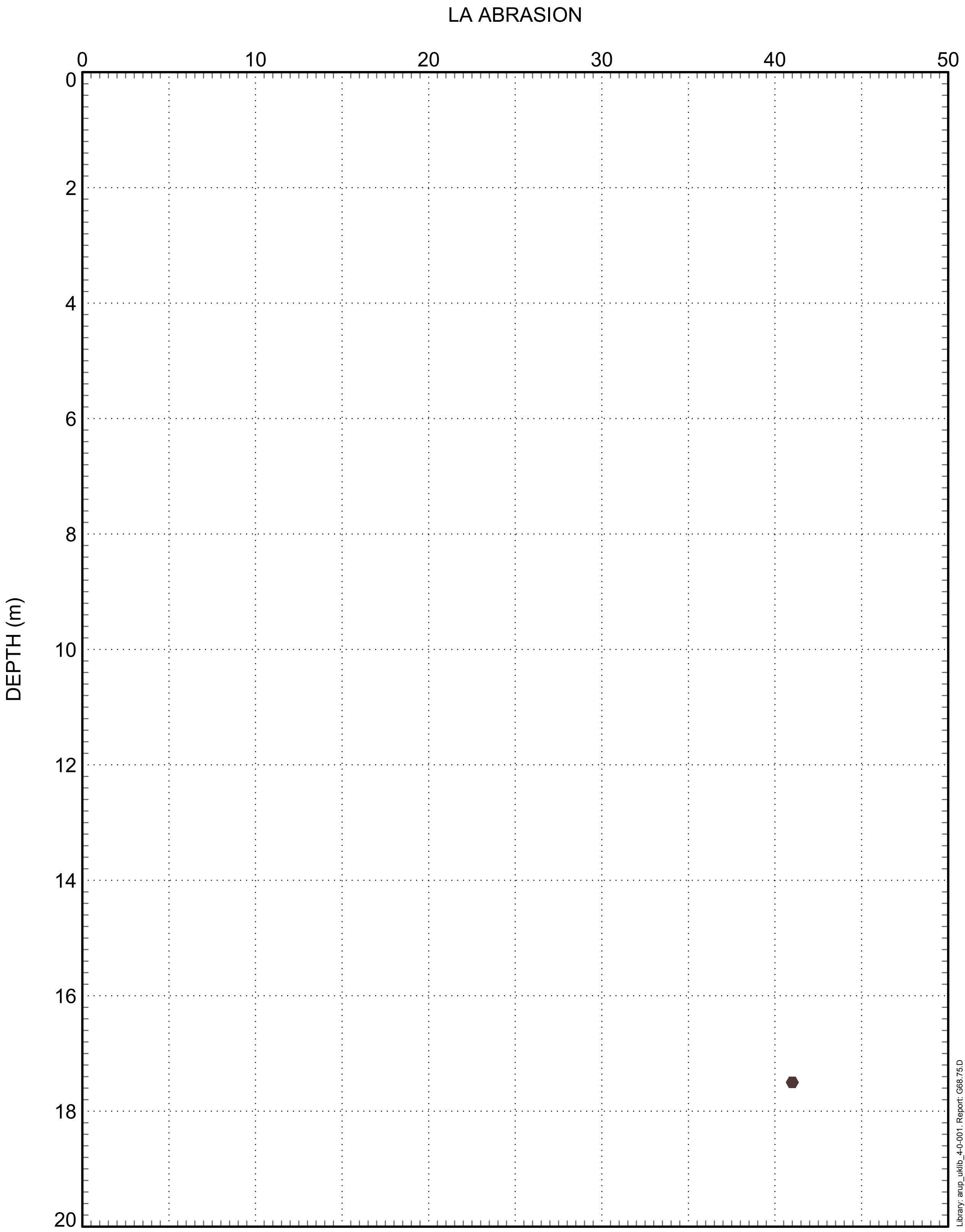
COLOUR LEGEND

⬛ Topsoil
🟪 Made Ground
🟧 Weathered mudstone - Haverford Mudstone Formation
🟦 Siltstone - Haverford Mudstone Formation
🟪 Weathered sandstone - Haverford Mudstone Formation
🟥 Weathered mudstone - Portfield and Haverford Mudstone Formation
🟥 Mudstone - Portfield and Haverford Mudstone Formation
🟦 Weathered siltstone - Portfield and Haverford Mudstone Formation
🟨 Weathered sandstone - Portfield and Haverford Mudstone Formation
🟨 Sandstone - Portfield and Haverford Mudstone Formation
🟩 Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟩 Conglomerate - Portfield and Haverford Mudstone Formation
🟫 Weathered mudstone - Slade & Redhill Formation
🟫 Mudstone - Slade & Redhill Formation

Slake Durability Index Mudstone

253875

FIGURE **34**



⬢ BH05

COLOUR LEGEND

⬛	Topsoil	🟦	Weathered siltstone - Portfield and Haverford Mudstone Formation
🟪	Made Ground	🟨	Weathered sandstone - Portfield and Haverford Mudstone Formation
🟧	Weathered mudstone - Haverford Mudstone Formation	🟫	Sandstone - Portfield and Haverford Mudstone Formation
🟦	Siltstone - Haverford Mudstone Formation	🟩	Weathered conglomerate - Portfield and Haverford Mudstone Formation
🟪	Weathered sandstone - Haverford Mudstone Formation	🟩	Conglomerate - Portfield and Haverford Mudstone Formation
🟥	Weathered mudstone - Portfield and Haverford Mudstone Formation	🟫	Weathered mudstone - Slade & Redhill Formation
🟥	Mudstone - Portfield and Haverford Mudstone Formation	🟫	Mudstone - Slade & Redhill Formation

Los Angeles Abrasion Mudstone

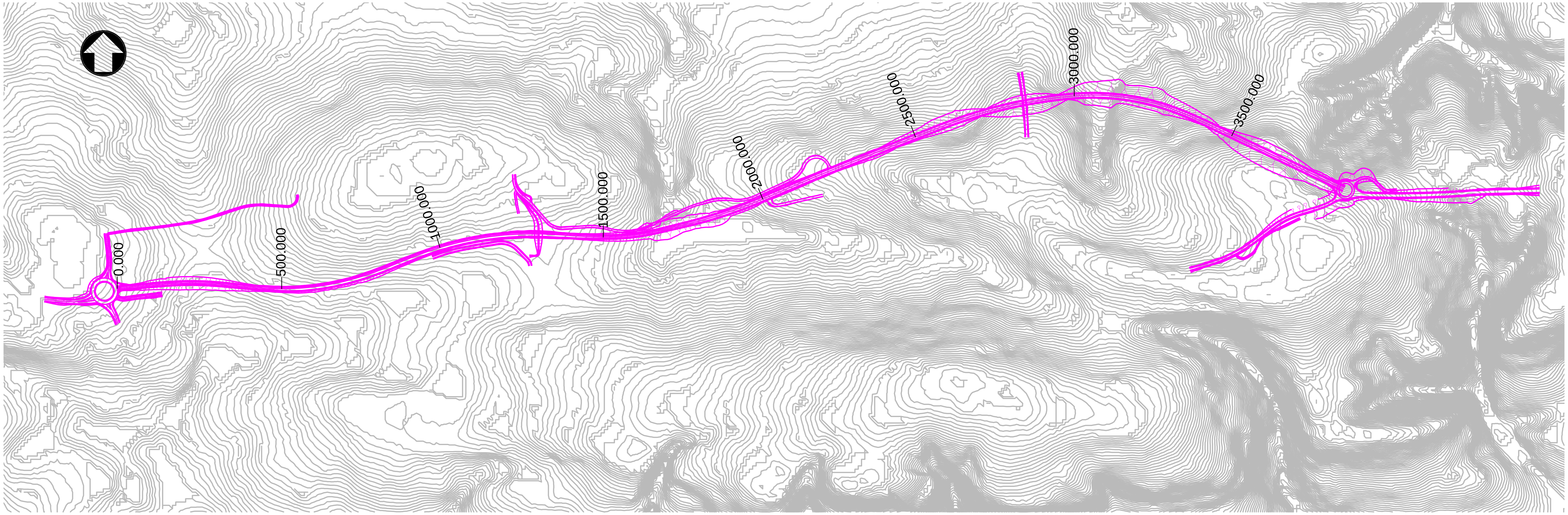
253875

FIGURE 35

Library: arup_uklib_4-0-001. Report: G68.75.D
Database: \\global\europe\cardiff\jobs\253000\253875-004 internal project data\4-100 gint\project file\a40.gpj RevP1.1 (S0 - Work in progress)

ARUP_gINT v8.30.004
Made by Ian Mach on 15-May-17

Appendix A – Scheme topographical plan extracted from PSSR



Mott MacDonald

Fitzalan House
Fitzalan Road
Cardiff
CF24 0EL
GB

T (0)29 2046 7800
F (0)29 2046 7801
W www.mottmac.com

Client

Llywodraeth Cymru
Welsh Government

ARCADIS Design & Consultancy for natural and built assets

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	07.03.16	NM	First Issue	PF	PF

Title

A40 Llanddewi Velfrey - Penblewin Improvement Scheme Pembrokeshire Scheme Topography

Drawn	N Moktan
Checked	P Fellows
Approved	P Fellows

Scale at A3
NTS

Drawing Number
Figure-1.3

Security	Status	Rev
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Appendix B – Photographs from site walkover

Photograph 1 – Existing topography dropping gently to the south at Ch. 0-100m (west of Penblewin Roundabout)

Photograph 2 – Existing topography rising gently to the north at Ch. 0+520m

Photograph 3 – Existing topography sloping gently towards existing A40 at Ch. 1+270m

Photograph 4 – Area of boggy ground south of existing A40 at Ch. 1+300m

Photograph 5 – North face of sandstone quarry north of A40 at Ch. 1+800m

Photograph 6 – Sandstone at quarry north of A40 at Ch. 1+800m

Photograph 7 – Existing culvert under current A40 at Ch. 1+740m

Photograph 8 – Weathered mudstone exposure at Ch. 2+230m, broken down to a gravel on the ground

Photograph 9 – Topography rising gently to the south, looking south-east towards proposed alignment at approximate Ch. 2+500m

Photograph 10 – View from centreline of proposed cutting looking north towards Pen-Troydin-Fawr Farm at Ch. 2+840m

Photograph 11 – Mudstone quarry at Ch. 3+250m. Note in bottom left hand corner the large boulder of what appears to be conglomerate comprising gravels cemented in a silty sandy matrix.

Photograph 11 – Mudstone in quarry at Ch. 3+250m

Photograph 12 – Established stream in path at Ch. 3+470m

Photograph 13 – Mudstone exposure in path at Ch. 3+800m

Photograph 14 – Northern side of eastern cutting

Photograph 15 – Southern side of eastern cutting

Appendix C – Geotechnical earthworks summary forms

Cutting 1 – Ch 2+030m to 2+450m

Cutting 2 – Ch 2+720m to 2+950m

Cutting 3 – Ch 3+480m to 3+850m

Embankment 1 – Ch 0+040m to 0+370m

Embankment 2 – Ch 0+370m to 1+610m

Embankment 3 – Ch 1+610m to 2+030m

Embankment 4 – Ch 2+460m to 2+720m

Embankment 5 – Ch 2+950m to 3+480m

Llanddewi Velfrey Roundabout

Penblewin Roundabout

Cutting 1 – Geotechnical Summary Form

EARTHWORKS ZONE	Cutting 1			REFERENCES / COMMENTS
CHAINAGE:	2+030m to 2+460m	TYPE:	Cutting	
RELEVANT EXPLORATORY HOLES				
BH101				
EXISTING TOPOGRAPHY				
The current ground level at Ch 2+030m is approximately 90mOD which then rises up in an easterly direction to approximately 100mOD at Ch 2+460m. The road alignment in this zone roughly follows the route of a ridge feature with the land sloping downwards away from the road to the north and south.				
LOCATION-SPECIFIC GROUND PROFILE				
STRATA	DEPTH OF BASE (mbgl)	TYPICAL DESCRIPTION		
Weathered Mudstone	3	Grey sandy **gravel** of mudstone and firm sandy gravely **clay**.		Dip angles indicate a 25° dip of the Slade and Redhill formation to the south. Conglomerate of Portfield and Haverford Mudstone formation encountered in BH101 and therefore boundary of Portfield and

Mudstone	>3	Moderately strong grey **mudstone** with very closely spaced planar smooth bedding discontinuities. Conglomerate and sandstone of the Portfield and Haverford Mudstone formation may also be encountered in the south face of the cutting, as per BH101	Haverford Mudstone formation may be further to the northwest than shown on geological plans. In the absence of any further GI in this area, the ground profile presented is based on a typical profile for the Slade & Redhill formation which is anticipated to be more commonly present in the earthworks zone. Published geology indicates an inferred fault line immediately to the west of the earthworks zone, displacement 40m.
PREVIOUS GROUND HISTORY	Proposed highway alignment through existing farmland.		
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.		
GROUNDWATER	Groundwater seepage recorded at 3.2m bgl at BH101. Spring located approximately 50m to the north of the alignment. Monitoring undertaken in BH11 approximately 250m to the east where the existing ground is at a similar elevation. Monitoring results indicated groundwater level at circa 4mbgl. Monitoring undertaken in BH102 located approximately 80m to the west of the cutting further down slope was dry.		
PRELIMINARY EARTHWORKS DESIGN			
SLOPE ANGLE	1V:2H		
MAX. EARTHWORKS HEIGHT	6m		
DESIGN GROUNDWATER	TBC		

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2	
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2	
Sandstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2	
Conglomerate	24 kN/m^3	60°	120 kPa	50 MPa	N/A	

Notes

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2. The parameters derived for the Conglomerate have been derived on a location specific basis as detailed in Appendix C1 of the GIR.

SETTLEMENT

TOTAL (mm)	N/A	
DIFFERENTIAL (mm)	N/A	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

NOTES

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2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Cutting 2 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Cutting 2</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>2+720m to 2+950m</td><td>TYPE:</td><td>Cutting</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">BH09, BH10, BH11</td><td></td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">The ground level at Ch 2+720m is 97mOD which rises to approximately 105mOD by Ch 2+860m. The ground level then falls back to approximately 95mOD at Ch 2+950m. The proposed road alignment will cut through a ridge feature which generally slopes to the north.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>18</td><td colspan="2">Dark grey, occasional red brown, sandy clays and sub-angular to angular mudstone gravels with occasional mudstone cobbles.</td><td rowspan="4">Cutting likely to be generally within the Slade and Redhill formation with the Portfield and Haverford Mudstone formation in part of the southern face of the cutting to the south. Dip angles indicate axis of anticline lies within earthworks zone with a 15° northernly dip to the north and a southernly dip to the south with no angle provided.
Weathered conglomerate (Portfield and Haverford Mudstone formation) was encountered overlying weathered mudstone (Slade and Redhill formation) in BH09</td></tr>
<tr><td>Mudstone</td><td>>20</td><td colspan="2">Drillers description indicates mudstone between 17.6 – 20.0 mbgl at BH10.</td></tr>
<tr><td>Weathered Conglomerate
(BH09 only)</td><td>3.5</td><td colspan="2">Brown occasionally grey slightly clayey sand with occasional rounded to sub-angular gravel of mixed lithologies and rare sandstone cobbles.</td></tr>
<tr><td>Conglomerate (BH09 only)</td><td>9.5</td><td colspan="2">Very weak brown fine grained conglomerate with red brown staining and very closely spaced 45° bedding with rough planar discontinuities of variable angle.
Underlain by Weathered Mudstone as described above</td></tr>
</table>

PREVIOUS GROUND HISTORY	Proposed alignment through existing farmland. The Llanfallteg road crosses the alignment at Ch 2+840m. Historic gravel pit has been identified ~10m to the south of the proposed cutting at Ch 2+860m.	
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.	
GROUNDWATER	The base of the cutting varies from approximately 95mOD to 90mOD from west to east. Groundwater seepage at 4.5m bgl (100mOD), 6.0m bgl (94mOD) and 3.0m bgl (94mOD) were recorded in BH09, BH10 and BH11 respectively. Groundwater monitoring in BH11 recorded a ground water level between 3.6-4.2m bgl (93.4-92.8mAOD) which is equivalent to approximately the base of the cutting at this location. Groundwater monitoring in BH10 was dry, with a response zone from 3.0 to 12mbgl (96.4 to 87.4mOD). It is unclear why the results of monitoring from BH10 does not correspond with the monitoring from BH11 and the groundwater strikes.	

PRELIMINARY EARTHWORKS DESIGN	
SLOPE ANGLE	1V:2H
MAX. EARTHWORKS HEIGHT	14m (Ch 2+830m)
DESIGN GROUNDWATER	TBC

MATERIAL	**DENSITY** γ’	**ANGLE OF FRICTION** φ’	**COHESION** c’	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E’
Weathered Conglomerate	18 kN/m^3	41°	0	-	N/A
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2
Conglomerate	24 kN/m^3	40°	30 kPa	1 MPa	N/A
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2

Notes

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2. The parameters derived for the Conglomerate have been derived on a location specific basis as detailed in Appendix C1 of the GIR.

<table>
<tr><td colspan="3">SETTLEMENT</td></tr>
<tr><td>**TOTAL (mm)**</td><td>N/A</td><td rowspan="2"></td></tr>
<tr><td>**DIFFERENTIAL (mm)**</td><td>N/A</td></tr>
<tr><td colspan="3">OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*</td></tr>
<tr><td colspan="2">Earthworks design may be locally impacted by the following:
▪ Proposed bridge over the proposed route at Ch 2+840m to preserve the existing Llanfallteg road that runs perpendicular to the proposed highway alignment.</td><td></td></tr>
<tr><td colspan="3">NOTES</td></tr>
<tr><td colspan="3">1. This summary sheet has been prepared as part of the Key Stage 3 GIR. Any subsequent changes will be presented in an update of the summary sheet in the Key Stage 3 preliminary GDR or Key Stage 6 GDR.
2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.</td></tr>
</table>

Cutting 3 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Cutting 3</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>3+480m to 3+850m</td><td>TYPE:</td><td>Cutting</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">TP04, TP05, BH04, BH05, BH06</td><td></td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">Existing ground level increases from 107mOD at western end of cutting (Ch 3+480m) to 131mOD at Ch 3+680m. Road alignment is approximately perpendicular to slope of existing ground and therefore southern side of cutting is greater in height.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>1.4 to 2.4</td><td colspan="2">Typically brown and/or grey sandy **gravel** of mudstone. Also described locally as **sand** and **clay**.</td><td rowspan="2">Dip angles indicate cutting may be located near a anticline in the Slade and Redhill bedding, with the bedrock dipping towards the north to the north of the cutting and to the south to the south of the cutting.</td></tr>
<tr><td>Mudstone</td><td>>18</td><td colspan="2">Moderately weak becoming moderately strong with depth dark grey **mudstone** with very closely spaced smooth planar discontinuities at variable angle.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="3">Proposed highway alignment through existing farmland.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="3">To be completed as part of GDR.</td><td></td></tr>
<tr><td>GROUNDWATER</td><td colspan="3">Base of cutting varies from 108mOD to 112mOD from west to east. Groundwater strike at 1.8mbgl (125.8mAOD) recorded in BH04 within Mudstone of the Slade and Redhill formation. No groundwater was detected during the subsequent ground water monitoring at BH04 with a response zone 3 to 18mbgl (124.6 to 109.6mOD)</td><td></td></tr>
<tr><td colspan="4">PRELIMINARY EARTHWORKS DESIGN</td><td rowspan="4"></td></tr>
<tr><td>**SLOPE ANGLE**</td><td colspan="3">1V:2H</td></tr>
<tr><td>**MAX. EARTHWORKS HEIGHT**</td><td colspan="3">21m (Ch 3+670m)</td></tr>
<tr><td>**DESIGN GROUNDWATER**</td><td colspan="3">TBC</td></tr>
</table>

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2	
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2	

Notes

1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.

SETTLEMENT

TOTAL (mm)	N/A	
DIFFERENTIAL (mm)	N/A	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be locally impacted by the following:

- 1 No. Proposed footbridge at Ch 3+550m

NOTES

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Embankment 1 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Embankment 1</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>0+040m to 0+37m0</td><td>TYPE:</td><td>Embankment</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">TP27, TP28, BH16, BH17</td><td>CBR01</td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">Ground level at 88mOD at Ch 0+040m falls to a minimum level of 77mOD at Ch 0+300m before rising back to 80mOD at Ch 0+370m. Topography generally slopes gently down to the south approximately perpendicular to the highway alignment.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>>7.8</td><td colspan="2">Orange brown to dark grey sands, silts and clays with frequent sub-angular to sub-rounded mudstone and sandstone gravels and occasional cobbles .</td><td rowspan="2">The boundary between the Slade and Redhill formation and Portfield and Haverford Mudstone formation lies directly to the north of the proposed highway alignment. Dip angles indicate a variable 15° to 77° northerly bedrock dip angle.
Conglomerate of Portfield and Haverford Mudstone formation encountered in BH16 and therefore boundary may be further to the south than shown on geological plans in this location.</td></tr>
<tr><td>Weathered Conglomerate
(encountered from ground level in BH16 only)</td><td>GL to >8.0</td><td colspan="2">Firm orange brown to dark grey brown sandy silt and clay with numerous fine to coarse sub-angular gravels of mudstone and sandstone.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="3">Proposed highway alignment travels existing farmland and runs parallel to existing A40 alignment.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="3">To be completed as part of GDR.</td><td></td></tr>
</table>

GROUNDWATER	Groundwater strikes of 1.2m bgl (Conglomerate) and 5.2m bgl (Weathered Mudstone) were recorded at BH16 and BH17 respectively. Subsequent groundwater monitoring at BH17 recorded groundwater levels between 4.1 and 4.4m bgl. Groundwater strike and monitoring indicate a ground water level of approximately 75mAOD.	

PRELIMINARY EARTHWORKS DESIGN

SLOPE ANGLE	1V:2H
MAX. EARTHWORKS HEIGHT	2.5m (Ch 0+260m) (Note: incomplete topographical data between Ch 0+000m and Ch 0+180m)
DESIGN GROUNDWATER	TBC

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** **c'**	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** **E'**
Weathered Mudstone - Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2
Weathered Conglomerate	18 kN/m3	28°	0	40 kPa	10,000 kN/m^2

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2. The parameters derived for the Weathered Conglomerate have been derived on a location specific basis as detailed in Appendix C1 of the GIR.

SETTLEMENT

TOTAL (mm)	TBC
DIFFERENTIAL (mm)	TBC

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be impacted by the following:

- Existing culvert at Ch 0+290m to be retained and extended
- 1no. proposed 1.8m diameter bat crossing at Ch 0+300m

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Embankment 2 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Embankment 2</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>0+370m to 1+610m</td><td>TYPE:</td><td>Embankment (localised cutting in western end)</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, BH14, BH15</td><td>CBR01, CBR02, CBR03, CBR04, CBR05, CBR06, CBR07, CBR08</td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">The ground level at Ch 0+370m is at 80mOD which then rises up to maximum level of 96mOD at Ch 1+280m. The ground level then drops down to approximately 85mOD at Ch 1+610m. Between Ch 0+420m to Ch 1+000m the slope perpendicular to the alignment falls to the south. However, after Ch 1+000m the ground level rises to both the north and south of the proposed highway alignment.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Made Ground (BH14 only)</td><td>0.85</td><td colspan="2">Dark grey to brown sandy silty **clays** and **gravels**. Inclusions of metal nails and clay pipe observed.</td><td rowspan="2">Published geology indicates the location of a Glaciofluvial superficial deposit at the western most extent of the earthworks zone which was not identified in any of the exploratory holes.
The boundary between Haverford formation and underlying Portfield and Haverford Mudstone formation lies immediately to the</td></tr>
<tr><td>Weathered bands of mudstone and sandstone</td><td>>14.5</td><td colspan="2">Predominantly orange brown to occasionally grey gravelly **sands**, **silts** and **clays**. Gravel is rounded to angular mudstone and sandstone with occasional inclusions of quartz and igneous rock. Occasional to frequent mudstone and sandstone cobbles and boulders also present.</td></tr>
</table>

Weathered siltstone overlying siltstone bedrock (BH15 only)	GL to >14.5	Brown sandy **clays** and **silts** with frequent fine to coarse sub-angular grey siltstone gravel and cobbles to 6.2m depth. Grey with red brown black staining moderately strong **siltstone** with very closely spaced sub horizontal planar smooth bedding discontinuities. Occasionally undulating bedding.	north of the proposed highway alignment. Geological maps indicate an anticline to the north of the alignment and a syncline to the south. From review of the available logs it is anticipated that BH15 encountered the directly underlying Portfield and Haverford Mudstone formation rather than the Haverford formation which was encountered at all other ground investigation locations.
PREVIOUS GROUND HISTORY	Proposed highway alignment through existing farmland parallel to current A40 alignment between Ch 0+420m and Ch 1+200m. Beyond Ch 1+200m proposed alignment involves widening of existing A40 alignment. Existing Trefangor Cottage is to be demolished. Historic gravel pit identified to the south of the proposed alignment at Ch 0+450m. An unnamed road crosses the alignment at Ch 1+250m. A spring is located near the eastern end of the earthworks zone.		
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.		
GROUNDWATER	Groundwater strike of 4.5m bgl recorded at BH14. The strike at BH14 was within Weathered Mudstone. No groundwater monitoring installation within earthworks zone.		

PRELIMINARY EARTHWORKS DESIGN		
SLOPE ANGLE	1V:2H	
MAX. EARTHWORKS HEIGHT	4m (Ch 0+880m) Localised shallow cutting <2m in height in western end of zone	
DESIGN GROUNDWATER	TBC	

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone - Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2	
Weathered Sandstone	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Weathered Siltstone	20 kN/m^3	34°	0	-	NA	
Siltstone	22 kN/m^3	55°	400 kPa	75 MPa	NA	

Notes

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SETTLEMENT

TOTAL (mm)	TBC
DIFFERENTIAL (mm)	TBC

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be locally impacted by the following:

- 1 No. Proposed bridleway underpass and associated access tracks at Ch 1+260m with localised cuttings.

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Embankment 3 – Geotechnical Summary Form

EARTHWORKS ZONE	Embankment 3			REFERENCES / COMMENTS
CHAINAGE:	1+610m to 2+030m	TYPE:	Embankment	

RELEVANT EXPLORATORY HOLES

TP17, BH102, BH12	CBR11

EXISTING TOPOGRAPHY

The existing ground level at Ch 1+610m is approximately at 85mOD which initially falls and then rises up, with minor undulations, to approximately 90mOD at C h2+030m. The topography of the earthworks zone generally slopes down into a stream fed valley formation to the north and rises up to the south perpendicular to the highway alignment.

LOCATION-SPECIFIC GROUND PROFILE

STRATA	DEPTH OF BASE (mbgl)	TYPICAL DESCRIPTION	
Made Ground	0.8 to 4.1	Dark grey to brown gravelly **clay** and sandy **gravel**. The gravel is coarse angular to sub-angular mudstone and sandstone. (BH12 log description states 'Probable Made Ground').	Published geology indicates the axis of an anticline passing through the earthworks zone with dip angles indicating a 40° to 75° dip either side of the axis. The earth works zone lies above the Portfield and Haverford Mudstone formation and Haverford Mudstone formation. Inferred fault line located at the easternmost extent of the earthworks zone, displacement 40m. Weathered Mudstone underlain by Sandstone bedrock encountered in BH12 only is interpreted to be of the Portfield and Haverford Mudstone formation which underlies the Haverford Mudstone formation.
Weathered Mudstone	3.2 to 6.9	Orange brown to grey slightly sandy **clays** and **gravels**. Gravels are fine to coarse angular to sub-rounded flat and friable mudstone.	
Mudstone	>8.5	Grey **mudstone** with red brown staining. Very closely spaced 45° planar smooth bedding discontinuities. Indication of increasing strength with depth.	
Weathered Mudstone underlain by Sandstone (BH12 only)	>8.0	Weathered mudstone underlain by strong dark grey medium grained **sandstone**.	

PREVIOUS GROUND HISTORY	Proposed highway alignment involves widening of existing A40 alignment between Ch 1+610m and Ch 1+700m before deviating away to travel through existing farmland. Historical quarry located directly to the north of proposed highway alignment at Ch 1+800m.	
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.	
GROUNDWATER	No groundwater strikes recorded. Monitoring of installation in BH102 with response zone 2.5 to 8mbgl (82.9 to 77.4mOD) was dry. Monitoring of installation in BH102 with response zone 2 to 8mbgl (73.7 to 67.7mbgL) was dry. A small watercourse passes through the earthworks zone at the low point in the topography. Springs are located 100m to the north and 40m to the south of the alignment. T	

<table>
<tr><td colspan="6">PRELIMINARY EARTHWORKS DESIGN</td><td rowspan="9">From Ch 1+610m to Ch 1+800m, earthwork comprise widening and raising alongside existing embankment</td></tr>
<tr><td colspan="2">SLOPE ANGLE</td><td colspan="4">1V:2H</td></tr>
<tr><td colspan="2">MAX. EARTHWORKS HEIGHT</td><td colspan="4">8.7m (Ch 1+700m)</td></tr>
<tr><td colspan="2">DESIGN GROUNDWATER</td><td colspan="4">TBC</td></tr>
<tr><th>MATERIAL</th><th>DENSITY
γ’</th><th>ANGLE OF FRICTION
φ’</th><th>COHESION
c’</th><th>UNDRAINED SHEAR STRENGTH / UCS
c_u / σ_c</th><th>YOUNGS MODULUS
E’</th></tr>
<tr><td>Weathered Mudstone – Granular</td><td>20 kN/m^3</td><td>34°</td><td>0</td><td>-</td><td>30,000 kN/m^2</td></tr>
<tr><td>Weathered Mudstone - Cohesive</td><td>20 kN/m^3</td><td>29°</td><td>0</td><td>75 kPa</td><td>19,000 kN/m^2</td></tr>
<tr><td>Mudstone</td><td>22 kN/m^3</td><td>28°</td><td>60 kPa</td><td>10 MPa</td><td>150,000 kN/m^2</td></tr>
<tr><td>Sandstone</td><td>22 kN/m^3</td><td>28°</td><td>60 kPa</td><td>10 MPa</td><td>150,000 kN/m^2</td></tr>
<tr><td colspan="6">Notes
1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.</td><td></td></tr>
</table>

<table>
<tr><td colspan="3">SETTLEMENT</td></tr>
<tr><td>TOTAL (mm)</td><td>TBC</td><td rowspan="2"></td></tr>
<tr><td>DIFFERENTIAL (mm)</td><td>TBC</td></tr>
</table>

<table>
<tr><th colspan="2">OTHER DESIGN FEATURES <i>(e.g. foundation treatment/hazards)</i></th></tr>
<tr><td>Earthworks design may be impacted locally by the following:
▪ Existing culvert at Ch 1+780m to remain. No extension required.</td><td></td></tr>
<tr><th colspan="2">NOTES</th></tr>
<tr><td colspan="2">1. This summary sheet has been prepared as part of the Key Stage 3 GIR. Any subsequent changes will be presented in an update of the summary sheet in the Key Stage 3 preliminary GDR or Key Stage 6 GDR.
2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.</td></tr>
</table>

Embankment 4 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Embankment 4</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>2+460m to 2+720m</td><td>TYPE:</td><td>Embankment (Fill)</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">BH11</td><td></td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">The existing ground level is approximately 100mOD at Ch 2+460m. The ground level then falls to approximately 90mOD at Ch 2+650m before rising back to 97mOD at Ch 2+720m. The topography of the land slopes gently down to the north and rises up to the existing route of the A40 in the south.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>>11.0</td><td colspan="2">Brown mottled grey to dark grey very clayey sandy sub-angular to angular mudstone gravel and lithorelicts. Occasional mudstone cobbles.</td><td>Dip angles indicate a 25° southerly dip to the south and a 15° northerly dip to the north, possibly indicating the location of an anticline in the Slade and Redhill formation.
Limited GI available in Embankment 4 earthworks zone.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="3">Proposed highway alignment through existing farmland.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="3">To be completed as part of GDR.</td><td></td></tr>
<tr><td>GROUNDWATER</td><td colspan="3">Groundwater strike of 3.0m bgl (94mOD) was recorded at BH11 and subsequent groundwater monitoring recorded a ground water level between 4.2-3.6m bgl (92.8-93.4mOD).</td><td></td></tr>
<tr><td colspan="4">PRELIMINARY EARTHWORKS DESIGN</td><td rowspan="4"></td></tr>
<tr><td>SLOPE ANGLE</td><td colspan="3">1V:2H</td></tr>
<tr><td>MAX. EARTHWORKS HEIGHT</td><td colspan="3">11m (Ch 2+640m)</td></tr>
<tr><td>DESIGN GROUNDWATER</td><td colspan="3">TBC</td></tr>
</table>

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone - Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Notes 1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.						

SETTLEMENT

TOTAL (mm)	TBC	
DIFFERENTIAL (mm)	TBC	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be locally impacted by the following:

- 1 No. Proposed underpass at Ch 2+570m
- 1 No. Proposed 1.8m diameter culvert at Ch 2+640m

NOTES

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2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Embankment 5 – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="3">Embankment 5</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td>2+950m to 3+480m</td><td>TYPE:</td><td>Embankment (Fill)</td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="4">BH07</td><td></td></tr>
<tr><td colspan="5">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="4">The existing ground surface undulates considerably between Ch 2+950m and Ch 3+480m. The ground level at Ch 2+950m is approximately 100mOD before then falling sharply to 80mOD within a wooded stream fed valley between Ch 3+000m to Ch 3+100m. The ground level then rises back up to 110mOD by Ch 3+480m.</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="2">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>4.4</td><td colspan="2">Dark brown to grey clayey sandy fine to coarse sub-angular to angular gravels and cobbles of mudstone. Red brown staining observed.</td><td rowspan="2">Dip angles indicate a 30° northerly dip in the Slade and Redhill formation to the northwest. Published geology indicates an area of natural superficial Till deposits between Ch 3+020m and Ch 3+090m however no ground investigation has been undertaken in this area.</td></tr>
<tr><td>Mudstone</td><td>>10.5</td><td colspan="2">Grey moderately strong mudstone with very closely spaced planar smooth sub horizontal to 45° bedding discontinuities and sub vertical discontinuities. Occasional bands of soft grey sandy clay.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="3">Proposed highway alignment through existing farmland.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="3">To be completed as part of GDR.</td><td></td></tr>
<tr><td>GROUNDWATER</td><td colspan="3">No groundwater strikes recorded or groundwater monitoring undertaken in BH7.
A small watercourse passes through the earthworks zone.</td><td></td></tr>
<tr><td colspan="4">PRELIMINARY EARTHWORKS DESIGN</td><td rowspan="4"></td></tr>
<tr><td>SLOPE ANGLE</td><td colspan="3">1V:2H</td></tr>
<tr><td>MAX. EARTHWORKS HEIGHT</td><td colspan="3">24m (Ch 3+130m)</td></tr>
<tr><td>DESIGN GROUNDWATER</td><td colspan="3">TBC</td></tr>
</table>

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2	

Notes

1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.

SETTLEMENT

TOTAL (mm)	TBC	
DIFFERENTIAL (mm)	TBC	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be locally impacted by the following:

- 1No. Proposed 1.8m diameter mammal crossing tunnel at Ch 2+990m
- 2No. Proposed 1.8m diameter culverts at Ch 3+150m and Ch 3+270m
- 1No. Proposed underpass for existing pathway at Ch 3+200m

NOTES

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2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as 'TBC' will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Llanddewi Velfrey Roundabout – Geotechnical Summary Form

EARTHWORKS ZONE	Llanddewi Velfrey Roundabout (see Earthworks Zones figure)			REFERENCES / COMMENTS
CHAINAGE:	Beyond 3+950m	TYPE:	Majority cut with some fill	

RELEVANT EXPLORATORY HOLES

TP01, TP02, TP03, BH01, BH02, BH03	

EXISTING TOPOGRAPHY

The ground level in the location of the proposed Llanddewi Velfrey Roundabout is at approximately 125mOD with the ground level rising to the west and falling steeply in a north-easterly direction. The ground level beyond the Bethel Chapel, at the schemes most easterly extent, is at approximately 98mOD.	

LOCATION-SPECIFIC GROUND PROFILE

STRATA	DEPTH OF BASE (mbgl)	TYPICAL DESCRIPTION	
Made Ground	0.5 to 3.1	Dark grey to brown sandy **clay** and fine to coarse mudstone **gravel** with mudstone cobble and boulder inclusions and pieces of metal, plastic, tile and concrete.	The majority of the earthworks zone is underlain by Slade and Redhill formation with the south-western spur of the proposed roundabout shown as the overlying Portfield and Haverford Mudstone formation and Haverford formations. Dip angles are typically towards the south, varying from 60° to 30°. A band of Conglomerate bedrock was identified in BH03 only. The conglomerate is interpreted to be from the Portfield and Haverford Mudstone formation that is overlying the mudstones within the Slade and Redhil formation.
Weathered Mudstone	2.5 to 4.4	Orange brown to light grey soft silty sandy clayey fine to coarse sub-angular predominantly mudstone **gravel**. Occasional sub-angular to sub-rounded sandstone and mudstone cobbles	
Mudstone	>15.0	Moderately weak to strong grey, red brown stained, **mudstone** with closely spaced planar smooth bedding discontinuities of variable angle with an indication of close random fractures. Some indication that strength increase with depth.	
Conglomerate (BH03 only)	4.5 (1.0m in thickness)	Moderately strong fine grained **conglomerate** of Portfield Formation and Haverford Mudstone Formation.	

PREVIOUS GROUND HISTORY	Majority of proposed alignment involves adaptation of existing A40 alignment. Localised areas where proposed highway alignment is through existing farmland. Historical quarry identified to the south of current A40 alignment within close proximity to the proposed Llanddewi Velfrey exit of proposed roundabout.	
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.	
GROUNDWATER	Two strikes were recorded in BH03, at 1.0m bgl and 3.5m bgl within Weathered Mudstone. Groundwater monitoring undertaken in BH01 recorded levels from 2.7 to 2.6mbgl (95.8 to 95.9mOD)	

PRELIMINARY EARTHWORKS DESIGN

SLOPE ANGLE	1V:2H
MAX. EARTHWORKS HEIGHT	15m cutting (Llanddewi Velfrey exit of proposed roundabout) 12m embankment (Bethel Chapel exit of proposed roundabout)
DESIGN GROUNDWATER	TBC

MATERIAL	**DENSITY** γ’	**ANGLE OF FRICTION** φ’	**COHESION** c’	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E’
Weathered Mudstone - Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Conglomerate	24 kN/m^3	45°	120 kPa	25 MPa	N/A
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2

Notes

1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.
2. The parameters derived for the Conglomerate have been derived on a location specific basis as detailed in Appendix C1 of the GIR.

SETTLEMENT

TOTAL (mm)	TBC
DIFFERENTIAL (mm)	TBC

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Earthworks design may be locally impacted by the following:

- Cutting predominantly required however, localised areas of considerable fill required at the Bethel Chapel exit of the Llanddewi Velfrey roundabout and the easternmost extent of the scheme.

NOTES

1. This summary sheet has been prepared as part of the Key Stage 3 GIR. Any subsequent changes will be presented in an update of the summary sheet in the Key Stage 3 preliminary GDR or Key Stage 6 GDR.
2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Penblewin Roundabout – Geotechnical Summary Form

<table>
<tr><td>EARTHWORKS ZONE</td><td colspan="4">Penblewin Roundabout</td><td rowspan="2">REFERENCES / COMMENTS</td></tr>
<tr><td>CHAINAGE:</td><td colspan="2">Includes 0+000m to 0+040m</td><td>TYPE:</td><td>Cut with localised shallow fill</td></tr>
<tr><td colspan="6">RELEVANT EXPLORATORY HOLES</td></tr>
<tr><td colspan="5">TP28, TP29, TP30</td><td></td></tr>
<tr><td colspan="6">EXISTING TOPOGRAPHY</td></tr>
<tr><td colspan="5">The ground level around the existing roundabout near Penblewin is at 93mOD which then drops down to 88mOD at Ch 0+040m. The ground in the Penblewin Roundabout zone generally slopes in an easterly to south-easterly direction.</td><td></td></tr>
<tr><td colspan="6">LOCATION-SPECIFIC GROUND PROFILE</td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (mbgl)</td><td colspan="3">TYPICAL DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>>3.2</td><td colspan="3">Orange brown to grey slightly clayey gravelly **sand** or sandy **gravel**. Gravel is sub-rounded to sub-angular sandstone and mudstone with mudstone cobbles present. Gravel described as flat and friable. Locally described as brown clay.</td><td>Dip angles indicate a general 15° dip of the Slade and Redhill formation to the north. Fault line located to the southwest of the roundabout, displacement unknown. Northern exit of proposed roundabout anticipated to lie within the Portfield and Haverford Mudstone (no existing GI in this location).</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="4">Majority of proposed highway alignment involves adaptation of existing A40 alignment. Some localised areas where the proposed alignment is through existing farmland.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="4">To be completed as part of GDR.</td><td></td></tr>
<tr><td>GROUNDWATER</td><td colspan="4">No groundwater strikes were recorded in the trial pits and no groundwater monitoring is available in the area.
Groundwater monitoring in BH17 located 200m to the east recorded groundwater levels between 4.1 and 4.4mbgl (76.0 to 75.7mOD).</td><td></td></tr>
</table>

PRELIMINARY EARTHWORKS DESIGN

SLOPE ANGLE	1V:2H
MAX. EARTHWORKS HEIGHT	5m
DESIGN GROUNDWATER	TBC

MATERIAL	**DENSITY** **γ'**	**ANGLE OF FRICTION** **φ'**	**COHESION** **c'**	**UNDRAINED SHEAR STRENGTH / UCS** **c_u / σ_c**	**YOUNGS MODULUS** **E'**
Weathered Mudstone - Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2

Notes

1. Unless stated below, the parameters presented in this table are site wide parameters as described in Section 6 of the GIR.

SETTLEMENT

TOTAL (mm)	TBC
DIFFERENTIAL (mm)	TBC

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

NOTES

1. This summary sheet has been prepared as part of the Key Stage 3 GIR. Any subsequent changes will be presented in an update of the summary sheet in the Key Stage 3 preliminary GDR or Key Stage 6 GDR.
2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the earthworks design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Appendix D – Geotechnical structures summary forms

Underpass 1 (SBR-0130) – Ch 1+300m

Underpass 2 (SBR-0257) – Ch 2+570m

Overbridge 1 (SBR-0285) – Ch 2+850m

Underpass 3 (SBR-0320) – Ch 3+200m

Footbridge 1 (SBR-0355) – Ch 3+550m

Underpass 1 – Geotechnical Summary Form

<table>
<tr><td>CHAINAGE INTERVAL:</td><td>Ch 1+300m</td><td>TYPE:</td><td colspan="2">Underpass 1 (SBR-0130)</td><td>REFERENCE / COMMENTS</td></tr>
<tr><td>AIP REF No:</td><td>A40LVP-ARP-SBR-0130-RP-C-0001</td><td>DESIGN LIFE:</td><td colspan="2">120 years</td><td></td></tr>
<tr><td colspan="5">RELEVANT EXPLORATORY HOLES</td><td></td></tr>
<tr><td colspan="5">TP20, TP21, BH14, BH15</td><td></td></tr>
<tr><td colspan="5">LOCATION-SPECIFIC GROUND PROFILE</td><td></td></tr>
<tr><td>STRATA</td><td colspan="2">DEPTH OF BASE (m bgl)</td><td colspan="2">STRATA DESCRIPTION</td><td></td></tr>
<tr><td>Made Ground (BH14 only)</td><td colspan="2">0.85</td><td colspan="2">Dark grey to brown sandy silty **clays** and **gravels**. Inclusions of metal nails and clay pipe observed.</td><td rowspan="3">The boundary between Haverford formation and underlying Portfield and Haverford Mudstone formation is indicated to the north of the proposed structure. Geological maps indicate an anticline to the north of the structure and a syncline to the south.
Weathered bands and mudstone and sandstone (Haverford formation) underlying minimal made ground deposits anticipated in the southern section of the underpass.
Weathered siltstone overlying siltstone bedrock (Portfield and Haverford Mudstone formation) anticipated in the northern section of the underpass.</td></tr>
<tr><td>Weathered bands of mudstone and sandstone</td><td colspan="2">>14.5</td><td colspan="2">Predominantly orange brown to occasionally grey gravelly **sands**, **silts** and **clays**. Gravel is rounded to angular mudstone and sandstone with occasional inclusions of quartz and igneous rock (log description). Occasional to frequent mudstone and sandstone cobbles and boulders also present.</td></tr>
<tr><td>Weathered Siltstone overlying Siltstone (BH15 only)</td><td colspan="2">GL to >14.5</td><td colspan="2">Brown sandy **clays** and **silts** with frequent fine to coarse sub-angular grey siltstone gravel and cobbles to 6.2m depth.
Grey with red brown black staining moderately strong **siltstone** with very closely spaced sub horizontal planar smooth bedding discontinuities. Occasionally undulating bedding.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="4">Proposed underpass will pass beneath the existing alignment of the A40. Historic quarry located to the north of proposed underpass, see features and constraints plan.</td><td></td></tr>
</table>

CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.	
GROUNDWATER	Groundwater strike of 4.5m bgl recorded at BH14. The strike at BH14 was within Weathered Mudstone. No groundwater monitoring installation at BH14.	

RECOMMENDED PARAMETERS

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH** c_u	**YOUNGS MODULUS** E'
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2
Weathered Sandstone	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Siltstone	20 kN/m^3	34°	0	-	NA
Siltstone	22 kN/m^3	55°	400 kPa	75 MPa	NA

SPREAD FOUNDATION DESIGN

STRUCTURE ELEMENT	**BASE (mOD)**	**FOUNDING STRATUM**	**FOOTING SIZE (m)**	**‘ALLOWABLE’ BEARING PRESSURE (kN/m^2)**
Underpass	TBC	TBC	TBC	TBC
Wing walls	TBC	TBC	TBC	TBC

PRELIMINARY PILE DESIGN

PILE TYPE:	NA
CRITERIA FOR TOE:	NA
NEG. SKIN FRICTION:	NA

STRUCTURE ELEMENT	**TOE LEVEL (mOD)**	**FOUNDING STRATUM**	**LENGTH (m)**	**DIAMETER (m)**	**ULS DESIGN LOAD (kN)**
NA	NA	NA	NA	NA	NA

<table>
<tr><td colspan="6">SETTLEMENT</td><td></td></tr>
<tr><td>STRUCTURE ELEMENT</td><td>BASE (mOD)</td><td>IMMEDIATE (mm)</td><td>TOTAL (mm)</td><td>90% (Months)</td><td>REMAINING (mm)</td><td rowspan="4"></td></tr>
<tr><td>Underpass</td><td>TBC</td><td>TBC</td><td>TBC</td><td>TBC</td><td>TBC</td></tr>
<tr><td>Wingwalls</td><td>TBC</td><td>TBC</td><td>TBC</td><td>TBC</td><td>TBC</td></tr>
<tr><td colspan="4">DIFFERENTIAL (mm):</td><td colspan="2">TBC</td></tr>
<tr><td colspan="6">CHEMICAL ANALYSIS</td><td></td></tr>
<tr><td>Material</td><td colspan="2">ACEC Class</td><td colspan="3">DS Class</td><td rowspan="2">Further details in Section 6 of the GIR</td></tr>
<tr><td>All</td><td colspan="2">AC-1</td><td colspan="3">DS-1</td></tr>
<tr><td colspan="6">OTHER DESIGN FEATURES <i>(e.g. foundation treatment/hazards)</i></td><td></td></tr>
<tr><td colspan="6">Associated earthworks:
Cuttings are proposed at either side of the underpass for access. The proposed maximum height of the cutting is 6m at an angle of 1V:2H.</td><td></td></tr>
<tr><td colspan="6">NOTES</td><td></td></tr>
<tr><td colspan="7">1. This summary sheet has been prepared as part of the Key Stage 3 GIR. Any subsequent changes will be presented in an update of the summary sheet in the Key Stage 3 preliminary GDR or Key Stage 6 GDR.
2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the geotechnical design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.</td></tr>
</table>

Underpass 2 – Geotechnical Summary Form

CHAINAGE INTERVAL:	Ch 2+570m	TYPE:	Underpass 2 (SBR-0257)	REFERENCES / COMMENTS
AIP REF No:	A40LVP-ARP-SBR-0257-RP-C-0001	DESIGN LIFE:	120 years	
RELEVANT EXPLORATORY HOLES				
BH11 (located approximately 150m to the east)				
LOCATION-SPECIFIC GROUND PROFILE				
STRATA	DEPTH OF BASE (m bgl)	STRATA DESCRIPTION		
Weathered Mudstone	>11.0	Brown mottled grey to dark grey very clayey sandy sub-angular to angular mudstone **gravel** and lithorelicts. Occasional mudstone cobbles.		*No GI within 150m of proposed underpass.* Geology indicates slade and Redhill Formation with dip of 25° southerly to the south and a 15° northerly dip to the north, possibly indicating the location of an anticline in this area
PREVIOUS GROUND HISTORY	Proposed underpass in area of existing farmland.			
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.			
GROUNDWATER	Groundwater data from BH11 (Ch 2+720m) identified a groundwater seepage at 3.0m bgl and subsequent groundwater monitoring recorded groundwater levels between 3.6-4.2m bgl (93.4 to 92.8mOD).			

RECOMMENDED PARAMETERS

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	

SPREAD FOUNDATION DESIGN

STRUCTURE ELEMENT	BASE (mOD)	FOUNDING STRATUM	FOOTING SIZE (m)	'ALLOWABLE' BEARING PRESSURE (kN/m^2)
Underpass	TBC	TBC	TBC	TBC
Wing walls	TBC	TBC	TBC	TBC

PRELIMINARY PILE DESIGN

PILE TYPE:	NA
CRITERIA FOR TOE:	NA
NEG. SKIN FRICTION:	NA

STRUCTURE ELEMENT	TOE LEVEL (mOD)	FOUNDING STRATUM	LENGTH (m)	DIAMETER (m)	ULS DESIGN LOAD (kN)
NA	NA	NA	NA	NA	NA

SETTLEMENT

STRUCTURE ELEMENT	BASE (mOD)	IMMEDIATE (mm)	TOTAL (mm)	90% (Months)	REMAINING (mm)
Underpass	TBC	TBC	TBC	TBC	TBC
Wing walls	TBC	TBC	TBC	TBC	TBC
DIFFERENTIAL (mm):				See AIP Section 6.3	

CHEMICAL ANALYSIS

Material	ACEC Class	DS Class	
All	AC-1	DS-1	Further details in Section 6 of the GIR

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Associated earthworks:

TBC

NOTES

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3. Fields marked as ‘TBC’ will be confirmed following completion of the geotechnical design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Overbridge 1 – Geotechnical Summary Form

<table>
<tr><td>CHAINAGE INTERVAL:</td><td colspan="2">Ch 2+850m</td><td colspan="2">TYPE:</td><td>Overbridge 1 (SBR-0285)</td><td>REFERENCES / COMMENTS</td></tr>
<tr><td>AIP REF No:</td><td colspan="2">A40LVP-ARP-SBR-0285-RP-C-0001</td><td colspan="2">DESIGN LIFE:</td><td>120 years</td><td></td></tr>
<tr><td colspan="6">RELEVANT EXPLORATORY HOLES</td><td></td></tr>
<tr><td colspan="6">BH09, BH10</td><td></td></tr>
<tr><td colspan="6">LOCATION-SPECIFIC GROUND PROFILE</td><td></td></tr>
<tr><td colspan="2">STRATA</td><td colspan="2">DEPTH OF BASE (m bgl)</td><td colspan="2">STRATA DESCRIPTION</td><td></td></tr>
<tr><td colspan="6">Northern Abutment (BH10)</td><td rowspan="7">Northern abutment anticipated to be within the Slade and Redhill formation. Southern abutment interpreted to be within Portfield and Haverford Mudstone formation.
Dip angles suggest axis of anticline lies within earthworks zone with a 15° northernly dip to the north and a southernly dip to the south with no angle provided.</td></tr>
<tr><td colspan="2">Weathered Mudstone</td><td colspan="2">17.6</td><td colspan="2">Dark grey, occasional red brown, sandy **clays** and sub-angular to angular mudstone **gravels**. Occasional mudstone cobbles.</td></tr>
<tr><td colspan="2">Mudstone</td><td colspan="2">>20.0</td><td colspan="2">Drillers based description indicates **mudstone** between 17.6 – 20.0 mbgl at BH10.</td></tr>
<tr><td colspan="6">Southern abutment (BH09)</td></tr>
<tr><td colspan="2">Weathered Conglomerate</td><td colspan="2">3.5</td><td colspan="2">Brown occasionally grey slightly clayey **sand** with occasional rounded to sub-angular gravel of mixed lithologies and rare sandstone cobbles.</td></tr>
<tr><td colspan="2">Conglomerate</td><td colspan="2">9.5</td><td colspan="2">Very weak brown fine grained **conglomerate** with red brown staining and very closely spaced 45° bedding with rough planar discontinuities of variable angle.</td></tr>
<tr><td colspan="2">Weathered mudstone</td><td colspan="2">>13</td><td colspan="2">Dark grey very sandy **clay**</td></tr>
<tr><td colspan="2">PREVIOUS GROUND HISTORY</td><td colspan="4">Proposed overbridge in area of existing farmland. Historic gravel pit has been identified ~10m to the south of the proposed cutting at Ch 2+860m.</td><td></td></tr>
<tr><td colspan="2">CONTAMINATION RISK ASSESSMENT</td><td colspan="4">To be completed as part of GDR.</td><td></td></tr>
</table>

GROUNDWATER	Groundwater strikes of 4.5m bgl (100mOD) and 6.0m bgl (94mOD) were recorded in BH09 and BH10 and BH11 respectively. Groundwater monitoring in BH10 was dry, with a response zone from 3.0 to 12mbgl (96.4 to 87.4mOD). Groundwater monitoring in BH11 approximately 100m to the west recorded a ground water level between 3.6-4.2m bgl (93.4-92.8mAOD). It is unclear why the results of monitoring from BH10 does not correspond with the monitoring from BH11 and the groundwater strikes.	

RECOMMENDED PARAMETERS

MATERIAL	**DENSITY** γ’	**ANGLE OF FRICTION** φ’	**COHESION** c’	**UNDRAINED SHEAR STRENGTH** c_u	**YOUNGS MODULUS** E’
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2
Weathered Conglomerate	18 kN/m3	41°	0	-	NA
Conglomerate	24 kN/m3	50°	34 kPa	1 MPa	NA

SPREAD FOUNDATION DESIGN

STRUCTURE ELEMENT	**BASE (mOD)**	**FOUNDING STRATUM**	**FOOTING SIZE (m)**	**‘ALLOWABLE’ BEARING PRESSURE (kN/m^2)**
Northern abutment	TBC	TBC	TBC	TBC
Southern abutment	TBC	TBC	TBC	TBC

PRELIMINARY PILE DESIGN

PILE TYPE:	NA
CRITERIA FOR TOE:	NA
NEG. SKIN FRICTION:	NA

STRUCTURE ELEMENT	**TOE LEVEL (mOD)**	**FOUNDING STRATUM**	**LENGTH (m)**	**DIAMETER (m)**	**ULS DESIGN LOAD (kN)**
NA	NA	NA	NA	NA	NA

SETTLEMENT

STRUCTURE ELEMENT	**BASE (mOD)**	**IMMEDIATE (mm)**	**TOTAL (mm)**	**90% (Months)**	**REMAINING (mm)**
Northern abutment	TBC	TBC	TBC	TBC	TBC
Southern abutment	TBC	TBC	TBC	TBC	TBC
DIFFERENTIAL (mm):				TBC	

CHEMICAL ANALYSIS

Material	**ACEC Class**	**DS Class**	
All	AC-1	DS-1	Further details in Section 6 of the GIR

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

NOTES

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Underpass 3 – Geotechnical Summary Form

CHAINAGE INTERVAL:	Ch 3+200m	TYPE:	Underpass 3 (SBR-0320)	REFERENCES / COMMENTS
AIP REF No:	A40LVP-ARP-SBR-0320-RP-C-0001	DESIGN LIFE:	120 years	
RELEVANT EXPLORATORY HOLES				
BH07				
LOCATION-SPECIFIC GROUND PROFILE				

STRATA	DEPTH OF BASE (m bgl)	STRATA DESCRIPTION	
Weathered Mudstone	4.4	Dark brown to grey clayey sandy fine to coarse sub-angular to angular **gravels** and **cobbles** of mudstone. Red brown staining observed.	Dip angles indicate a 30^{o} northerly dip in the Slade and Redhill formation to the northwest.
Mudstone	>10.5	Grey moderately strong **mudstone** with very closely spaced planar smooth sub horizontal to 45^{o} bedding discontinuities and sub vertical discontinuities. Occasional bands of soft grey sandy clay.	

PREVIOUS GROUND HISTORY	Proposed underpass in area of existing farmland.	
CONTAMINATION RISK ASSESSMENT	To be completed as part of GDR.	
GROUNDWATER	No groundwater strikes or monitoring recorded for BH07. Proposed location of the underpass is approximately 50m to the east of the watercourse.	
RECOMMENDED PARAMETERS		

MATERIAL	**DENSITY** γ'	**ANGLE OF FRICTION** φ'	**COHESION** c'	**UNDRAINED SHEAR STRENGTH / UCS** c_u / σ_c	**YOUNGS MODULUS** E'	
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2	
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2	

SPREAD FOUNDATION DESIGN

STRUCTURE ELEMENT	BASE (mOD)	FOUNDING STRATUM	FOOTING SIZE (m)	'ALLOWABLE' BEARING PRESSURE (kN/m^2)
Underpass	TBC	TBC	TBC	TBC
Wing walls	TBC	TBC	TBC	TBC

PRELIMINARY PILE DESIGN

PILE TYPE:	NA
CRITERIA FOR TOE:	NA
NEG. SKIN FRICTION:	NA

STRUCTURE ELEMENT	TOE LEVEL (mOD)	FOUNDING STRATUM	LENGTH (m)	DIAMETER (m)	ULS DESIGN LOAD (kN)
NA	NA	NA	NA	NA	NA

SETTLEMENT

STRUCTURE ELEMENT	BASE (mOD)	IMMEDIATE (mm)	TOTAL (mm)	90% (Months)	REMAINING (mm)
Underpass	TBC	TBC	TBC	TBC	TBC
Wing walls	TBC	TBC	TBC	TBC	TBC

DIFFERENTIAL (mm):	TBC

CHEMICAL ANALYSIS

Material	ACEC Class	DS Class	Further details in Section 6 of the GIR
All	AC-1	DS-1	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Associated earthworks:

TBC

NOTES	

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2. The information presented within this summary sheet is on the basis of the available ground investigation information. Should further ground investigation be undertaken as part of Key Stage 6, the summary sheet will be updated accordingly.
3. Fields marked as ‘TBC’ will be confirmed following completion of the geotechnical design and will be presented in an updated version of the summary sheet in the Key Stage 3 preliminary GDR.

Footbridge 1 – Geotechnical Summary Form

<table>
<tr><td>CHAINAGE INTERVAL:</td><td>Ch 3+550</td><td>TYPE:</td><td>Footbridge 1 (SBR-0355)</td><td>REFERENCES /COMMENTS</td></tr>
<tr><td>AIP REF No:</td><td>A40LVP-ARP-SBR-0355-RP-C-0001</td><td>DESIGN LIFE:</td><td>120 years</td><td></td></tr>
<tr><td colspan="4">RELEVANT EXPLORATORY HOLES</td><td></td></tr>
<tr><td colspan="4">TP04, TP05, BH04, BH05, BH06</td><td></td></tr>
<tr><td colspan="4">LOCATION-SPECIFIC GROUND PROFILE</td><td></td></tr>
<tr><td>STRATA</td><td>DEPTH OF BASE (m bgl)</td><td colspan="2">STRATA DESCRIPTION</td><td></td></tr>
<tr><td>Weathered Mudstone</td><td>1.4 to 2.4</td><td colspan="2">Typically brown and/or grey sandy gravel of mudstone. Also described locally as sand and clay.</td><td rowspan="2">Dip angles indicate cutting may be located near a anticline in the Slade and Redhill formation bedding, with the bedrock dipping towards the north to the north of the cutting and to the south to the south of the cutting.</td></tr>
<tr><td>Mudstone</td><td>>18</td><td colspan="2">Moderately weak becoming moderately strong with depth dark grey mudstone with very closely spaced smooth planar discontinuities at variable angle.</td></tr>
<tr><td>PREVIOUS GROUND HISTORY</td><td colspan="3">Proposed footbridge in area of existing farmland.</td><td></td></tr>
<tr><td>CONTAMINATION RISK ASSESSMENT</td><td colspan="3">To be completed as part of GDR.</td><td></td></tr>
<tr><td>GROUNDWATER</td><td colspan="3">Groundwater seepage at 1.8mbgl (125.8mAOD) recorded at BH04 within mudstone of the Slade and Redhill formation. No groundwater was detected during the subsequent ground water monitoring at BH04 with a response zone 3 to 18mngl (124.6 to 109.6mOD)</td><td></td></tr>
</table>

RECOMMENDED PARAMETERS

MATERIAL	DENSITY γ’	ANGLE OF FRICTION φ’	COHESION c’	UNDRAINED SHEAR STRENGTH / UCS c_u / σ_c	YOUNGS MODULUS E’
Weathered Mudstone – Granular	20 kN/m^3	34°	0	-	30,000 kN/m^2
Weathered Mudstone - Cohesive	20 kN/m^3	29°	0	75 kPa	19,000 kN/m^2
Mudstone	22 kN/m^3	28°	60 kPa	10 MPa	150,000 kN/m^2

SPREAD FOUNDATION DESIGN

STRUCTURE ELEMENT	BASE (mOD)	FOUNDING STRATUM	FOOTING SIZE (m)	‘ALLOWABLE’ BEARING PRESSURE (kN/m^2)
Northern abutment	TBC	TBC	TBC	TBC
Southern abutment	TBC	TBC	TBC	TBC

PRELIMINARY PILE DESIGN

PILE TYPE:	NA
CRITERIA FOR TOE:	NA
NEG. SKIN FRICTION:	NA

STRUCTURE ELEMENT	TOE LEVEL (mOD)	FOUNDING STRATUM	LENGTH (m)	DIAMETER (m)	ULS DESIGN LOAD (kN)
NA	NA	NA	NA	NA	NA

SETTLEMENT

STRUCTURE ELEMENT	BASE (mOD)	IMMED’TE (mm)	TOTAL (mm)	90% (Months)	REMAINING (mm)
Northern abutment	TBC	TBC	TBC	TBC	TBC
Southern abutment	TBC	TBC	TBC	TBC	TBC
DIFFERENTIAL (mm):				TBC	

CHEMICAL ANALYSIS

Material	**ACEC Class**	**DS Class**	Further details in Section 6 of the GIR
All	AC-1	DS-1	

OTHER DESIGN FEATURES *(e.g. foundation treatment/hazards)*

Details of any associated earthworks or retaining walls are yet to be determined.

NOTES

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Appendix E – RocLab assessment

Mudstone

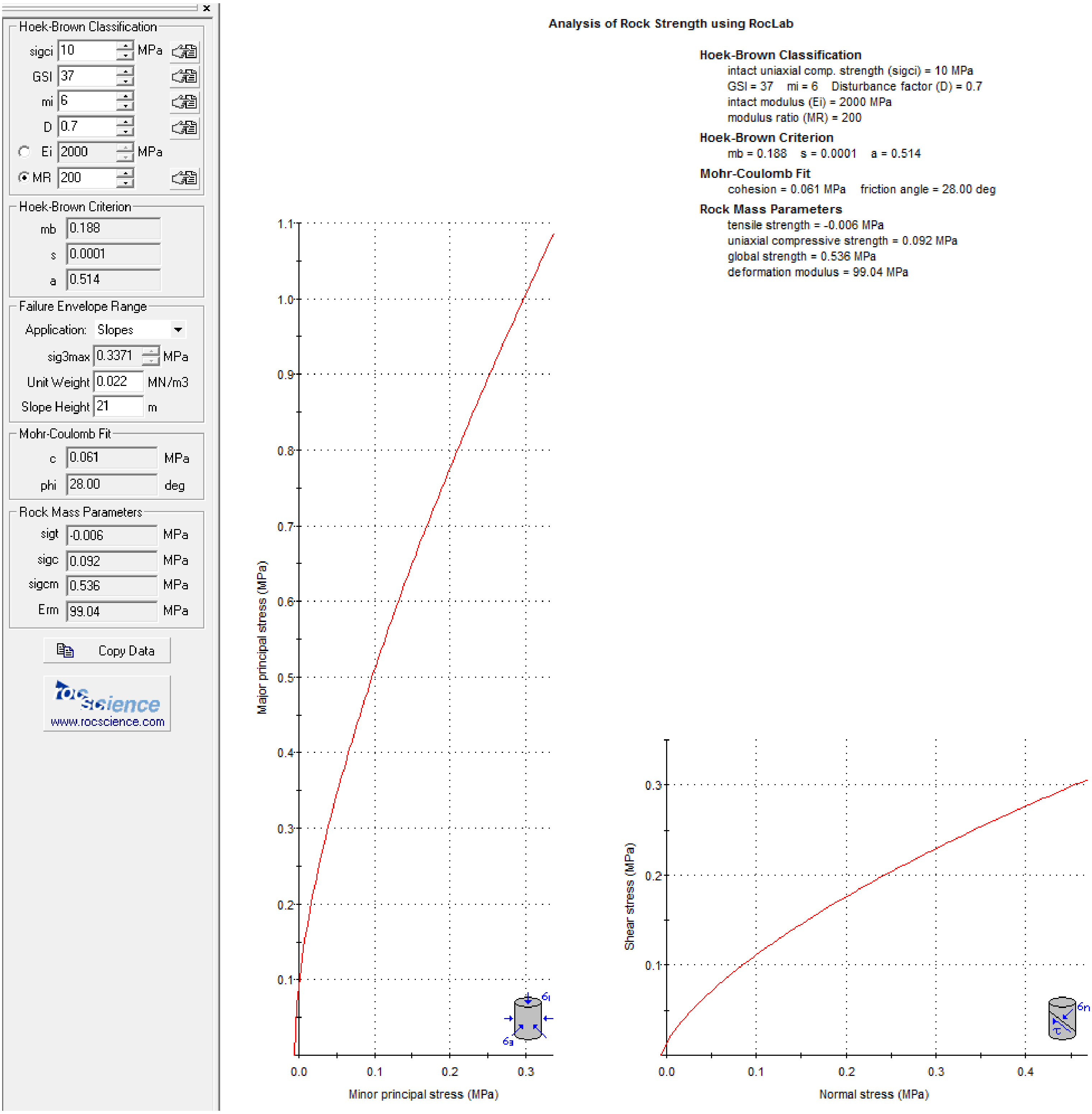
Siltstone

Conglomerate – BH03

Conglomerate – BH09

Conglomerate – BH101

Mudstone



Hoek-Brown Classification
sigci 10 MPa
GSI 37
mi 6
D 0.7
○ Ei 2000 MPa
● MR 200

Hoek-Brown Criterion
mb 0.188
s 0.0001
a 0.514

Failure Envelope Range
Application: Slopes
sig3max 0.3371 MPa
Unit Weight 0.022 MN/m3
Slope Height 21 m

Mohr-Coulomb Fit
c 0.061 MPa
phi 28.00 deg

Rock Mass Parameters
sigt -0.006 MPa
sigc 0.092 MPa
sigcm 0.536 MPa
Erm 99.04 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 10 MPa
GSI = 37 mi = 6 Disturbance factor (D) = 0.7
intact modulus (Ei) = 2000 MPa
modulus ratio (MR) = 200

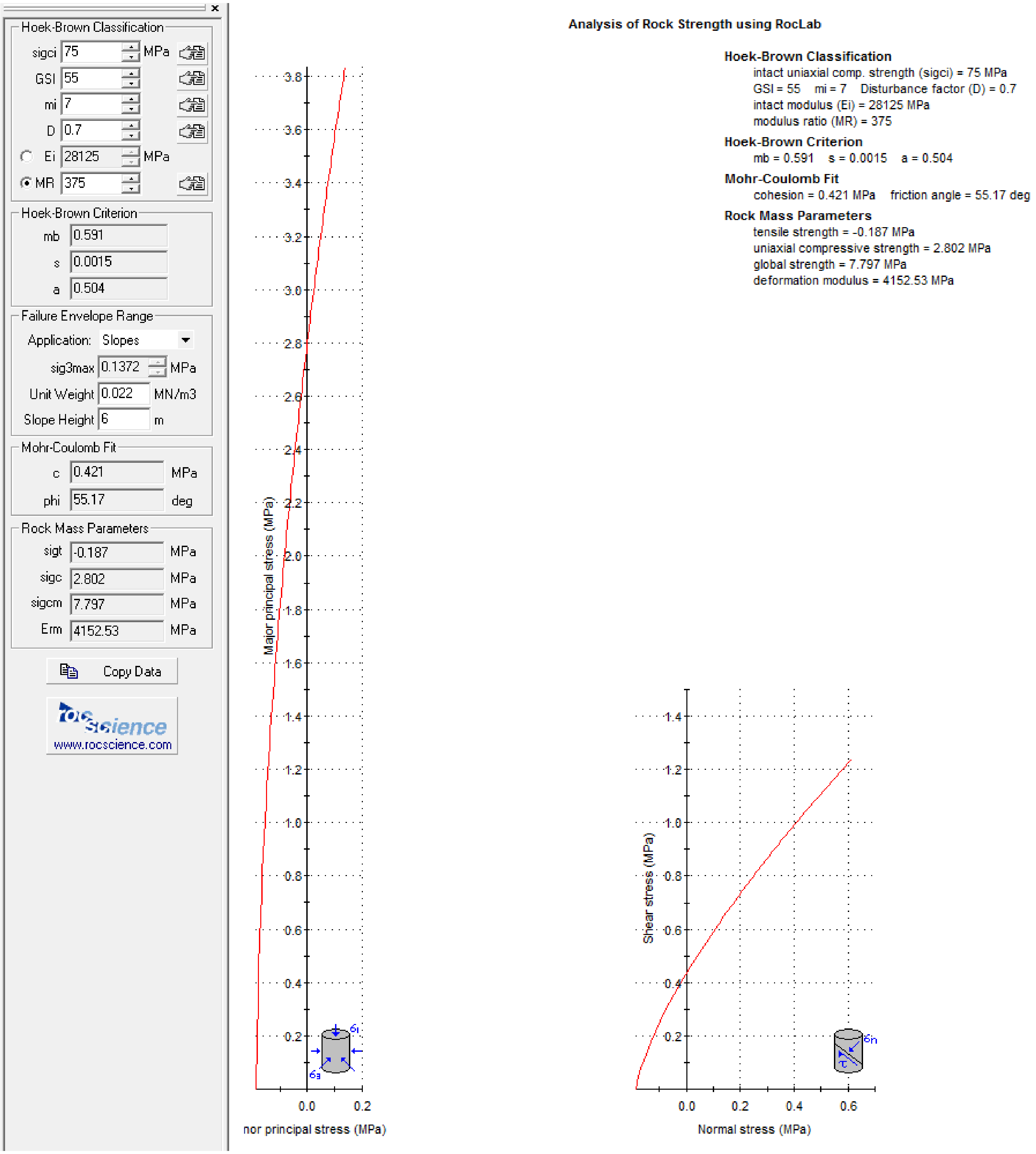
Hoek-Brown Criterion
mb = 0.188 s = 0.0001 a = 0.514

Mohr-Coulomb Fit
cohesion = 0.061 MPa friction angle = 28.00 deg

Rock Mass Parameters
tensile strength = -0.006 MPa
uniaxial compressive strength = 0.092 MPa
global strength = 0.536 MPa
deformation modulus = 99.04 MPa

Parameter	Value	Basis
UCS (sigci)	10	Characteristic value based on PLI and strength descriptions of typically moderately week to moderately strong
GSI	37	Fair to poor surface condition. Very blocky to disturbed/seamy structure
Mi	6	Typical value for shales
D	0.7	Mechanical excavation of slopes
MR	200	Typical value for shales
Failure envlope	Slopes	
Unit weight	22	Density as derived in GIR
Slope height	21	Maximum slope height in mudstone

Siltstone



Hoek-Brown Classification
sigci 75 MPa
GSI 55
mi 7
D 0.7
○ Ei 28125 MPa
● MR 375

Hoek-Brown Criterion
mb 0.591
s 0.0015
a 0.504

Failure Envelope Range
Application: Slopes
sig3max 0.1372 MPa
Unit Weight 0.022 MN/m3
Slope Height 6 m

Mohr-Coulomb Fit
c 0.421 MPa
phi 55.17 deg

Rock Mass Parameters
sigt -0.187 MPa
sigc 2.802 MPa
sigcm 7.797 MPa
Erm 4152.53 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 75 MPa
GSI = 55 mi = 7 Disturbance factor (D) = 0.7
intact modulus (Ei) = 28125 MPa
modulus ratio (MR) = 375

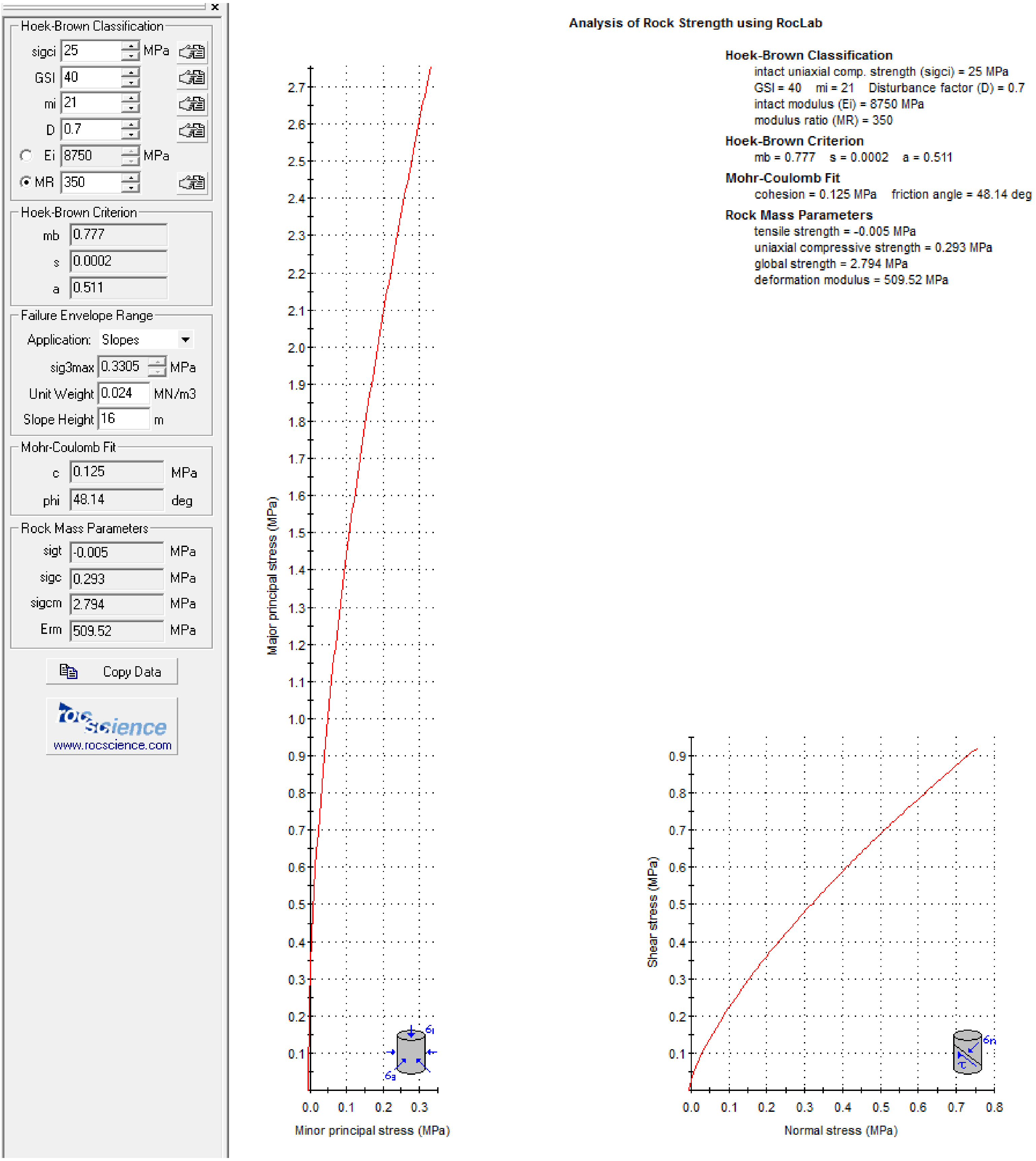
Hoek-Brown Criterion
mb = 0.591 s = 0.0015 a = 0.504

Mohr-Coulomb Fit
cohesion = 0.421 MPa friction angle = 55.17 deg

Rock Mass Parameters
tensile strength = -0.187 MPa
uniaxial compressive strength = 2.802 MPa
global strength = 7.797 MPa
deformation modulus = 4152.53 MPa

Parameter	Value	Basis
UCS (sigci)	75	Characteristic value based on PLI, UCS and strength descriptions of strong
GSI	55	Good to fair surface condition. Blocky structure
Mi	7	Typical value for silstone
D	0.7	Mechanical excavation of slopes
MR	375	Typical value for silstone
Failure envlope	Slopes	
Unit weight	22	Density as derived in GIR
Slope height	6	Maxium slope height in area of siltstones

BH03 - Conglomerate



Hoek-Brown Classification

sigci 25 MPa

GSI 40

mi 21

D 0.7

○ Ei 8750 MPa

● MR 350

Hoek-Brown Criterion

mb 0.777

s 0.0002

a 0.511

Failure Envelope Range

Application: Slopes

sig3max 0.3305 MPa

Unit Weight 0.024 MN/m3

Slope Height 16 m

Mohr-Coulomb Fit

c 0.125 MPa

phi 48.14 deg

Rock Mass Parameters

sigt -0.005 MPa

sigc 0.293 MPa

sigcm 2.794 MPa

Erm 509.52 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification

intact uniaxial comp. strength (sigci) = 25 MPa

GSI = 40 mi = 21 Disturbance factor (D) = 0.7

intact modulus (Ei) = 8750 MPa

modulus ratio (MR) = 350

Hoek-Brown Criterion

mb = 0.777 s = 0.0002 a = 0.511

Mohr-Coulomb Fit

cohesion = 0.125 MPa friction angle = 48.14 deg

Rock Mass Parameters

tensile strength = -0.005 MPa

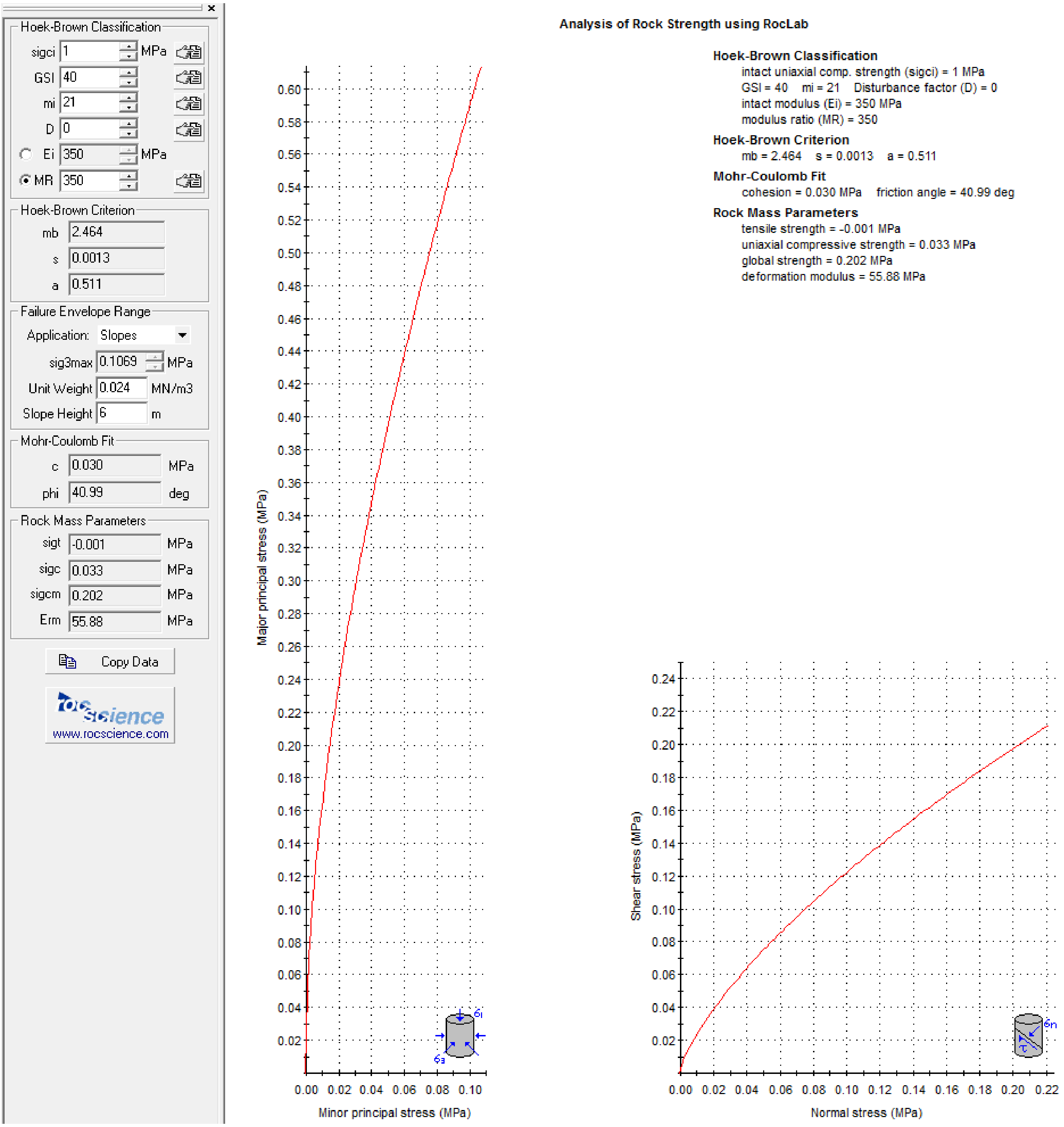
uniaxial compressive strength = 0.293 MPa

global strength = 2.794 MPa

deformation modulus = 509.52 MPa

Parameter	Value	Basis
UCS (sigci)	25	Lower bound for moderately strong
GSI	40	Fair surface condition. Very blocky to blocky/disturbed/seamy structure.
Mi	21	Typical value for conglomerates
D	0.7	Mechanical excavation of slopes
MR	350	Typical value for conglomerates
Failure envlope	Slopes	
Unit weight	24	Density as derived in GIR
Slope height	16	Maximum cutting height in cutting

BH09 - Conglomerate



Hoek-Brown Classification
- sigci: 1 MPa
- GSI: 40
- mi: 21
- D: 0
- ○ Ei: 350 MPa
- ● MR: 350

Hoek-Brown Criterion
- mb: 2.464
- s: 0.0013
- a: 0.511

Failure Envelope Range
- Application: Slopes
- sig3max: 0.1069 MPa
- Unit Weight: 0.024 MN/m3
- Slope Height: 6 m

Mohr-Coulomb Fit
- c: 0.030 MPa
- phi: 40.99 deg

Rock Mass Parameters
- sigt: -0.001 MPa
- sigc: 0.033 MPa
- sigcm: 0.202 MPa
- Erm: 55.88 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 1 MPa
GSI = 40 mi = 21 Disturbance factor (D) = 0
intact modulus (Ei) = 350 MPa
modulus ratio (MR) = 350

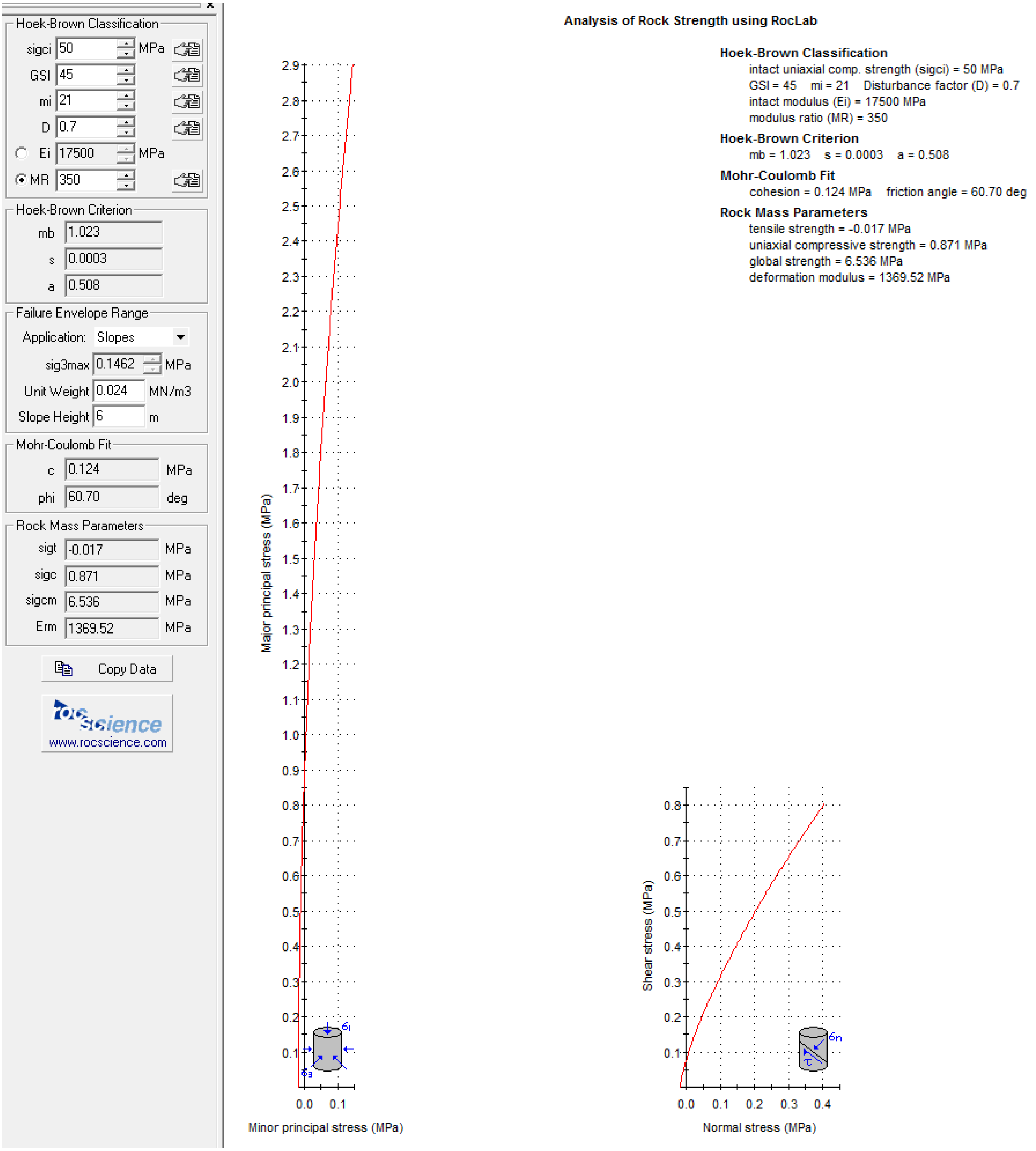
Hoek-Brown Criterion
mb = 2.464 s = 0.0013 a = 0.511

Mohr-Coulomb Fit
cohesion = 0.030 MPa friction angle = 40.99 deg

Rock Mass Parameters
tensile strength = -0.001 MPa
uniaxial compressive strength = 0.033 MPa
global strength = 0.202 MPa
deformation modulus = 55.88 MPa

Parameter	Value	Basis
UCS (sigci)	1	Lower bound for very weak
GSI	40	Fair surface condition. Very blocky to blocky/disturbed/seamy structure.
Mi	21	Typical value for conglomerates
D	0.7	Mechanical excavation of slopes
MR	350	Typical value for conglomerates
Failure envlope	Slopes	
Unit weight	24	Density as derived in GIR
Slope height	6	Maximum cutting height in cutting

BH101 - Conglomerate



Hoek-Brown Classification

sigci 50 MPa

GSI 45

mi 21

D 0.7

○ Ei 17500 MPa

● MR 350

Hoek-Brown Criterion

mb 1.023

s 0.0003

a 0.508

Failure Envelope Range

Application: Slopes

sig3max 0.1462 MPa

Unit Weight 0.024 MN/m3

Slope Height 6 m

Mohr-Coulomb Fit

c 0.124 MPa

phi 60.70 deg

Rock Mass Parameters

sigt -0.017 MPa

sigc 0.871 MPa

sigcm 6.536 MPa

Erm 1369.52 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification

intact uniaxial comp. strength (sigci) = 50 MPa

GSI = 45 mi = 21 Disturbance factor (D) = 0.7

intact modulus (Ei) = 17500 MPa

modulus ratio (MR) = 350

Hoek-Brown Criterion

mb = 1.023 s = 0.0003 a = 0.508

Mohr-Coulomb Fit

cohesion = 0.124 MPa friction angle = 60.70 deg

Rock Mass Parameters

tensile strength = -0.017 MPa

uniaxial compressive strength = 0.871 MPa

global strength = 6.536 MPa

deformation modulus = 1369.52 MPa

Parameter	Value	Basis
UCS (sigci)	50	Lower bound for strong
GSI	45	Good surface conditions. Blocky/disturbed/seamy structure.
Mi	21	Typical value for conglomerates
D	0.7	Mechanical excavation of slopes
MR	350	Typical value for conglomerates
Failure envlope	Slopes	
Unit weight	24	Density as derived in GIR
Slope height	6	Maximum cutting height in cutting

Appendix F – Groundwater strikes and monitoring summary table

Groundwater strikes and monitoring summary table

					Groundwater monitoring								
								19/05/2016		01/06/2016		07/06/2016	
Exploratory Hole	Ground level (mAOD)	Depth of groundwater strike (mbgl)	Elevation (mAOD)	Stratum	Response zone (m)	Stratum	Installation Date	Depth (m)	Elevation (mAOD)	Depth (m)	Elevation (mAOD)	Depth (m)	Elevation (mAOD)
BH01	98.49	none	-	-	2.0-8.0	Weathered mudstone - Slade & Redhill Formation & Mudstone - Slade & Redhill Formation	15/04/2016	2.7	95.79	2.63	95.86	2.56	95.93
BH02	115.4	none	-	-	-	-	No installation						
BH03	127.47	1.0	126.5	Weathered mudstone - Portfield and Haverford Mudstone Formation	-	-	No installation						
	127.47	3.5	124.0	Conglomerate - Portfield and Haverford Mudstone Formation	-	-	No installation						
BH04	127.56	1.8	125.8	Mudstone - Slade & Redhill Formation	3.0-18.0	Mudstone - Slade & Redhill Formation	03/05/2016	dry	-	dry	-	dry	-
BH05	121.23	none	-	-	-	-	No installation						
BH06	123.19	none	-	-	-	-	No installation						
BH07	79.28	none	-	-	-	-	No installation						
BH08	66.35	none	-	-	1.5-10.5	Weathered mudstone - Slade & Redhill Formation & Mudstone - Slade & Redhill Formation	21/04/2016	0.18	66.17	0.35	66	0.48	65.87
BH09	105.17	4.5	100.67	Conglomerate - Portfield and Haverford Mudstone Formation	-	-	No installation						
BH10	99.44	6.0	93.4	Weathered mudstone - Slade & Redhill Formation	3.0-12.0	Weathered mudstone - Slade & Redhill Formation & Mudstone - Slade & Redhill Formation	15/04/2016	dry	-	dry	-	dry	-
BH11	97	3.0	94.0	Weathered mudstone - Slade & Redhill Formation	2.0-11.0	Weathered mudstone - Slade & Redhill Formation	19/04/2016	3.6	93.4	4	93	4.2	92.8
BH12	75.71	none	-	-	2.0-8.0	MG, Weathered mudstone - Portfield and Haverford Mudstone Formation & Sandstone - Portfield and Haverford Mudstone Formation	03/05/2016	dry	-	dry	-	dry	-
BH14	92.96	4.5	88.5	Weather mudstone - Haverford Mudstone Formation	-	-	No installation						
BH15	96.2	none	-	-	-	-	No installation						
BH16	77.44	1.2	76.2	Conglomerate - Portfield and Haverford Mudstone Formation	-	-	No installation						
BH17	80.08	5.2	74.9	Weathered mudstone - Slade & Redhill Formation	1.8-8.0	Mudstone - Slade & Redhill Formation	06/05/2016	4.09	75.99	4.31	75.77	4.43	75.65
BH101	103.44	3.2	100.2	Mudstone - Portfield and Haverford Mudstone Formation	-	-	No installation						
BH102	85.4	1.2	84.2	Weather mudstone - Haverford Mudstone Formation	2.5-8.0	Weather mudstone - Haverford Mudstone Formation & Mudstone - Portfield and Haverford Mudstone Formation	06/05/2016	dry	-	dry	-	dry	-

Notes:

1. All installation types are slotted pipe and gravel filter.
2. No groundwater strikes were recorded in the trial pits, however, water observed in base of TP19 and TP29 on the photographs included in the Ground Investigation Factual Report

Appendix G – Geotechnical risk register

Geotechnical extract of Combined Risk Register. Extracted on 8th July 2019.

Project Name	A40 Llanddewi Velfrey to Penblewin Improvements	Client	Welsh Government
Document Number		Current Project Stage:	KS3 Preliminary Design

Part A- Risk Identification	Risk Ref Number	Risk Location Chainage, Structure ID, Description	Description of risk or hazard	Date Risk Identified	Identified By (Initials)	Risk Status : (Resolved / Continued/ Active: Use Continued where more than one mitigation step is required to control risk adequately. Use resolved only where the risk has been controlled by design or is already communicated)	Discipline	Revision	Project Lifecycle Stage (During Which the Hazard Obtains)	H&S Risk (CDM Regs)	Commercial	Environmental Risk	Likelihood	Severity	Risk Product (Unmitigated)	Relevant Documentation	Owner of Risk (Who will Manage the Risk)	Part B- Risk Elimination/Reduction	Can the Risk be eliminated Yes/No	Mitigation or action	Likelihood	Severity	Risk Product (Mitigated)	Further Action Required	Part C - Residual RiskRisk	Continuation Risk Reference	Means of communicating the Risk SHE boxes, drawing hazard triangle, HSF etc	Coordinate (x,y) for inclusion on drawings & webviewer
INCOMPLETE	G01	Scheme wide	Unidentified areas of 'soft' ground along the alignment of the scheme. In particular, this is a risk at locations of infilled land, in the vicinity of the various minor watercourses and low spots along the scheme, and potential for localised high degrees of weathering of the bedrock. The potential impacts are: - potential for deep seated instability of embankment slopes - high magnitudes of total settlement of embankments, which may be unacceptable in terms of future performance of drainage etc. - high magnitudes of differential settlement, which may be unacceptable in terms of the finished road levels, interfaces with structures, performance of drainage, kerbs etc.	08/07/2019	AT	ACTIVE	GEO	1	O	H			3	5	H	GIR, GDR	Designer, Contractor		Yes	Site specific Preliminary Ground Investigation carried out to identify general ground and groundwater conditions. Note that limited ground investigation was undertaken between Ch. 1+950m and Ch. 3+550m and limited groundwater monitoring was carried out due to limited land access. - Additional ground investigation is to be undertaken at detailed design at Key Stage 6. - It is standard practice for all formations to be checked for 'soft spots' during construction, and for any soft spots to be excavated and replaced with suitable material, placed and compacted in layers to achieve an acceptable strength/stiffness. - Detailed design may take account of the potential variation in ground conditions which may include alternative designs where it is not practical not excavate areas of soft spots	2	5	H	Y		TBC	Construction specifications and drawings, GDR	
INCOMPLETE	G02	Scheme wide	Faulting and unfavourable geological conditions resulting in: - possible instability of cuttings and excavations. - possible requirement for slacker/engineered cutting slopes.	18/05/2017	IM	ACTIVE	GEO	1	C O	H	C		2	3	M	GIR, GDR	Designer		No	Site specific Preliminary Ground Investigation carried out to identify general ground and groundwater conditions. Note that limited ground investigation was undertaken between Ch. 1+950m and Ch. 3+550m. - Additional ground investigation is to be undertaken at detailed design at Key Stage 6. - Detailed design may take account of the potential variation in ground conditions. This may include the adoption of an observational approach during construction, with the designer carrying out visual inspections of cuttings to verify that the design assumptions are valid, and potentially to modify the design accordingly.	2	2	M	Y		TBC	Construction specifications and drawings, GDR	
INCOMPLETE	G03	Areas of cuttings, embankments and structures locations	Potential for the mudstones that are present across the scheme to contain high levels of sulfates and pyritic conditions, which have the potential to: - be aggressive to concrete in contact with the ground leading to deterioration of structures over time. - deterioration/damage to the highway, structures and earthworks due to potential for expansion of soils/rock should they contain pyrite.	18/05/2017	IM	ACTIVE	MULTI	1	O				3	4	H	GIR, GDR	Designer		Yes	Sulfate related testing has been undertaken as part of the preliminary ground investigation and sulfate assessments have been carried out in accordance with BRE Digest 1 and TRL 447. It is recommended that additional sulfate related testing is carried out to enable more detailed assessment to be completed during detailed design at Key Stage 6.	2	4	M	Y		TBC	Construction specifications and drawings, GIR, GDR	
INCOMPLETE	G04	Scheme wide	Presence of previously unidentified made ground and contamination, and risks posed by known areas of made ground and contamination. Possible sources include, the existing roads, tracks and hardstandings; areas of past fly tipping; infilled pits and quarries; and sewage discharge points. Amongst others, possible contaminants include coal tar, metals, hydrocarbons, asbestos, high bacterial levels etc. - potential risks to human health. For example, site operatives during construction, and future maintenance workers. - potential risks to the environment. In particular, water bodies as a consequence of potential exposure to surface water runoff and infiltration via areas of contaminated ground. - potential cost implications if materials are classified as 'unsuitable', and require disposal to an appropriately licenced facility. Possible high costs if materials are to be disposed of as non-hazardous or hazardous landfill classifications.	18/05/2017	ALP	ACTIVE	MULTI	1	C O	H	C	E	3	3	M	SHE, CEMP	Designer, Contractor		No	Preliminary desk study carried out by Mott MacDonald in 2016. Supplementary desk study and site walkover survey carried out by a geotechnical and geo-environmental engineer as part of the Ground Investigation Report - to provide supplementary information on the potential presence of contaminants. Geo-environmental testing undertaken as part of the Preliminary Ground Investigation. Note that limited ground investigation was undertaken between Ch. 1+950m and Ch. 3+550m, and limited groundwater sampling and testing was carried out. Carry out supplementary geo-environmental testing ahead of detailed design at Key Stage 6, should any additional areas of potential contamination be identified. An observational approach with a contamination watching brief shall be adopted during contruction, supplemented by the requirement to carry out geo-environmental testing at regular intervals to 'screen' the encountered ground conditions for possible contaminants of concern. Contractor to develop an action plan to manage unexpected contamination and limit impact on human health and environment. Engagment of a specialist contractor may be required. Appropriate health and safety risks assessments will be required.	2	3	M	Y		TBC	Construction drawings, CEMP, SHE	
INCOMPLETE	G05	Scheme wide	Site won fill material unsuitable for reuse resulting in: - possible need to dry out due to relatively high natural moisture contents, or improve (eg, lime) the material prior to or at the point of placement. - probable need to process the rock, eg through crushing and sorting, prior to placement - to achieve the required grading for use as fill. - alternative sources of fill material required. - additional disposal costs for unsuitable material. Delays during construction and cost implications for all of the above if the proportion of unsuitable material is greater than assessed.	18/05/2017	IM	ACTIVE	GEO	1	C		C	E	2	4	M	GDR, SHE	Designer, Contractor		No	Site specific Preliminary Ground Investigation including a suite of suitability/acceptability tests have been carried out. Note that limited ground investigation was undertaken between Ch. 1+950m and Ch. 3+550m. Detailed assessment of suitability will be carried out at design stage, and reported on in the GDR. It is anticipated that some of the weathered rock will be unsuitable for reuse in its as-dug condition on account of its high moisture content. The less weathered rock is likely to require crushing and sorting prior to placement and compactinon, in order to provide a suitable grading for reuse as fill. It is recommended that supplementary investigation is carried out at detailed design stage - during Key Stage 6. This may comprise regularly spaced trial pits and associated testing at the start of the construction phase, in order for the D&B team to better assess the extent of any unsuitable material. Site compaction trials may also form part of any early construction-phase investigation. In order to maximise the reuse of fill for the scheme, the earthworks specification will need to retain an element of flexibility, and allow the design and construction team to regularly update earthworks acceptability criteria on the basis of feedback on the materials (in particular, from earthworks test results) as they are excavated during the course of the works.	2	3	M	Y		TBC	GDR, SHE	
INCOMPLETE	G06	Scheme wide	Unidentified services resulting in potential damage to services presenting a H&S hazard, disruption to third parties, causing delays during construction, and possible cost implications.	18/05/2017	IM	ACTIVE	MULTI	1	C	H	C		3	4	H	Services plans	Designer, Contractor		No	Comprehensive searches through contacting all mainstream providers ahead of the main works Contact landowners for existing private drainage and services plans. Appropriate use of a safe system of work by the contractor, which may include cable avoidance equipment and inspection pits.	2	4	M	Y		TBC	SHE boxes on construction drawings	
INCOMPLETE	G07	Attenuation ponds locations	Possible instability of earthworks due to construction of attenuation ponds leading to saturation of the ground locally.	18/05/2017	IM	ACTIVE	MULTI	1	O	H			2	4	M	GDR	Designer		Yes	Safe distance between ponds and earthworks in relation to slope stability being considered as part of design development.	1	4	M	Y		TBC	GDR, construction specifications and drawings	
INCOMPLETE	G08	Areas of cuttings	Basal heave of formations following excavations for large cuttings due to removal of overburden leading to: - risk of damage to road formations, drainage etc. - impact on construction program and cost of the works, should mitigation measures be required [Identified by Mott MacDonald in PSSR]	18/05/2017	IM	ACTIVE	GEO	1	O	H	C		2	4	M	GDR	Designer		Yes	Site specific Preliminary Ground Investigation carried out for identification of ground and groundwater conditions. Note that limited ground investigation was undertaken between Ch. 1+950m and Ch. 3+550m due to land access constraints. Additional ground investigation to be undertaken at detailed design stage during Stage 6. Potential magnitude and duration of heave to be assessed at detailed design stage, with potential options to include displacement monitoring of formations	1	4	M	Y		TBC	GDR, construction specifications and drawings	
INCOMPLETE	G09	Areas of cuttings	Construction of embankments, dewatering in the permanent case due to the construction of cuttings, and dewatering for temporary works purposes. Risk that the proposed works: - lower the groundwater table and impact on nearby boreholes and wells operated by private landowners. - dry out existing springs that provide important flows for watercourses. - block the alignment of existing minor watercourses that provide important flows to receiving water bodies.	18/05/2017	IM	ACTIVE	MULTI	1	C O			E	3	4	H	Water Framework Directive	Designer		No	Desk study carried out to identify presence of wells and boreholes form existing published information. D&B team to investigate the possible presence of any additional wells or boreholes, through liaison wiht local landowners. Further desk study investigations to be carried out as part of the Environmental Impact Assessment for the scheme, which include identification of minor watercourses that may be impacted by the proposals, and consideration of appropriate response measures that may be adopted. Design to incorporate culverts for watercourses that are present to prevent loss of flows to recveiving water bodies.	2	4	M	Y		TBC	GDR, EIA, construction specification and drawings	
INCOMPLETE	G10	Scheme wide	Presence of pits, quarries and unidentified pit locations potentially backfilled with animal remains. The risk is biohazard (for example: anthrax, foot and mouth) to human health and environment. See also G04	18/05/2017	MC	ACTIVE	MULTI	1	O			E	2	3	M	PSSR, GIR	Designer, Contractor		No	Desk study carried out to identify locations of potential backfilled pits. Watching brief to be adopted during the course of the construction works.	2	3	M	Y		TBC	CEMP, SHE, GIR	
INCOMPLETE	G11	Scheme wide	Based on the PSSR, supplementary desk study and the Preminlinary Ground Investigation, an interpretation has been carried out with regards to rock excavability. It is expected that excavations through rock will not require hard ripping or blasting. Risk for impact on the programme and cost of the works if the rock is harder and/or less fractured than anticipated.	18/05/2017	MC	ACTIVE	GEO	1	C		C		2	5	H	PSSR, GIR, GDR	Designer, Contractor		No	Further ground investigation will be carried out on commencement of the site works, which will enable further confidence to be gained in the likely scope of excavation works across the extent of the proposed cuttings. This may be used to inform the programming of the works.	2	5	H	Y		TBC	Construction specification and drawings, GDR	

INCOMPLETE	G12	Scheme wide	Ground conditions unsuitable for shallow foundations. Impact on programme and costs.	18/05/2017	MC	ACTIVE	MULTI	1	C		C		2	4	M	GIR, GDR	Designer		Yes	Location specific ground investigation carried out for most structures, and preliminary design being developed on the basis of the current scheme alignment. Opportunities for further ground investigation to be carried out detailed design stage, if this has potential to be beneficial for foundation design.	1	4	M	Y		TBC	GDR, construction specification and drawings	
INCOMPLETE	G13	Cuttings	It is anticipated that the proposed cuttings will intercept minor groundwater flows associated with permeable bands within the bedrock but not necessarily the main waterbody. Risk to encounter greater than anticipated groundwater seepage into cutting slopes, leading to potential reduction in stability, and the need for additional slope drainage measures.	18/05/2017	MC	ACTIVE	GEO	1	C O	H	C		3	4	H	GIR, GDR	Designer		No	Ground investigation has been carried out, which includes groundwater monitoring installations at some locations in the proposed cuttings. Design to take account of most onerous groundwater conditions that are likely to be encountered in the lifetime of the scheme. Crest drains will be incorporated at the crest of cuttings, where the natural ground slopes towards the cuttings. Toe drains are likely to be incorporated at the toes of all cut slopes. Additional groundwater monitoring would be prudent ahead of detailed design. This could comprise monitoring of existing standpipes and piezometers, and potentially supplemented by additional installations if considered necessary. Should a high groundwater level and high piezometric pressures be anticipated following additional monitoring, design options could include the incorporation of slope drains to draw down the water table and accommodate flows.	2	4	M	Y		TBC	GDR, construction specification and drawings	
INCOMPLETE	G14	Scheme wide	Potential impacts on adjacent watercourses as a result of significant earthworks operations in the area. In particular, particulate pollution (silt) to the watercourses and risk of pollution as a result of accidental spillages, leakage from fuel supplies etc..	18/05/2017	ALP	ACTIVE	MULTI	1	C O			E	3	3	M	Water Framework Directive, CEMP	Designer, Contractor		Yes	Contractor to develop water management plan to ensure protection of surface water bodies during construction. This should be carried out in liaison with NRW. Contractor to adopt standard good practice for storage and management of fuel.	2	3	M	Y		TBC	CEMP	
	G15	Shallow embankments	Low strength/stiffness at shallow depths due to surface weathering identified in places. It is anticipated that the thickness of embankment fill will provide reasonable founding material for pavement construction over these areas. Risk that low CBR values are applicable where shallow embankments are proposed that are therefore to be founded close to existing ground surface leading to more onerous pavement foundation requirements.	18/05/2017	MC	ACTIVE	GEO	1	C		C		3	4	H	GIR, GDR	Designer		No	Regular trial pitting and CBR testing has been carried out as part of the Preliminary Ground Investigation. At detailed design stage, additional investigation may be carried out where there are 'gaps' in the ground investigation information, if it is considered that this may be beneficial to the scheme.	2	4	M	Y		TBC	Construction specification and drawings, GDR	
	G16	Cuttings	Dip angle of rock bedding is not suited to proposed slope angles for cuttings. There is a risk that low shear angle surfaces may exist within the rock formations, and if these are orientated so that they crop at an unfavourable angle into the cut faces, rock wedge failures are possible. Also see G02	18/05/2017	MC	ACTIVE	GEO	1	C O	H	C		2	5	H	GIR, GDR	Designer		No	Preliminary Sources Study Report and ground investigation completed. Supplementary desk study carried out at GIR stage, which has included obtaining and interpreting field slip and county geological plans, to better inform the local solid geology. Supplementary ground investigation may be carried out at detailed design stage, during Key Stage 6 - if considered necessary. However, it should be acknowledged that due to the high level of folding and faulting along the length of the scheme, an accurate interpretation of the dip of the rock along the cuttings is unlikely to be achievable. Preliminary desing allows for 1 in 2 cut slope angles in rock, which should be suitably robust to ensure stability for most circumstances. An observational approach to the potential for wedge failure could be adopted, based on designer observations during the excavation works, with a contingency for localised rock bolting if considered necessary.	2	5	H	Y		TBC	Construction specification and drawings, GDR	
	G17	Attenuation ponds	Infiltration from attenuation ponds impacts on the environmental quality of the groundwater and receiving surface water bodies.	18/05/2017	MC	ACTIVE	MULTI	1	O			E	2	4	M	ES	Designer		Yes	Detailed assessment to be carried out to assess the level of this risk, as part of the 'Drainage and Water Environment' chapter of the Environmental Statement. Lining of attenuation ponds is an option that remains open that would effectively eliminate this risk.	1	4	M	Y		TBC	ES	
	G18	Cuttings	Long term weathering/erosion of rock results in deterioration of slopes, and shallow instability/spalling	22/05/2017	MC	ACTIVE	GEO	1	O	H			3	3	M	GDR	Designer		No	Design to allow for consideration of long term performance of rock slopes. Relatively shallow angles of 1 in 2 are currently proposed, which provides some robustness against long term weathering/erosion. Consider allowing for clearance of weathering scree.	2	2	M	Y		TBC	GDR	
	G19	Site wide	It is anticipated that a proportion of the rock arisings from the cuttings will be suitable for reuse as capping/improvement layer. Risk that the quantity of arisings suitable for reuse is less than anticipated and/or unpractical to extract. Also see G05	22/05/2017	MC	ACTIVE	GEO	1	C		C		3	3	M	GDR	Designer		No	Additional ground investigation, and in particular testing of the cores form the preliminary ground investigation could be carried out to identify whether such uses may be feasible. Testing could comprise additional LA abrasion coefficent testing, resistance to wear, particle density, water absorption, magnesium soundness, resistance to freezing and thawing and % of crushed and broken surfaces in coarse aggregate particles.	2	3	M	Y		TBC	GDR	
	G20	Ch. 1+600m to Ch 1+900m and Ch. 3+900m to Ch. 4+400m	Instability at locations of existing earthworks within the on-line section of the proposed alignment, where previous issues have been encountered as recorded on the IRIS database - including historic slips, development of tension cracks, settlement and damage caused by animal burrowing including undermining of the toes of earthworks - affecting proposed works.	08/07/2019	AT	ACTIVE	GEO	1	C	H			3	4	H	GDR	Designer		No	Further visual inspection of instability features to be carried out ahead of detailed design. Design to take due account of previous movements and instability features.	2	4	M	Y		TBC	GDR	

Geotechnical Risk Register Key

Likelihood	
5	Absolute Certainty
4	Very Likely
3	Likely
2	Unlikely
1	Remote

Severity			
	Health and Safety	Commercial	Environment
5	Fatality	>50% budget / >50% effect on programme	major environmental incident with irreversible effects and threat to public health or protected natural resource
4	Major Injury	>12% budget / >25% effect on programme	environmental incident leading to prosecution or protestor action
3	Significant Injury	>10% budget / >12% effect on programme	environmental incident requiring management input
2	Lost-Time Injury	>1% budget / >5% effect on programme	minor environmental incident
1	First Aid Case	negligible	negligible

Risk Scores	
1	L
2	L
3	L
4	M
5	M
6	M
7	M
8	M
9	M
10	H
11	H
12	H
13	H
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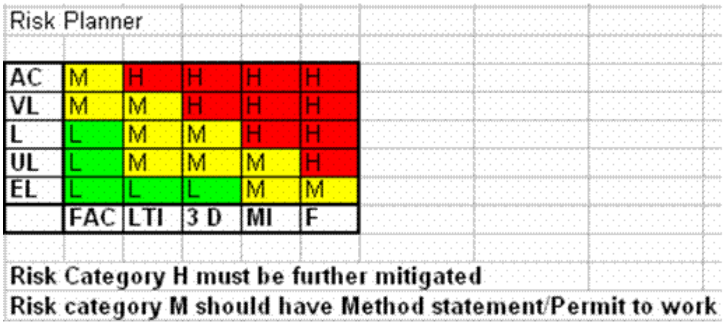
22	H
23	H
24	H
25	H



Risk Planner

AC	M	H	H	H	H
VL	M	M	H	H	H
L	L	M	M	H	H
UL	L	M	M	M	H
EL	L	L	L	M	M
	FAC	LTI	3 D	MI	F

Risk Category H must be further mitigated

Risk category M should have Method statement/Permit to work

Lifecycles	
C	Construction
M	Maintenance
O	Operation
D	Demolition

Risk Types	
H	H&S
C	Commercial
E	Environmental

Appendix H – Derivation of parameters for Weathered Conglomerate and Conglomerate

BH16 Weathered Conglomerate – Embankment 1

Material description

0 to 3.2mbgl: Firm orange brown very sandy silt/clay with many fine to coarse subangular to subrounded gravel of sandstone and mudstone.

3.2 to >8mbgl: Firm to stiff dark grey brown silty clay with many fine to coarse subangular gravel or sandstone and mudstone.

$\gamma' = 18$ kN/m^3 based on the material being a firm clay [19].

Strength parameters

$\varphi'_{cv} = 28°$ based on $I_p = 13\%$ from single Atterberg test using Equation 7 of BS8002 [19].

$c' = 0$ kPa

$c_u = 40$ kPa based on lower bound for firm material [22].

Compressibility

$E' = 250\ c_u = 10{,}000$ kN/m^2 based on Stroud [23].

BH101 Conglomerate – Cutting 1

Material description

6.5 to >8.5mbgl: Strong brown fine grained conglomerate with very closely spaced 45° bedding discontinuities and 70° planar rough discontinuities.

$\gamma' = 24$ kN/m^3.

Strength parameters

Derived using RocLab assessment (included in Appendix E).

$\varphi' = 60°$

$c' = 120$ kPa

UCS = 50MPa

For the GSI value, surface condition has been assumed to be smooth, moderately weathered (or fair) and the rock structure has been assumed to be blocky / disturbed.

BH09 Weathered Conglomerate and Conglomerate– Cutting 2 & Overbridge 1

Material description

0 to 3.5mbgl: Brown occasionally grey slightly clayey fine to coarse sand with occasional fine to coarse rounded to subangular gravel of mixed lithologies and rare cobbles of sandstone.

3.5 to 9.5mbgl: Very weak brown fine grained conglomerate with very closely spaced 45° bedding and very closely spaced 45° to 80° planar rough discontinuities.

$\gamma' = 18$ kN/m^3 for Weathered Conglomerate based on the material being a firm clay [19].

$\gamma' = 24$ kN/m^3 for Conglomerate.

Strength parameters – Weathered Conglomerate

The peak angle of friction has been derived using the guidance in BS8002 [19] where:

$\varphi'_{pk} = 30 + A + B + C$

A = 1 based on subangular to rounded

B = 4 based on descriptions indicating clay, sand, gravel and cobble content

C = 6 based on dense from SPT N values of 32 and 50

Therefore $\varphi'_{pk} = 41°$ and c' = 0 kPa.

Strength parameters – Conglomerate

Derived using RocLab assessment (included in Appendix E).

$\varphi' = 40°$

c' = 30 kPa

UCS = 1MPa

For the GSI value, surface condition has been assumed to be rough, slightly weathered (or good) and the rock structure has been assumed to be blocky / disturbed.

BH03 Conglomerate – Llanddewi Velfrey Roundabout

Material description

3.4 to 4.5mbgl: Moderately strong fine grained conglomerate.

$\gamma' = 24$ kN/m^3 for Conglomerate.

Strength parameters

Derived using RocLab assessment (included in Appendix E).

$\varphi' = 45°$

c' = 120 kPa

UCS = 25MPa

For the GSI value, surface condition has been assumed to be smooth, moderately weathered (or fair) and the rock structure has been assumed to be very blocky / disturbed.

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement

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

Appendix 6.4 Controlled waters assessment criteria

Determinand	Environmental Quality Standards, ug/l	Drinking Water Standards, ug/l
Arsenic	50	10
Chromium (III)	4.7	50
Chromium (VI)	3.4	-
Copper	1	2000
Cyanide	1	50
Mercury	0.05	1
Phenol	7.7	0.5
Zinc	10.9	5000
Toluene	74	-
Anthracene	0.1	-
Benzene	10	1
Cadmium	0.08	5
Fluoranthene	0.0063	-
Lead	1.2	10
Naphthalene	2	-
Nickel	4	20
Benzo(a)pyrene	0.00017	-
Petroleum hydrocarbons	-	10

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Environmental Statement

Appendix 7.1: WFD Compliance Assessment

A40LVP-ARP-EWE-SWI-RP-LE-0002

P02 | S3

02/10/18

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Figures

Executive Summary

A WFD compliance assessment has been undertaken for the proposed widening of the A40 from Penblewin Roundabout to Llanddewi Velfrey (the Scheme) in Pembrokeshire. The Scheme consists of 2.5km of improvements west of Ffynnon Wood and a 2.5km offline bypass from Ffynnon Wood to Bethel Chapel. The proposed alignment broadly following the watershed crest between the Cleddau, Taf and Marlais catchments.

Only non-temporary impacts, defined as having a duration of greater than 3 years, have been considered in the assessment. The results of assessments required by the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10: HD45/09 Road Drainage and the Water Environment (November 2009) were used to screen out impacts to water quality and resource as a result of the Scheme (Appendix B). Potential impacts related to the physical modification of watercourses from new culverts and outfalls have been retained through to the scoping stage.

To address the potential impacts of new in-channel structures such as outfalls and culverts, mitigations should be included in the detailed design of the Scheme to ensure potential effects on the water environment are minimised. These mitigations centre on minimising the potential for scour around the structures and ensuring that sediment transport and fish/invertebrate migration are maintained.

No permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of the Scheme provided the recommended mitigation measures are incorporated into the detailed design of the Scheme. NRW should be consulted on the outcomes of this assessment prior to detailed design of the Scheme, with this assessment updated when detailed design information becomes available.

1 Introduction

1.1 Overview of the Project

1.1.1 This report assesses the proposed widening of the A40 from Penblewin Roundabout to Llanddewi Velfrey (the Scheme) in Pembrokeshire for compliance with the European Union (EU) Water Framework Directive (WFD).

1.1.2 The WFD has been in force since 2000 and is currently the largest and most influential piece of European Union (EU) legislation relating to the water environment. The Directive was transposed into UK law by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. NRW is the competent authority responsible for delivering the Directive in Wales. The Directive requires that Environmental Objectives be set for all surface and groundwater water bodies to enable them to achieve ‘Good Ecological Status’ (GES) – or ‘Good Ecological Potential’ (GEP) for Heavily Modified and Artificial Water Bodies – by a defined date.

1.1.3 The A40 Scheme is 5km in length, from SN 12021 16649 to SN 16150 16975 (Figure 7.1), and consists of 2.5km of improvements west of Ffynnon Wood and a 2.5km offline bypass from Ffynnon Wood to Bethel Chapel. It will add 1.4km and 1km of extra overtaking (2+1 carriageway) eastbound and westbound respectively.

1.1.4 The Scheme alignment broadly follows the watershed crest between the Cleddau, Taf and Marlais catchments. West of Ffynnon Wood, the Scheme is in the Marlais catchment before crossing Longford Brook, a tributary of the Cleddau, in Ffynnon Wood and finally crossing the headwaters of several small watercourses, including the Afon Daulan, in the Taf catchment. As the Scheme follows the ridgeline, the topography of the proposed alignment is flat relative to the local landscape. There are three areas of cutting between Ffynnon Wood and the eastern extent of the Scheme.

1.2 Purpose of Document

1.2.1 Arup, working on behalf of Welsh Government, has been commissioned to undertake a WFD Compliance Assessment for the proposed widening of the A40 from Penblewin Roundabout to Llanddewi Velfrey.

1.2.2 Under the WFD, all proposed schemes with the potential to impact upon WFD-designated water bodies must be assessed to ensure:

a) no deterioration of the current status or potential of any WFD quality elements; and

b) no prevention of future attainment of the 'good' status or potential objectives of any WFD quality elements.

1.2.3 This report follows emerging guidance produced by Natural Resources Wales (NRW)[1] and the Planning Inspectorate (PINS)[2] to assess whether proposed activities have the potential to adversely impact upon the various WFD quality elements of the relevant water bodies. The report also outlines any associated impact mitigation that is required to ensure compliance of the proposed works with WFD objectives.

1.2.4 This assessment is based on currently available NRW WFD baseline data and scheme information. This assessment should be considered as a 'live' document that should be updated if:

a) NRW update or provide additional WFD baseline data for the relevant water bodies; and/or

b) Significant changes to the nature, alignment, scale or construction methods of the proposed development are made.

1.2.5 NRW has provided an opinion on the environmental scoping report and a site walkover has also been undertaken with an NRW geomorphology specialist on 30th June 2017.

1.3 Data Sources

1.3.1 The data sets and resources listed below, as provided by NRW and Natural England, have been used to inform this assessment. No WFD monitoring data is available for any of the watercourses directly crossed or affected by the Scheme.

a) A site walkover, accompanied by an NRW geomorphology technical specialist, on 30th June 2017;

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[1] OGN072: Guidance for assessing activities and project for compliance with the Water Framework Directive, May 2017.

[2] Advice Note Eighteen: The Water Framework Directive. The Planning Inspectorate, June 2017.

b) Cycle 2 River Basin Management Plan, Western Wales (NRW, 2015);

c) RBMP Cycle 2 water body classification data for the WFD waterbodies listed in Table 3;

d) Lle Geo Portal: http://lle.gov.wales/map;

e) NRW's 'Water Watch Wales' website http://waterwatchwales.naturalresourceswales.gov.uk/en/; and

f) Natural England 'MAGIC' website http://www.magic.gov.uk.

2 Scheme Design

2.1 Overview

2.1.1 The section only describes the elements of the Scheme design that are relevant to the WFD compliance assessment.

2.2 Carriageway drainage

2.2.1 The carriageway drainage includes a series of mitigation measures to ensure that flood risk in not increased in the vicinity of the Scheme and elsewhere and to ensure that soluble and suspended pollutants in carriageway runoff are reduced to acceptable levels prior to discharge to groundwater or local watercourses.

2.2.2 Where possible, highway runoff is to be infiltrated into the ground using attenuation/ infiltration basins. If infiltration is not possible, surface water runoff would be restricted to the 1-year return period Greenfield Runoff Rate and discharged into a local watercourse.

2.2.3 Attenuation is to be provided by basins, sized to accommodate the 1 in 100-year event with an allowance for climate change. This allowance has been agreed with Pembrokeshire CC at the detailed design stage.

2.2.4 To ensure that discharges from the new carriageway drainage do not have an adverse effect upon the existing water environment the carriageway drainage has been designed to include a three stage treatment train of filter drains, catch-pits and detention basins to remove and retain soluble and suspended pollutants. The assessment of spillage risk has indicated that this risk is negligible without additional mitigation measures.

2.3 Physical modifications

2.3.1 New structures introduced to surface waters as a result of the Scheme include three culverts, two culvert extensions and four outfalls (Table 1). None of the watercourses where new structures are proposed are classified as main rivers.

2.3.2 The scale of these modifications is to be confirmed during detailed design.

Table 1 Proposed physical modifications to surface waters

Approximate Chainage	**Watercourse**	**Structure**
0+290	Unnamed tributary of Afon Marlais 2	Existing culvert to be extended and new outfall from Attenuation Basin A.
1+800	Longford Brook	Existing culverts to remain & culvert extension of 20m.
1+880	Longford Brook	New outfall from Attenuation Basin B.
2+640	Unnamed tributary of Afon Daulan 1	Proposed culvert 1.8m dia.
3+020	Unnamed tributary of Afon Daulan 2	New outfall from Attenuation Basin C.
3+150	Afon Daulan	Proposed culvert 1.8m dia.
3+270	Unnamed tributary of Afon Daulan 3	Proposed culvert 1.8m dia.
4+240	Unnamed tributary of Afon Marlais 1	New outfall from Attenuation Basin D.

2.4 Cuttings and embankments

2.4.1 The Scheme follows a ridgeline for much of its length and therefore does not have many major cuttings or embankments. Table 2 describes principal areas of cutting or embankment along the Scheme.

Table 2 Proposed areas of significant cutting and embankments

Start Chainage	**End Chainage**	**Location**	**Feature**
1+600	2+000	Ffynnon Wood (existing crossing of Longford Brook)	Embankment
2+050	2+450	South of Pen-troydin-fach	Cutting
2+450	2+720	East of Pen-troydin-fach	Embankment
2+720	2+950	South of Pen-troydin-fawr	Cutting
2+950	3+440	North of Blaen-pen-troydin	Embankment
3+440	3+848	East of Blaen-pen-troydin	Cutting

3 WFD Baseline

3.1 Overview

3.1.1 Three WFD river (surface water) water bodies and two groundwater bodies would be crossed by the Scheme (Table 3). The extents of these waterbodies are shown in Figure 7.5 (surface water bodies) and 7.6. (groundwater bodies).

3.1.2 The potential effects of the Scheme are confined to localised changes in minor watercourses and groundwater. When considered against the scale of WFD waterbodies, these potential effects do not to extend beyond the boundaries of the above waterbodies and therefore no other WFD waterbodies are included in this assessment.

3.1.3 The following sections describe the water bodies in greater detail and include observations made during a site walkover on 29th & 30th June 2017.

Table 3 WFD waterbodies within the Scheme area

Waterbody Name	**ID**	**Waterbody Type**	**River Basin District**	**Management Catchment**	**Area (km^2)**
Taf -Felin Cwrt to Gronw	GB110060036283	River	Western Wales	Carmarthen Bay and the Gower	41.42
Marlais - headwaters to confluence with Taf	GB110060029240				26.63
Longford Brook - HW to conf with E. Cleddau	GB110061030680			Cleddau and Pembrokeshire Coastal Rivers	14.54
Tywi, Taf and Gwendraeths	GB41002G200500	Groundwater		N/a	1947.43
Cleddau and Pembrokeshire	GB41002G200400				1115.63

3.2 'Taf -Felin Cwrt to Gronw' (GB110060036283)

3.2.1 The current status, failing elements, and reasons for failure of the 'Taf -Felin Cwrt to Gronw' (GB110060036283) river water body for Cycle 2 (2015-2021) of the WFD are outlined in Table 4. As of 2018, the water body currently has an overall status of good.

3.2.2 Watercourses within this catchment that have the potential to be impacted by the Scheme include two unnamed tributaries of the Afon Taf, the Afon Daulan and four of its unnamed tributaries.

Unnamed tributary of Afon Daulan 1

3.2.3 A reach of this watercourse, a tributary of the Afon Daulan, surrounding the proposed culvert was surveyed on 29th June 2017. The proposed crossing is close to the upstream end of the watercourse and crosses an area of marshy ground from which the watercourse emanates. The channel had a small amount of flowing water on the day of survey and had a straightened and uniform profile that followed the field boundary. The watercourse had a silt bed and alternated between glide and pool flow units with a moderate cover of riparian vegetation, dominated by well-established trees. An artificial cross-slope ditch feeds into the upstream end of the watercourse. Heavy poaching by cattle was evident where the watercourse reaches the field boundary at the downstream end of the surveyed reach.

Figure 1 (A) Looking west at a cross-slope drainage ditch that supplied the watercourse. (B) The general condition of the watercourse. (C) Cattle poaching of the watercourse at the downstream end of the survey reach. Photos taken in the vicinity of ID 21 on Figure 7.2.

Unnamed tributary of Afon Daulan 2

3.2.4 This watercourse could not be accessed during the walkover survey due to dense vegetation. At the proposed location of the attenuation basin outfall, the watercourse flows along the field boundary within dense vegetation consisting of trees and shrubs.

Afon Daulan

3.2.5 Multiple reaches of the Afon Daulan were surveyed on 29th June 2017. The upstream end of the survey reach began where the watercourse is crossed by a public footpath 220m to the south of the proposed Scheme crossing. At this location the watercourse flows through dense, natural woodland and has a cobble bed with extensive areas of moss and macrophyte (e.g. water hemlock) growth. The bankfull channel is approximately 1m wide and 0.3m deep, with the water on the day of the survey approximately 0.4m wide and 0.05m deep. There was evidence of active geomorphological adjustment in this reach with areas of eroded bank and gravel deposits evident. A small tributary entered the watercourse at this location.

Figure 2 The Afon Daulan where it is crossed by a footpath, approximately 220m south of the proposed road crossing. Photos taken at ID 28 on Figure 7.2.

3.2.6 At the proposed Scheme crossing, the watercourse has a steep sided valley side to the east and a flatter, marshy area to the west. The watercourse has a cobble bed with accumulations of smaller gravels, an incised profile with regularly spaced areas of eroding banks and suffers from extensive cattle poaching. The riparian cover is limited to established trees as a result of the poaching. Flow types alternative between riffles and runs.

3.2.7 Downstream of the proposed crossing point, the watercourse flows through a 300mm pipe culvert at a field entrance. There was visible evidence of poor water quality as a result of silt and nutrient runoff from cattle at this location.

Figure 3 (A) The general condition of the Afon Daulan at the proposed crossing location. (B) Area of poaching, (C) A culvert downstream of the proposed crossing, note the potential for improvements in silt and nutrient runoff management. (D) Looking from west to east across the watercourse at the proposed crossing. Note the steep bank on the eastern side. Photos taken 100m south of ID 39 on Figure 7.2.

Unnamed tributary of Afon Daulan 3

3.2.8 This watercourse could not be accessed during the walkover survey. At the proposed location of the Scheme crossing, the watercourse flows through a pastoral field with occasional mature trees along its banks.

Unnamed tributary of Afon Daulan 4

3.2.9 This watercourse could not be accessed during the walkover survey but would not be directly modified by the Scheme.

Unnamed tributary of Afon Taf 1

3.2.10 This watercourse could not be accessed during the walkover survey but would not be directly modified by the Scheme.

Unnamed tributary of Afon Taf 2

3.2.11 This watercourse could not be accessed during the walkover survey but would not be directly modified by the Scheme.

3.3 'Marlais - headwaters to confluence with Taf' (GB110060029240)

3.3.1 The current status, failing elements, and reasons for failure of the 'Marlais - headwaters to confluence with Taf' (GB110060029240) river water body for Cycle 2 (2015-2021) of the WFD are outlined in Table 4. The water body currently has an overall status of moderate related to a moderate classification for ammonia.

3.3.2 Watercourses within this catchment that have the potential to be impacted by the Scheme include two unnamed tributaries of the Afon Marlais.

Unnamed tributary of Afon Marlais 1

3.3.3 This watercourse could not be accessed during the walkover survey. From Ordnance Survey mapping, the proposed outfall location appears to be at the head of the watercourse.

Unnamed tributary of Afon Marlais 2

3.3.4 The watercourse flows through an existing culvert beneath the A40, which was surveyed on 29th June 2017. The culvert is approximately 800m in diameter and has a 150mm step from the invert to the bed at the downstream end. The watercourse was wet but flowing water was not evident on the day of the survey.

3.3.5 The channel downstream of the culvert had a canalised, overdeepened form (i.e. a ditch) and appeared to be artificial with well-established vegetation growth indicating that flows in the watercourse are infrequent at these flows.

Figure 4 A view of the unnamed tributary of Afon Marlais 2 downstream of the existing A40 culvert. Photo looking south at rest area 200m east of Penblewin roundabout.

3.4 'Longford Brook - HW to conf with E. Cleddau' (GB110061030680)

3.4.1 The current status, failing elements, and reasons for failure of the 'Longford Brook - HW to conf with E. Cleddau' (GB110061030680) river water body for Cycle 2 (2015-2021) of the WFD are outlined in Table 4.

3.4.2 The water body currently has an overall status of moderate due fish, with a measure to reduce diffuse source pollution. The Cleddau Rivers Special Area of Conservation (SAC) begins at the downstream end of the catchment and has an objective to achieve good overall status by 2021.

3.4.3 Watercourses within this catchment that have the potential to be impacted by the Scheme include Longford Brook.

Longford Brook

3.4.4 Longford Brook flows through an existing, approximately 125m long, culvert beneath the A40, which was surveyed on the 30th June. This Scheme design includes retaining this culvert.

3.4.5 The upstream end of the culvert is approximately 450mm in diameter with an invert 50mm below the upstream riverbed. It appeared that the culvert did not present a barrier to sediment transport. The riverbed upstream of the culvert was composed of a mixture of bedrock sections and angular gravels. Flows alternated between glides and runs and the riparian vegetation was moderate with well-established trees present upstream and downstream of the culvert. Water levels on the day of survey were approximately 1m wide and 0.1m deep.

Figure 5 The upstream end of Ffynnon Culvert.

3.4.6 The downstream end of the culvert is approximately 1.2m wide, 2.5m high and made of brick/stone. The downstream end has a 0.3m drop from the invert of the culvert to a large scour pool. There is evidence of scour at the culvert base and the culvert walls have been strengthened by wooden supports. The scour pool is impounded by a small concrete weir that from observation during the walkover appeared to be in very poor condition. At the time of the survey the flow at the bottom end of the culvert was approximately 5cm deep, it was unclear if there was any flow beneath the culvert base.

Figure 6 (A) The downstream end of the Ffynnon Culvert. (B) Evidence of scour at the downstream end and (C) the scour pool downstream of the culvert (from the roadway above).

3.5 ‘Tywi, Taf and Gwendraeths’ (GB41002G200500)

3.5.1 The current status, failing elements, and reasons for failure of the ‘Tywi, Taf and Gwendraeths’ (GB41002G200500) groundwater body for Cycle 2 (2015-2021) of the WFD are outlined in Table 5.

3.5.2 The water body currently has an overall status of poor due to the chemical dependant surface water body status, resulting from point source pollution from abandoned mines. It currently does not have any objective set to achieve good overall status.

3.6 ‘Cleddau and Pembrokeshire’ (GB41002G200400)

3.6.1 The current status, failing elements, and reasons for failure of the ‘Cleddau and Pembrokeshire’ (GB41002G200400) groundwater body for Cycle 2 (2015-2021) of the WFD are outlined in Table 5.

3.6.2 The water body currently has an overall status of poor as the result of poor chemical status resulting from the assessment of the status of Ground Water Dependant Terrestrial Ecosystems (GWDTE) within the waterbody. It has an objective to achieve good overall status by 2021.

3.7 WFD classifications

Table 4 A breakdown of the status of WFD river water bodies potentially affected by the Scheme[3].

WFD Waterbody	**Taf -Felin Cwrt to Gronw**	**Marlais - headwaters to confluence with Taf**	**Longford Brook - HW to conf with E. Cleddau**
ID	GB110060036283	GB110060029240	GB110061030680
HMWB/AWB	No	No	No
Overall Status	Good	Moderate	Moderate
Objective	NA	NA	Good by 2021
Ecological Status	Good	Moderate	Moderate
Chemical Status	Good	Good	Good
Drivers of failure to achieve Good status	NA	Ammonia (Phys-Chem)	Fish
Reason for not achieving Good status	NA	Unknown	Other (not on list)
Other (including Mitigation Measures)	Dwr Cymru to investigate sources, transport and pathways of microbial pollution to Shellfish Waters as part of AMP 6 NEP programme. NRW to regulate.		Reduce diffuse source pollution at source by controlling or managing diffuse source inputs. Cleddau Rivers SAC at downstream end of catchment.

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[3] Natural Resources Wales. 2018 Cycle 2 Interim Classification Data. Available at: http://waterwatchwales.naturalresourceswales.gov.uk/en/

Table 5 A breakdown of the status of WFD groundwater bodies potentially affected by the Scheme[3]

WFD Waterbody	**Tywi, Taf and Gwendraeths**	**Cleddau and Pembrokeshire**
ID	GB41002G200500	GB41002G200400
HMWB/AWB	No	No
Overall Status	Poor	Poor
Objective	Poor by 2015	Good by 2021
Chemical Status	Poor	Poor
Quantitative Status	Good	Good
Driver of failure to achieve Good status	Chemical Dependent Surface Water Body Status	Chemical GWDTEs test
Reason for not achieving Good status	Point source pollution from abandoned mines.	Unknown

3.8 Protected Areas & Species

3.8.1 Under the WFD, 'Protected Areas' are defined as areas requiring special protection because of their sensitivity to pollution or due to their particular economic, social or environmental importance. These areas are waterbodies or parts of them:

a) used for the abstraction of water intended for human consumption (Drinking Water Protected Area);

b) supporting economically significant shellfish or freshwater fish stocks (Freshwater Fish Water; Shellfish Water);

c) where a large number of people are expected to bathe (Bathing Water);

d) supporting habitats or species of international biodiversity conservation importance (Special Area of Conservation, Special Protection Area);

e) sensitive to nutrient enrichment (Nitrate Vulnerable Zone; UWWTD Sensitive Zone).

3.8.2 The specific environmental designations, measures and actions for these protected areas have been established under previous European Directives, which set out the requirements to ensure the protection of the area's water environment or protection of wildlife that is directly dependant on that water environment. Where a WFD waterbody falls within or forms all or part of one of these designated predicted areas, the waterbody is subject to additional environmental objectives (and associated monitoring regimes, risk assessments, and regulations) in accordance with the relevant, previous Directive(s).

3.8.3 The Scheme is not located within any designated areas. However, Longford Brook and its tributaries are upstream of the 'Cleddau Rivers' SAC (Site Code: UK0030074). The proposed Scheme crossing of Longford Brook is approximately 6km upstream of the SAC.

3.8.4 The SAC is designated due to the presence of Bullhead (*Cottus gobio*), River Lamprey (*Lampetra fluviatilis*), Brook Lamprey (*Lampetra planeri*), Sea Lamprey (*Petromyzon marinus*) and Otter (*Lutra lutra*), as well as rare habitats including 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation', 'Active raised bogs' and 'Alder woodlands on floodplains'.

The latter two designations are priority habitat types as defined in the Habitats Directive[4].

3.8.5 Otter surveys were undertaken on two occasions in 2016 and two otter holts were recorded, one on a stream in Castell-Gwyndy Wood to the north of Bethel Chapel, and the other within woodland adjacent to the stream to the south of Ca'rmaenau Fach. Desk and field surveys have not identified any other records of protected species within 1km of the Scheme. The Nature Conservation chapter of the Environment Statement describes these findings in greater detail.

3.8.6 Desk and walkover surveys have identified records of invasive species (Japanese Knotweed and Rhododendron) in the vicinity of the Scheme.

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[4] EU Habitats Directive: Directive 92/43/EEC of the European Parliament and of the Council; of 21 May 1992; *on the Conservation of natural habitats and of wild fauna and flora.*

4 Assessment Methodology

4.1.1 The assessment comprises of three stages, as recommended by NRW[1], to assess the potential for each proposed activity (individually and in combination) to impact on individual (or multiple) WFD quality elements:

a) Screening - exclude any activities that do not need to go through the scoping or detailed assessment stages;

b) Scoping - identify the quality elements that are potentially at risk from the proposed activity and need further detailed assessment; and

c) Detailed Assessment - consider the potential impacts of an activity on bodies of surface and ground water, identify ways to avoid or minimise impacts (mitigations), and identify if an activity may prevent the water body achieving good status or cause deterioration.

4.1.2 NRW guidance[1] states that for a project or activity to be compliant with the WFD, the assessment should demonstrate that:

a) there is no risk of it causing a deterioration of the status of any element; in addition, for groundwater we will limit or prevent the input of pollutants;

b) there is no risk of it preventing WFD Protected Areas from achieving their objectives;

c) it will not jeopardise any water body from achieving good status/potential;

d) it will contribute to the protection, enhancement and restoration of water bodies.

4.1.3 The WFD is primarily concerned with non-temporary deterioration. Here, temporary impacts are defined as *less than three years*, with impacts not considered to constitute deterioration of status of the water body if the water body:

a) is only impacted for a short time period (less than three years);

b) recovers within a short time period (less than three years); and/or

c) recovers without the need for any restoration measures.

4.1.4 Temporary works where impacts have the potential to be longer lasting (i.e. longer than three years) are considered in the assessment.

4.1.5 To identify potential impacts upon surface and ground waters as a result of the Scheme, this report uses the results of assessments carried as required by the Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10: HD45/09 Road Drainage and the Water Environment (November 2009), subsequently referred to as HD45/09.

4.1.6 HD45/09 provides a series of accepted methods (e.g. HAWRAT; Method C) for conducting assessments of likely impacts to the water environment, the results of which are presented in Appendix B.

4.2 Assumptions

4.2.1 Watercourses that are crossed by the Proposed Scheme which are not officially designated as WFD water bodies by NRW are included in the assessment. It is assumed that these water bodies have the same status objectives as the designated water body into which they flow. However, the measures proposed to mitigate any adverse impacts on these water bodies aims to be appropriate to their local context.

5 Screening

5.1.1 Activities that may result in an impact on WFD quality elements may take place during construction and/or operation of the proposed development. Table 6 details the expected activities, whether they have been screened in/out of further assessment, along with an explanation for the screening decision. Where activities have been screened in to the assessment, they are considered against WFD quality elements in the scoping stage.

Table 6 Screening of proposed activities against WFD objectives

Proposed Activity	**Screen In/Out**	**Explanation**
Construction Activities		
Temporary modification of watercourses during instream works	Out	Measures considered to be best practice will be adopted during construction to ensure that temporary impacts to watercourse morphology are minimised and that any modifications are removed and the channel restored to its previous condition following construction. Where required, instream works will be timed to take place outside of the main fish migration/spawning seasons. These measures have been detailed in the draft CEMP produced for the Scheme. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Temporary discharge of site runoff to surface waters	Out	Measures considered to be best practice will be adopted during construction to ensure that runoff discharged from the site is of acceptable quality and is discharged in a manner that does not impact upon geomorphology or hydrology of local watercourse. These measures have been detailed in the draft CEMP produced for the Scheme. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Temporary discharge of site runoff to groundwater	Out	Measures considered to be best practice will be adopted during construction to ensure that where site runoff is allowed to infiltrate to groundwater it is of acceptable quality and is discharged in a manner that does not impact upon other users of the groundwater. These measures have been detailed in the draft CEMP produced for the Scheme.

Proposed Activity	**Screen In/Out**	**Explanation**
		With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Dewatering during the construction of cuttings	Out	Construction of the cuttings has a potential to locally impact hydrogeology by influencing groundwater levels, gradient and flow rates as a result of either dewatering works or drainage. The cuttings may also reduce the catchment areas for water courses where a base flow is dependent on surface water run-off and/or flows within shallow subsurface. The impact of this dewatering and drainage has been considered in Appendix B5. Eight features that may be impacted by the construction of the cuttings were identified; with impacts likely to be localised and only reducing baseflow in several minor watercourses. This impact would be temporary and is therefore not considered under the WFD. In the majority of the cases, the flows intercepted by the highway drainage would be returned into the affected catchments via attenuation basins and therefore the overall impact on hydrogeological and hydrological setting of the scheme area is unlikely to be significant. No permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Accidental spillage of pollutants	Out	Measures considered to be best practice, which have been detailed in the draft CEMP, will be adopted during construction to ensure that if an accidental spillage occurs it will be contained and disposed of appropriately. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Operational Activities		
Discharge of routine carriageway runoff to groundwater	Out	Infiltration to groundwater is the preferred method of drainage for the Scheme. Filter drains will be installed in areas of cutting and where possible, detention basins will allow for water to infiltrate to the ground in preference to discharge to local watercourses. An assessment of the potential effects of discharging carriageway runoff to groundwater has been undertaken using the Method C procedure detailed in HD45/09 (Appendix B2). This assessment indicated a potential impact that required the more detailed P20 assessment conducted in Appendix B3. The results of this detailed assessment demonstrate that the contaminant concentrations resulting from a long-term discharge of surface runoff diminish to the acceptable levels for copper at a distance of approximately 10m from the attenuation basins and outfalls. This is due to the anticipated dilution within the aquifer. Therefore, although the initial assessment indicated a potential 'medium' risk scenario of impact on groundwater, the detailed assessment indicated that the routine run-off discharge may only result in the localised impact limited to the proximity of the attenuation basin or outfall. No permanent impacts on the current status or status objectives of WFD groundwater quality elements are expected as a result of this activity and therefore this activity is scoped out of the assessment.
Discharge of routine carriageway runoff to surface waters	Out	Runoff from the carriageway will pass through a treatment train (see Section 2.2.4) prior to its discharge to local watercourses. Where possible, runoff will be infiltrated to groundwater in preference to discharge to surface watercourses.

Proposed Activity	**Screen In/Out**	**Explanation**
		An assessment of the potential effect of discharging carriageway runoff to surface waters has been undertaken using the Method A (HAWRAT) procedure in HD45/09 (Appendix B1). Following the inclusion of the treatment train embedded in the Scheme design all of the drainage outfalls pass the assessment for soluble pollutants, although Basin A marginally fails for sediment accumulation (Appendix B1: Table 12). Despite this, the low flow (Q95) of the receiving watercourse indicate that discharge is most likely to infiltrate to groundwater and therefore the sediment impact can be discounted. The assessment of long term impacts of surface water runoff from the highway has been undertaken by comparing the annual average concentrations of copper and zinc predicted in the HAWRAT results with the EQSs stated in the WFD (Standards and Classifications) Directions 2015. The predicted concentrations are below the EQS thresholds for both copper and zinc at all locations, other than Basin's A and C, where the threshold for copper is exceeded (Table 17). These failures are discounted as discharges of road runoff at these locations would likely be infiltrating into groundwater rather than entering surface waters, due to the low flow of the watercourses (Q95 < 0.001 m^3/s). No permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity and therefore this activity is scoped out of the assessment.
Accidental spillage to ground or surface waters	Out	An assessment of the risk of accidental spillage to surface or ground waters has been undertaken using the Method-D approach detailed in HD45/09 (Appendix B4). This assessment indicated a negligible risk of accidental spillage. No permanent impacts on the current status or status objectives of WFD quality elements are therefore expected as a result of this activity and this activity is scoped out of the assessment.
Changes in groundwater levels as a result of new cuttings & their associated drainage	Out	An assessment of the changes in groundwater levels as a result of the cuttings and drainage has been undertaken in Appendix B5. The assessment has indicated that localised depressions in groundwater level are likely in the vicinity of new cuttings. Feature ID 22 (Figure 7.2B), unnamed tributary of the Afon Daulan 1, is likely to experience a reduction in baseflow as a result of lowered groundwater levels in the vicinity of Cutting 2. However, given the limited value of the groundwater in these areas and the localised scale in relation to the WFD groundwater bodies, no permanent impacts on the current status or status objectives of WFD quality elements are therefore expected as a result of this activity and this activity is scoped out of the assessment.
Changes in surface water flow regimes as a result of new cuttings or embankments	Out	An assessment of the changes in surface water flow regimes as a result of the cuttings, embankments and road drainage has been undertaken in Appendix B5. Six minor, low value watercourses have been identified as having modified flow regimes due to changes to surface water run-off or shallow groundwater flow from the Scheme (Table 25: Surface water catchments). In the majority of the cases, the flows intercepted by the highway drainage would be returned into the affected catchments via detention basins. Detailed discussion of the potential modifications to these flow regimes can be found in Appendix B5.

Proposed Activity	Screen In/Out	Explanation
		Given the scale of the WFD surface water bodies in relation to the localised potential effect to minor watercourses and the lack of any designated areas in proximity of the Scheme, no permanent impacts on the current status or status objectives of WFD quality elements are therefore expected as a result of this activity and this activity is scoped out of the assessment.
Physical modification of watercourses due to new structures (e.g. culverts or headwalls)	In	The new structures included in the Scheme design (Table 1) have the potential to cause local reductions in habitat availability and prevent the migration of aquatic organisms. Culverts can act as barriers to fish passage and sediment transport and any new structure can disturb flow regimes and result in localised erosion. These new structures should be designed sensitively to ensure that any impact on the water environment is minimised. All three WFD surface water bodies are screened into this activity. Groundwater bodies are not considered to be impacted by physical structures. There is potential for this activity to result in localised impacts to WFD quality elements.

6 Scoping

The following sections assess activities identified in the screening stage against the WFD quality elements of the relevant water bodies, in order to identify quality elements that may be impacted by the proposed development. Where potential impacts are identified, these quality elements are taken forward to detailed impact and mitigation assessment.

6.1 'Taf -Felin Cwrt to Gronw' (GB110060036283)

Table 7 Potential effects of the proposed development on WFD quality elements of the 'Taf -Felin Cwrt to Gronw' river water body.

WFD quality elements	**Physical modification of watercourses due to new structures (e.g. culverts or headwalls)**	**Mitigation required?**
Invertebrates	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale and present barriers to migration.	Yes
Fish		
Macrophytes & Phytobenthos	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale.	Yes
pH	No impact: No changes in water chemistry are likely as a result of physical modifications.	No
Phosphorus		
Dissolved Oxygen		
Ammonia		
Specific Pollutants		
Temperature	No impact: Although the shading effect of culverts can alter water temperature, this effect would only act over localised reaches of low value, minor watercourses.	No
Hydrology	No impact: The proposed physical structures would not impact upon the flow regime of any surface watercourses.	No

Morphology	Potential impact: Physical modifications (particularly culverts) have the potential to impact upon morphological quality elements.	Yes

6.2 'Marlais - headwaters to confluence with Taf' (GB110060029240)

Table 8 Potential effects of the proposed development on WFD quality elements of the 'Marlais - headwaters to confluence with Taf' river water body.

WFD quality elements	**Physical modification of watercourses due to new structures (e.g. culverts or headwalls)**	**Mitigations required?**
Invertebrates	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale and present barriers to migration.	Yes
Fish		
Macrophytes & Phytobenthos	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale.	Yes
pH	No impact: No changes in water chemistry are likely as a result of physical modifications.	No
Phosphorus		
Dissolved Oxygen		
Ammonia		
Specific Pollutants		
Temperature	No impact: Although the shading effect of culverts can alter water temperature, this effect would only act over localised reaches of low value, minor watercourses.	No
Hydrology	No impact: The proposed physical structures would not impact upon the flow regime of any surface watercourses.	No

Morphology	Potential impact: Physical modifications (particularly culverts) have the potential to impact upon morphological quality elements.	Yes

6.3 ‘Longford Brook - HW to conf with E. Cleddau’ (GB110061030680)

Table 9 Potential effects of the proposed development on WFD quality elements of the ‘Longford Brook - HW to conf with E. Cleddau’ river water body.

WFD quality elements	**Physical modification of watercourses due to new structures (e.g. culverts or headwalls)**	**Mitigations required?**
Invertebrates	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale and present barriers to migration.	Yes
Fish		
Macrophytes & Phytobenthos	Potential impact: The inclusion of new structures (particularly culverts) has the potential to reduce habitat area at a local scale.	Yes
pH	No impact: No changes in water chemistry are likely as a result of physical modifications.	No
Phosphorus		
Dissolved Oxygen		
Ammonia		
Specific Pollutants		
Temperature	No impact: Although the shading effect of culverts can alter water temperature, this effect would only act over localised reaches of low value, minor watercourses.	No
Hydrology	No impact: The proposed physical structures would not impact upon the flow regime of any surface watercourses.	No
Morphology	Potential impact: Physical modifications (particularly culverts) have the potential to impact upon morphological quality elements.	Yes

7 Mitigation measures

7.1.1 To address the potential impacts of new in-channel structures such as outfalls and culverts, mitigations should be included in the detailed design of the Scheme to ensure potential effects on the water environment are minimised.

7.1.2 The mitigation measures listed below are considered best practice for the design of outfalls and culverts and should be included for all structures to ensure that WFD objectives can be met in the future.

7.1.3 The design of any new or extended culverts should ensure that:

a) The base of the culvert is set >150mm below the existing bed of the watercourse with structures attached to the base of the culvert (e.g. wooden batons) to retain sediment within the full length of the culvert. This will help to retain habitat connectivity either side of the culvert and promote continued sediment transport downstream;

b) The culvert width is greater than that of the existing watercourse, such that it does not constrict the watercourse at the entrance or exit to the structure;

c) Culvert gradients are such that flow velocities within the culvert are suitable for fish passage across a range of flows; and

d) Any scour protection at the inlet or outlet uses bioengineering methods wherever practicable to maximise habitat potential.

7.1.4 The design of any new outfalls should ensure that:

a) The headwall structure is set back from or flush with the channel profile and does not protrude into the channel;

b) The outfall is angled to direct flow at an angle no greater than 60 degrees from the existing flow direction in the watercourse; and

c) Any scour protection surrounding the outfall headwall uses bioengineering methods wherever practicable to maximise habitat potential.

7.1.5 The design and construction supervision of these mitigation measures should be led by a qualified geomorphologist.

7.1.6 Provided that these mitigation measures are included then given the minor nature of the watercourses effected, no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of the proposed in-channel structures.

8 Conclusions

8.1.1 This WFD assessment has been conducted as part of the Environmental Statement and relies upon the results of the HD45/09 assessments detailed in Appendix B.

8.1.2 The assessment identified the new structures (culverts and outfalls) required for the Scheme drainage, as having the potential to impact upon WFD quality elements and objectives. To ensure that these structures do not impact upon the status or the future objectives of any WFD quality elements, mitigation measures have been proposed to be incorporated in the detailed design of the Scheme.

8.1.2.1 The assessment has concluded that no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of the Scheme provided that the recommended mitigation measures are incorporated into the detailed design of the Scheme.

8.1.3 It is recommended that NRW is consulted on the outcomes of this assessment prior to detailed design of the Scheme.

8.1.4 This assessment should be considered as a ‘live’ document that should be updated following detailed design, if NRW update or provide additional WFD baseline data for the relevant water bodies; and/or significant changes to the nature, alignment, scale or construction methods of the proposed development are made.

Appendix A: WFD Background Information

A1 Overview of the WFD

A1.1 Aims

The Water Framework Directive (WFD) aims to protect and enhance the quality of the water environment across all European Union (EU) member states. It takes a holistic approach to the sustainable management of water by considering the interactions between surface water, groundwater and water-dependent ecosystems.

Under the WFD, ‘water bodies’ are the basic management units and are defined as all or part of a river system or aquifer. These water bodies form part of a larger ‘River Basin District’ (RBD), for which ‘River Basin Management Plans’ (RBMP) are developed by EU member states and environmental objectives are set. These RBMP are produced every six years, in accordance with the river basin management planning cycle.

The WFD requires all EU member states to classify the current condition or ‘status or potential’ of surface water and groundwater bodies and to set a series of objectives for maintaining or improving conditions so that water bodies maintain or reach ‘good status or potential’.

A1.2 WFD requirements for new developments

To ensure compliance with the WFD, decision makers must consider whether proposals for new developments have the potential to:

- cause a deterioration of a water body from its current status or potential;
- prevent future attainment of good status or potential where not already achieved;
- impact on protected or priority species and habitats; and/or
- provide opportunities to improve the water environment.

A2 Legislative Context

A2.1 EU Water Framework Directive

The Water Framework Directive (WFD)[5] has been in force since 2000 and is currently the largest and most influential piece of European Union (EU) legislation relating to the water environment. The Directive was transposed into UK law by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[6]. NRW is the competent authority responsible for delivering the Directive in Wales.

The Directive requires that Environmental Objectives be set for all surface and groundwater water bodies to enable them to achieve ‘Good Ecological Status’ (GES) – or ‘Good Ecological Potential’ (GEP) for Heavily Modified and Artificial Water Bodies – by a defined date. These Environmental Objectives are to:

- prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters;
- aim to achieve at least ‘Good’ status for all water bodies by 2021. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve Good status by 2027;
- meet the requirements of WFD Protected Areas;
- promote sustainable use of water as a natural resource;
- conserve habitats and species that depend directly on water;
- progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment;
- progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants; and
- contribute to mitigating the effects of floods and droughts.

The framework for delivering the Directive is through the definition of River Basin Districts (RBDs) and the River Basin Management Plans (RBMPs)[7]. The current and objective ‘Overall Status’, ‘Ecological Status/Potential’ and ‘Chemical Status’ classifications of each surface water body is set out in the relevant RBMP. Background information regarding the water body status classification process that applies under the WFD is provided in Appendix A.

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[5] EU Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council; of 23 October 2000; Establishing a framework for Community action in the field of water policy.

[6] Statutory Instruments, 2017 No.407, The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017

[7] See: https://www.gov.uk/government/collections/river-basin-management-plans

All new (and currently on-going) activities in the water environment need to consider the requirements of the WFD to ensure that no changes occur that:

a. cause a deterioration of current status of a water body; and
b. prevent the achievement of the future status objectives of a water body (i.e. GES or GEP by 2021 or 2027).

This principle is now integrated into the project/option appraisal process, as well as the EIA requirements for proposed schemes/activities under the town and country planning system.

A2.2 Water Framework Directive Directions (England & Wales) 2015

Under the WFD, a range of environmental standards and condition limits are applied in order to define water body status and the set status objectives via the RBMP process to support “healthy” aquatic life. For instance, standards are set for the composition of biological communities, the physicochemical water quality parameters, the concentration of pollutants, and the level of flows in rivers. These standards inform NRW on the implementation of the RBMP process, including the identification of measures required to support the achievement of GES/GEP objectives, as well as underpinning efforts to protect the water environment by helping to regulate activities that could cause adverse impacts.

A2.3 Cycle 2 River Basin Management Plans

The ‘Cycle 2’ RBMPs were released in 2015 and are an update to the ‘Cycle 1’ plans originally published in 2009. This study has been conducted based on the 2015 Cycle 2 RBMP water body status classification data. This data comprises the latest information that is currently available regarding the baseline condition of WFD water bodies in the UK.

A3 Determination of WFD status

A3.1 Introduction

Surface water bodies and Groundwater bodies are defined within WFD legislation. There are three types of surface water body, as follows:

- Natural water bodies;
- Heavily Modified Water Bodies (HMWBs);
- Artificial Water Bodies (AWBs).

The overall status of natural surface water bodies is determined on the basis of their Ecological Status and Chemical Status (see **Figure B2.1** below). The overall status of Heavily Modified and Artificial Water Bodies is classified based on their Ecological Potential and Chemical Status. The overall status of groundwater bodies is determined on the basis of their Quantitative Status and Chemical Status.

Groundwater bodies are defined within WFD legislation as Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU) and their status is determined on the basis of quantitative and chemical sub-elements.

The means by which these determinations are made for both surface water and ground water bodies is described below.

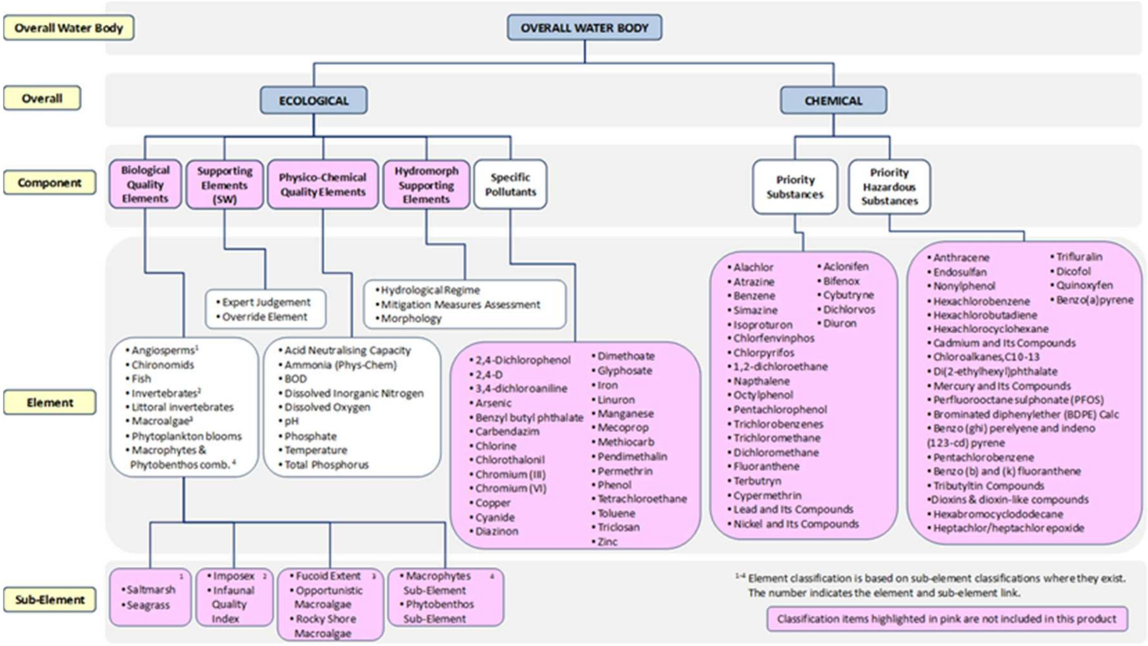

Figure B2.1 Overview of the Ecological Status and Chemical Status classification components for natural surface water bodies [EA, 2015]

A3.2 Determination of the Ecological Status of natural surface water bodies

A3.2.1 Ecological Status

Ecological Status is defined by the overall quality of the structure and functioning of aquatic ecosystems associated with surface waters, i.e. the condition of the watercourse. This is assigned on a scale of High, Good, Moderate, Poor or Bad, and on the basis of four classification elements or 'tests', as follows:

Biological - This test is designed to assess the status indicated by a Biological Quality Element such as fish, invertebrates, macrophytes or phytobenthos (diatoms). The Biological Quality Elements can influence an overall water body status from Bad through to High. It is also important to note that the presence of invasive species prevents a water body from achieving high status when all other elements attain high.

Physicochemical - This test is designed to assess the status indicated by Physicochemical Quality Elements such as dissolved oxygen, phosphorus and ammonia, against environmental standards. The Physicochemical Quality Elements can only influence an overall water body status from Moderate through to High.

Specific pollutants - This test is designed to assess compliance with environmental standards for concentrations of Specific Pollutants, such as zinc, cypermethrin or arsenic. As with the physicochemical test, the specific pollutant assessment can only influence an overall water body status from Moderate through to High.

Hydromorphology - For natural surface water bodies this test is undertaken by the Environment Agency during classification when the biological and physicochemical tests indicate that a water body may be of High status. It specifically assesses Hydromorphological Quality Elements such as water flow, sediment composition and movement, continuity, and structure of the habitat against reference or 'largely undisturbed' conditions. If the Hydromorphological Quality Elements do not support High Ecological Status, then the status of the water body is limited to Good overall status. Hydromorphological assessments are used to determine 'High' overall Ecological Status only, and are not be used to drive a water body status class below Good. The 'does not support good' classification should be reported for the purposes of identifying water bodies which fail the flow test.

The worst case classification is assigned as the overall surface water body status, in a 'one-out all-out' system. This system is summarised in **Figure B2.2**.

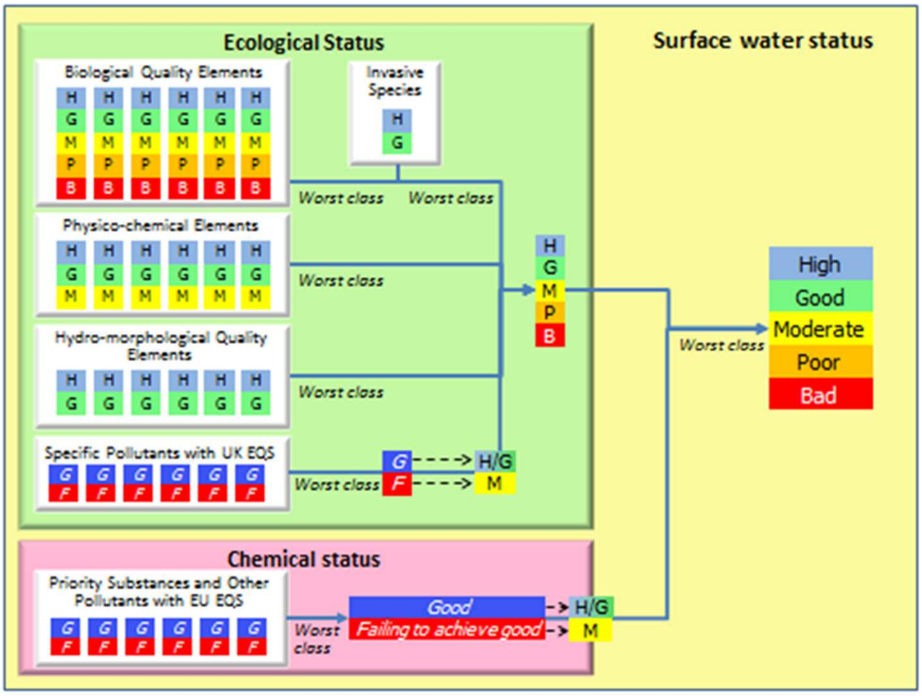

Figure B2.2 WFD classification elements for surface water body status. [Source: Environment Agency Rules for Assessing Surface Water Body Status and Potential (2015)]

A3.2.2 Chemical Status

Chemical Status is defined by compliance with environmental standards for chemicals that are Priority Substances and/or Priority Hazardous Substances, in accordance with the Environmental Quality Standards Directive (2008/105/EC). This is assigned on a scale of Good or Fail.

Surface water bodies are only monitored for Priority Substances where there are known discharges of these pollutants; otherwise surface water bodies are reported as being of Good Chemical Status.

A3.3 Determination of Ecological Potential for Heavily Modified (and Artificial) Water Bodies

Ecological Potential is assigned to Artificial Water Bodies (AWB) (such as reservoirs and canals), or natural water bodies which, as a result of physical alterations by human activity, are substantially changed in character. The latter are termed Heavily Modified Water Bodies (HMWB). The term ‘Ecological Potential’ is used to classify AWBs and HMWBs as it may be impossible for these water bodies to achieve Good Ecological Status (GES) because of their creation or modification for a specific use, such as navigation, water supply or flood protection. The Ecological Potential of an AWB or HMWB represents the degree to which the quality of the water body approaches the optimum condition it could achieve given its artificial or heavily modified state.

AWB and HMWBs are subject to an additional set of rules that need to be implemented prior to running the one-out-all-out process. These rules determine which Biological Quality Elements should be used in the water body Ecological Potential classification. Under normal circumstances, AWB and HMWBs are classified according to an assessment of Mitigation Measures, which defines Good Ecological Potential in water bodies where all applicable mitigation is in place, and Moderate Ecological Potential in water bodies where some or all relevant mitigation is missing. However, to prevent AWB and HMWBs being incorrectly classified as good potential in situations where all mitigation is in place, but other pressures are causing an impact (e.g. nutrient enrichment or pollution from toxic substances), the methodology adopted in the UK additionally considers biological indicators providing they are not sensitive to the heavily modified nature of the water body.

AWB and HMWB hydromorphological elements are assessed using a 3 stage process, firstly looking at flow, then Mitigation Measures and Biological Quality Elements.

Flow conditions are assessed initially on a fail or pass basis to determine which of the Biological and Physicochemical Quality Elements should be used in the classification of Ecological Potential.

Where the flow conditions are unaffected by the physical modification (flow conditions pass), the water body potential is determined by the worst of either the Mitigation Measures assessment, or any element that is not sensitive to the modified nature of the water body.

Where the flow conditions are significantly impacted by the physical modification (flow conditions fail), the water body potential is determined by the worst of any of the Mitigation Measures assessments or the assessment of Biological Quality Elements, Physicochemical Quality Elements or Specific Pollutants.

Where a water body is designated as Artificial or Heavily Modified for water resources usage, either solely or jointly with other uses, the flow condition is assumed to be good (pass).

A3.4 Determination of the Ecological Status of groundwater bodies

Under the WFD, groundwater body status is classified on the basis of Quantitative Status and Chemical Status. The groundwater bodies are separated into Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU). GWMU are sub-divisions of the groundwater to aid the resource assessment process. WRMU are sub-divisions according to the water resource availability and the management of water.

A3.4.1 Quantitative Status

Quantitative Status is defined by the quantity of groundwater available as base flow to watercourses and water-dependent ecosystems and as ‘resource’ available for use as drinking water and other consumptive purposes. It is assigned on a scale of Good or Poor, and on the basis of four classification elements or 'tests' as follows:

Saline or other intrusions - This test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions.

Surface water - This test is designed to identify groundwater bodies where groundwater abstraction is leading to a significant diminution of the Ecological Status of associated surface water bodies.

Groundwater Dependent Terrestrial Ecosystems (GWDTE) - This test is designed to identify groundwater bodies where groundwater abstraction is leading to significant damage to associated GWDTE.

Water balance - This test is designed to identify groundwater bodies where groundwater abstraction exceeds the 'available groundwater resource', defined as the rate of overall recharge to the groundwater body itself less the rate of flow required to meet the ecological needs of associated surface water bodies and GWDTE.

A3.4.2 Chemical Status

Chemical Status is defined by the concentrations of a range of key pollutants, by the quality of groundwater feeding into watercourses and water-dependent ecosystems and by the quality of groundwater available for drinking water purposes. This is assigned on a scale of Good or Poor, and on the basis of five classifications elements or 'tests', as follows:

Saline or other intrusions - This test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions.

Surface water - This test is designed to identify groundwater bodies where groundwater is leading to a significant diminution of the chemical status of associated surface water bodies.

GWDTE - This test is designed to identify groundwater bodies where groundwater is leading to significant damage to associated GWDTE.

Drinking Water Protected Areas (DrWPA) - This test is designed to identify groundwater bodies failing to meet the DrWPA objectives defined in Article 7 of the WFD or at risk of failing in the future. The aim is no deterioration in quality of waters for human consumption.

General quality assessment - This test is designed to identify groundwater bodies where widespread deterioration in quality has, or will, compromise the strategic use of groundwater. The aim is no significant impairment of human use of groundwater and no significant environmental risk from pollutants across a groundwater body.

Status is assessed primarily using data collected from the Environment Agency monitoring network; therefore the scale of assessment means that groundwater status is mainly influenced by larger scale effects such as significant abstraction or widespread diffuse pollution. The worst case classification is, as with surface water bodies, assigned as the overall groundwater body status, in a ‘one-out all-out’ system. This system is summarised below in **Figure B2.4.**

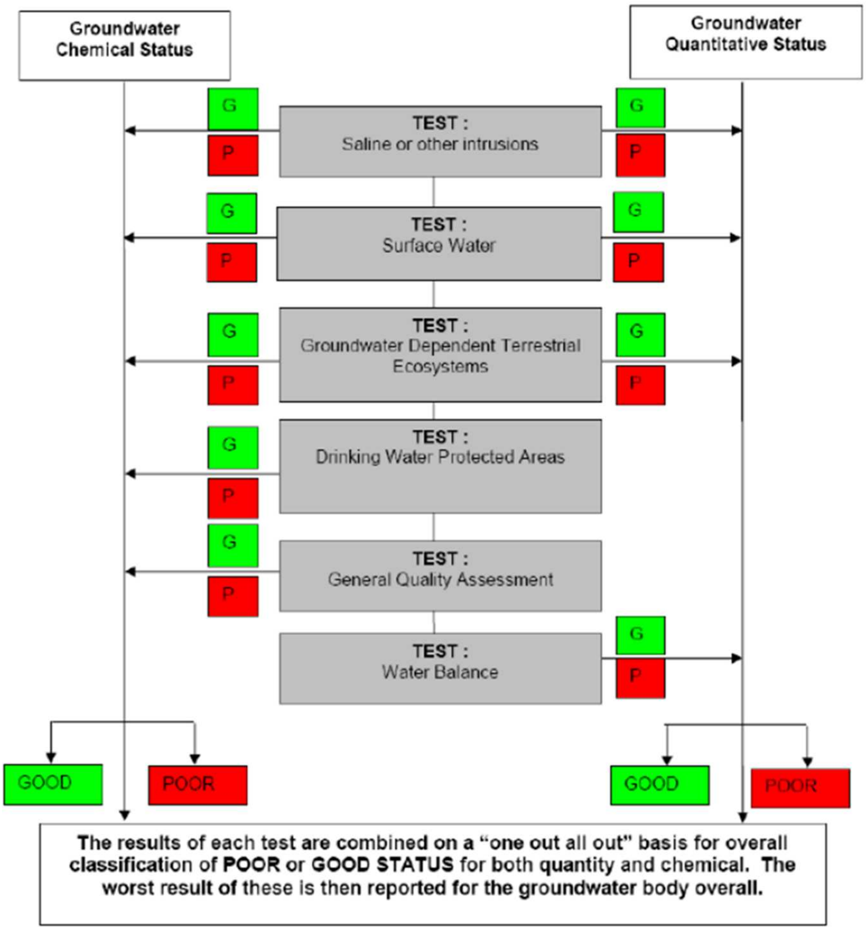

Figure B2.4 WFD classification elements for groundwater body status. [Source: Environment Agency Groundwater Quantitative Status Assessment (Classification) Method Statement]

A4 Assessing Deterioration

Any activity that has the potential to have an impact on ecological status of a water body (as defined by the biological, physic-chemical, and hydromorphological quality elements) needs consideration as to whether it could cause deterioration in the current Ecological Status or Ecological Potential classification. Deterioration is reported as a negative change between classes in Ecological Status or Potential (e.g. from Good to Moderate status).

Moreover, all activities that could impact on watercourses also need to be considered in terms of whether they will compromise the ability of the water body to reach Good Ecological Status or Good Ecological Potential by the date specified in the RBMP.

Appendix B: Detailed Assessment Results

B1 Method A – HAWRAT

B1.1 Methodology

The drainage design of the Scheme directs runoff from the carriageway to four attenuation basins prior to discharge into surface waters via four new outfalls. The locations of the outfalls and receiving water bodies are illustrated in Figure 7.3 and listed in Table 10.

Method-A of HD45/09 (‘Simple Assessment’) has been used to assess the operational effects of the road surface runoff from the four proposed outfalls (Figure 7.3). A cumulative assessment of impacts has not been undertaken as the outfalls either discharge to separate waterbodies or are greater than 1km apart.

B1.2 Inputs

The predicted traffic data for the proposed Scheme is 11,241 AADT in 2017 and 13,050 AADT in 2051, which is within the lowest range used in the HAWRAT assessment of between 10,000 and 50,000 AADT. The water hardness was estimated based on Dwr Cymru Welsh Water’s (DCWW’s) online checking service[8] at 70 mg/l CACO3, placing it within the Medium category for HAWRAT. This hardness of the local water supply (Llanddewi Velfrey) was assumed to be a robust proxy of the water hardness in local watercourses/runoff in the absence of water quality testing.

The effectiveness of the proposed 3 stage treatment train, provided to mitigate contamination in road runoff, is shown in Table 11.

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[8] Dwr Cymru Welsh Water: http://www.dwrcymru.com/en/In-Your-Area/Water-Quality.aspx

Table 10 Input values for the HAWRAT assessments. Undertaken using the Method-A approach in HD 45/09.

Outfall	**Chainage**	**Receiving Watercourse**	**Q95**	**Impermeable Area (ha)**	**Permeable Area (ha)**	**BFI**	**Downstream structure**	**Protected Site downstream**	**River Width**
Basin A	0+400	Unnamed tributary of Afon Marlais	0.001	2.21	0.398	0.551	N	N	0.5
Basin B	1+900	Longford Brook	0.003210805	2.219	0.391	0.551	N	N	1.5
Basin C	2+900	Unnamed tributary of Afon Daulan	0.001	2.444	0.411	0.551	N	N	1
Basin D	4+250	Unnamed tributary of Afon Marlais	0.001	1.305	0.456	0.551	N	N	1

Table 11 Treatment efficiencies of proposed carriageway runoff treatment trains

Treatment Step	**Proposed Mitigation**	**Treatment Efficiency (% reduction)**		
		Copper	**Zinc**	**Sediment**
Step 1	Filter Drain	65	65	67.5
Step 2	Catchpits	0	0	40
Step 3	Attenuation basin	65	65	77.5
Cumulative		76	76	84

Sources:

1. CIRIA C609: Table 3.7 for efficiency of filter drains and attenuation basins (median value used).
2. Auckland Regional Council: Quantification of Catchpit Sediments and Contaminants (October 2009), Table 1. Median value used.

NOTE: For cumulative efficiency the treatment stages were assumed to work at 50% of original efficiency for each subsequent step after step 1. This is based on the conservative cumulative removal efficiency recommended in CIRIA C609.

B1.3 Results

Table 12 Outputs from the HAWRAT assessments. Undertaken using the Method-A approach in HD45/09.

Outfall	**Chainage**	**Watercourse**	**HAWRAT**													
			Step 1			**Step 2**			**Treatment performance required (% reduction)**					**Step 3**		
			Copper	**Zinc**	**Sediment**	**Copper (ug/l)**	**Zinc (ug/l)**	**Sediment**	**Copper**	**Zinc**	**Sediment**	**Proposed Mitigation**	**Greenfield Runoff**	**Copper (ug/l)**	**Zinc (ug/l)**	**Sediment**
Basin A	0+400	Unnamed tributary of Afon Marlais	Fail	Fail	Fail	1.37 (Fail)	4.90 (Fail)	Fail	30	25	89	Filter drain, catchpit, detention basin	9.13	PASS	PASS	FAIL
Basin B	1+900	Longford Brook	Fail	Fail	Fail	0.61 (Pass)	2.24 (Pass)	Fail	0	0	76	Filter drain, catchpit, detention basin	9.14	PASS	PASS	PASS
Basin C	2+900	Unnamed tributary of Afon Daulan	Fail	Fail	Fail	1.47 (Fail)	5.23 (Fail)	Fail	30	30	84	Filter drain, catchpit, detention basin	9.99	PASS	PASS	PASS
Basin D	3+855 (on eastern roundabout)	Unnamed tributary of Afon Marlais	Fail	Fail	Fail	0.95 (Fail)	3.39 (Pass)	Fail	10	0	72	Filter drain, catchpit, detention basin	6.16	PASS	PASS	PASS

B1.4 Summary

The surface water quality of the undiluted runoff for all sections on the road fail Step 1 of the assessment because levels of sediment and dissolved metals in the runoff are above the threshold levels set in the HAWRAT model.

At Step 2, the surface water quality passes the HAWRAT assessment at Basin B and for zinc at Basin D but fails on all other counts for both sediment and dissolved metals.

At Step 3, the three stage treatment train included in the proposed drainage design (Table 11) is added to the assessment as a mitigation. With this included, all discharge locations pass the assessment for soluble pollutants and discharges from Basins B, C and D also pass for sediment but the discharge from Basin A marginally fails (Table 12).

This marginal failure for sediment can be discounted as any discharges of road runoff from Basin A would likely be going into groundwater due to the low flow of the watercourse (Q95 < 0.001 m^3/s). In this case a Method C assessment is more appropriate.

The assessment of long term impacts of surface water runoff from the highway has been undertaken by comparing the annual average concentrations of copper and zinc predicted in the HAWRAT results with the EQSs stated in the WFD (Standards and Classifications) Directions 2015. The standard for Copper is 1µg/l bioavailable. The standard for Zinc is 10.9 µg/l plus the ambient background concentration for freshwaters depending on the river catchment[9]. The ambient background concentration is not currently defined for the Cleddau, Marlais and Taf catchments so the default concentration of 1.4 µg/l is used.

The predicted concentrations are below the EQS thresholds for both copper and zinc at all locations, other than Basin's A and C, where the threshold for copper is exceeded. These failures are discounted as discharges of road runoff at these locations would likely be infiltrating into groundwater rather than entering surface waters, due to the low flow of the watercourses (Q95 < 0.001 m^3/s). A detailed assessment of the risk of this discharge to groundwater is undertaken in Appendix B3.

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[9] WFD (Standards and Classifications) Directions 2015; Table 2.

B2 Method C - Assessment of Pollution Impacts from Routine Runoff on Groundwater

B2.1 Methodology

Annex I of the DMRB Environmental Assessment Techniques guidance (Volume 11, Section 3, Part 10 HD 45/09) provides a methodology (Method C) to assess the potential impact on the quality of groundwater resources from routine runoff discharges to the ground.

This risk assessment procedure is based on the study of the source-pathway-receptor (S-P-R) protocol. The principles of this approach have been applied to the disposal of road drainage whereby the:

- Source term comprises the road drainage water with any pollutants contained therein, as it enters any unlined ditch, watercourse or soakaway discharge system, that has the potential to transmit water through the ground to groundwater;
- Pathway term represents the processes, which may modify the pollutants during transmission through the discharge system and soil and subsoil until the actual 'point of entry' to groundwater (this includes the unsaturated zone);
- Receptor, which is the groundwater.

For there to be a risk of impact to groundwater, all elements of the S-P-R model have to be present to create a pollutant linkage.

The drainage solution for the proposed Scheme includes four attenuation basins (Basins A to D) that discharge to the surface water courses. For the purpose of the assessment, two assessment scenarios have been conservatively assumed, a drainage ditch receiving the surface water runoff will be drained in a linear soakaway prior to discharging to a basin; on event of the runoff water discharging into the attenuation basin, it has been assumed that it will also act as a soakaway.

The method uses the tables below to determine the risk score, by incorporating the key factors affecting level of risk posed by the source of pollutants, the persistence and movement of pollutants within the pathway to groundwater and linkages between them. In this way the matrix provides a means of ranking specific road drainage discharge sites in terms of their potential risks to groundwater.

B2.2 Inputs

B2.2.1 Source (applied to all scenarios)

Traffic Density (component number 1)

The current two way annual average daily traffic (AADT) is currently very low and so is taken as a low risk score of <50,000.

Rainfall Volume (component number 2)

According to the Flood Estimation Handbook(FEH), the average annual rainfall for the A40 scheme is 1300mm

Rainfall Intensity (component number 2)

According to the Flood Estimation Handbook(FEH), which provides the mapped distribution of modelled 1 hour design rainfall for a 1 in 100 year return period, shows that the rainfall intensity is 38mm/hr. The A40 scheme therefore has a rainfall intensity in the uneven category in the risk assessment matrix, which relates to 35-39mm FEH hour rainfall.

B2.2.2 Pathway

Soakaway Geometry (component number 3)

While no soakaway exists, for the purpose of the assessment the drainage ditch and the basin to which road surface run-off is piped has been taken as a continuous linear ditch or a single point.

Unsaturated Zone (component number 4)

Groundwater monitoring undertaken as part of the 2016 Mott MacDonald investigations indicated shallow groundwater to be present within the lower lying areas of the scheme and in the vicinity of watercourses. Groundwater levels were typically recorded between 1 and 4mbgl.

Flow Type (component number 5)

The underlying geology consists of bedrock predominantly comprising mudstones strata, weathered in places to a firm/stiff clay near its surface. No significant fracturing of the bedrock was recorded. Flow type of infiltrating waters in the weathered and unweathered unsaturated zone is therefore considered to be dominantly intergranular flow although it should be noted that infiltration into the bedrock will be minimal.

Effective Grain Size (component number 6)

The ground investigation logs indicate the weathered bedrock to be recovered as gravelly clay or clayey gravels with the following clay minerals contents (grain size >0.07um):

- Weathered conglomerate of the Portfield and Haverford Formation -30%
- Weathered Haveford Mudstone Formation – between 12% and 40%
- Weathered Slade and Redhill Formation - between 18% and 25%

Therefore the dominant effective grain size has been categorised fine sand or below.

Lithology (component number 7)

Review of particle size distribution tests reveals that the majority of estuarine alluvium have a clay content >15%. The soils have been given a low risk score of >15% clay minerals.

B2.3 Results

Table 13 Overall Risk Score for Existing Site Conditions – Basin A

Component Number		Weighting Factor	Property or Parameter	Site Data	Risk Score	Component Score	
1	SOURCE	15	Traffic Density	<50,000	Low risk - 1	15	
2		15	Rainfall Volume (annual averages)	Average Annual Rainfall of 1300mm	High risk -3	45	
			Rainfall Intensity	38mm/ hour	Med. risk -2		
3	PATHWAY	15	Soakaway Geometry	Continuous linear ditch	Low risk - 1	15	30
				Single point – basin	Med. Risk - 2		
4		20	Unsaturated Zone	Water table is approximately 4m below ground level based on monitoring data	High risk - 3	60	
5		20	Flow Type	Intergranular flow in the bedrock – weathered conglomerate of Portfield and Haveford Mudstone Formation.	Low risk - 1	20	
6		7.5	Effective Grain Size	Review of logs suggest the predominant material is gravelly silt and clay	Low risk -1	7.5	
7		7.5	Lithology	The clay contents according to particle size distribution (PSD) results are typically >15%.	Low risk -1	7.5	
Overall Risk Score						**170**	**185**

Table 14 Overall Risk Score for Existing Site Conditions – Basin B

Component Number		**Weighting Factor**	**Property or Parameter**	**Site Data**	**Risk Score**	**Component Score**	
1	**SOURCE**	15	Traffic Density	<50,000	Low risk - 1	15	
2		15	Rainfall Volume (annual averages)	Average Annual Rainfall of 1300mm	High risk -3	45	
			Rainfall Intensity	38mm/ hour	Med. risk -2		
3	**PATHWAY**	15	Soakaway Geometry	Continuous linear ditch	Low risk - 1	15	30
				Single point –basin	Med. Risk - 2		
4		20	Unsaturated Zone	Water table is approximately 1.2m below ground level based on groundwater strikes	High risk - 3	60	
5		20	Flow Type	Intergranular flow in bedrock – weathered mudstone of Haverford and Portfield and Haveford Mudstone Formation.	Low risk - 1	20	
6		7.5	Effective Grain Size	Review of logs suggest the predominant material is weak mudstone	Low risk -1	7.5	
7		7.5	Lithology	Mudstone	Low risk -1	7.5	
					Overall Risk Score	**170**	**185**

Table 15 Overall Risk Score for Existing Site Conditions – Basin C

Component Number		**Weighting Factor**	**Property or Parameter**	**Site Data**	**Risk Score**	**Component Score**	
1	**SOURCE**	15	Traffic Density	<50,000	Low risk - 1	15	
2		15	Rainfall Volume (annual averages)	Average Annual Rainfall of 1300mm	High risk -3	45	
			Rainfall Intensity	38mm/ hour	Med. risk -2		
3	**PATHWAY**	15	Soakaway Geometry	Continuous linear ditch	Low risk - 1	15	30
				Single point –basin	Med. Risk - 2		
4		20	Unsaturated Zone	Water table is approximately <1m below ground level based on monitoring data	High risk - 3	60	
5		20	Flow Type	Intergranular flow in superficial deposits or bedrock – mudstones of Slade and Redhill Formation	Low risk - 1	20	
6		7.5	Effective Grain Size	Review of logs suggest the predominant material is clayey gravel/ gravelly clay	Low risk -1	7.5	
7		7.5	Lithology	The clay contents according to particle size distribution (PSD) results are typically <5% - >1%	Med. risk -2	15	
					Overall Risk Score	**177.5**	**192.5**

Table 16 Overall Risk Score for Existing Site Conditions – Basin D

Component Number		**Weighting Factor**	**Property or Parameter**	**Site Data**	**Risk Score**	**Component Score**	
1	**SOURCE**	15	Traffic Density	<50,000	Low risk - 1	15	
2		15	Rainfall Volume (annual averages)	Average Annual Rainfall of 1300mm	High risk -3	45	
			Rainfall Intensity	38mm/ hour	Med. risk -2		
3	**PATHWAY**	15	Soakaway Geometry	Continuous linear ditch	Low risk - 1	15	30
				Single point – basin	Med. Risk - 2		
4		20	Unsaturated Zone	Water table is approximately 2.5m below ground level based on monitoring data	High risk - 3	60	
5		20	Flow Type	Intergranular flow in bedrock – mudstones of Slade and Redhill formation	Low risk - 1	20	
6		7.5	Effective Grain Size	Review of logs suggest the predominant material is mudstone	Low risk -1	7.5	
7		7.5	Lithology	Mudstone	Low risk -1	7.5	
					Overall Risk Score	**170**	**185**

B2.4 Summary

The risk scores of between 170 and 192.5 are within the 150 – 250 DMRB suggested action class range, which indicates there is a **medium risk of impact**.

For the medium risk impact mitigation measures should be considered to protect groundwater, the DMRB guidance suggests the need for and nature of the mitigation measures should be informed by additional risk assessment (Section B3).

B3 Further Groundwater Assessment

B3.1 Methodology

Additional groundwater risk assessment has been carried out using the Environment Agency's P20 Hydrological Risk Assessment for Land Contamination. This is a more detailed computer based model, which takes account of transport and fate properties, and aquifer properties to identify the extent of any contaminative impact on the groundwater. The RD20 model conservatively considers a continuous input and does not take into account a potential reduction in source. No degradation is applied.

The purpose of this additional risk assessment is to demonstrate the level of concern of contamination in relation to specific receptors by determining the distance that a contaminant will reduce in concentration from an initial runoff value to a specific threshold value. Threshold values include Environmental Quality Standard (EQS) guidelines. In this case receptors include water courses with a Q95 flow of greater than 0.001 m^3/s.

The HAWRAT modelling undertaken for each of the basin locations derived the following concentrations of the marker contaminants, copper and zinc:

Table 17 HAWRAT derived concentrations of copper and zinc compared against the EQS standards

Outfall	Cu, ug/l	Zn, ug/l
Basin A Discharge	1.37	5.91
Basin B Discharge	0.6	2.63
Basin C Discharge	1.47	6.29
Basin D Discharge	0.95	4.14
EQS	1	13.7

This indicates that copper concentrations measured in Basin A and Basin C discharge may pose a risk to groundwater quality. These will be assessed further.

B3.2 Inputs

Parameters
The reasoning behind each parameter used in the model is discussed below.

Target Concentration

- Copper – 1 x 10^{-3} mg/l

Environmental Quality Standard guidelines.

Initial Contaminant Concentration

- Copper – 1.37 ug/l (Basin A) and 1.47 ug/l (Basin C)

95% ile contaminant concentration from HAWRAT assessment of no flow.

Half Life

9 x 10^{99} days – copper is soluble and assumed to have little or no degradation.

Width of Plume

2m – Q95 flow less than 0.001m^3/s, therefore assumed to be a point source with a width of approximately 2m.

Length of Plume

2m – Q95 flow less than 0.001m^3/s, therefore assumed to be a point source with a width of approximately 2m.

Plume Thickness

2.12 x 10^{-1} m – in accordance with Level 2 Soil Assessment which takes account of length of plume, aquifer thickness, hydraulic conductivity of aquifer, hydraulic gradient, width of plume and background concentration of contaminant in groundwater.

Saturated Aquifer Thickness

4m –the 2016 investigations encountered at least 8m of weathered conglomerates; considering the depth to the water table of 4m, thickness of the saturated aquifer has been assumed to be 4m for Basin A.
9m - the 2016 investigations encountered approximately 9m of weathered conglomerates; considering the depth to the water table of less than 1m, thickness of the saturated aquifer has been assumed to be 9m for Basin C.

Bulk Density of Aquifer Materials

1.84 g/cm^3 – literature value typical bulk density of weathered mudstones;
2.48 g/cm^3 - literature value typical bulk density of unweathered mudstones.

Effective Porosity

0.4/0.2 – Literature review indicates porosity of mudstones between 20 and 40%. 40% has been assumed for the weathered conglomerates and 20% for the unweathered mudstones.

Hydraulic Gradient

0.04/0.1 – Calculated using groundwater level at each outfall location and topography.

Hydraulic Conductivity of Aquifer

Literature review indicates permeability of mudstones between 0.1 and 0.3m/d.
0.3 m/d –weathered conglomerates
0.1m/d – unweathered mudstones

Partition Coefficient

- Copper – 2.5 l/kg

Values taken from Table 11.1 in RISC4 user manual.

B3.3 Results

Table 18 summarise the results of the additional risk assessment for copper for Basin A and C. The parameters used in the model and the reasoning behind the parameters are also discussed below.

Table 18 Summary of additional hydrogeological risk assessment for copper at Basin A.

95%ile Initial Contaminant Concentration (ug/l)	Distance to Compliance Point (m)	Remedial Target Concentration (ug/l)
1.37	10	0.027
1.37	20	0.007
1.37	30	0.003
1.37	40	0.002
1.37	50	0.001

Table 19 Summary of additional hydrogeological risk assessment for copper at Basin C.

95%ile Initial Contaminant Concentration (ug/l)	Distance to Compliance Point (m)	Remedial Target Concentration (ug/l)
1.47	10	0.029
1.47	20	0.008
1.47	30	0.003
1.47	40	0.002
1.47	50	0.001

🟩 •	Remedial target greater than initial concentration (no mitigation measures required)
🟥 •	Remedial target less than initial concentration (mitigation measures required for receptors within distance)

B3.4 Summary

The results demonstrate that the contaminant concentrations resulting from a long-term discharge of surface runoff diminish to the acceptable levels for copper at a distance of approximately 10m from the attenuation basins and outfalls. This is due to the anticipated dilution within the aquifer. Therefore, although the initial assessment indicated a potential ‘medium’ risk scenario of impact on groundwater, the detailed assessment indicated that the routine run-off discharge may only result in the localised impact limited to the proximity of the attenuation basin or outfall.

B4 Method D - Accidental Spillage

B4.1 Methodology

The risk of an accident resulting in a serious pollution incident to surface or groundwaters has been assessed for each proposed drainage outfall using the Method-D assessment outlined in the HD45/09 Volume 11, Section 3, Part 10. This assessment was carried out using vehicle numbers from the 2051 AADT flows to account for future growth.

On all roads, there is a risk that an accidental spillage or vehicle fire may lead to an acute pollution incident. It is generally accepted that the pollution risk on any road is linked to the risk of a HGV road traffic accident. Where a spillage does reach a surface watercourse the pollution effect can be *severe,* but is usually of short duration.

The acceptable risk of a pollution incident is stated in HD45/09. The acceptable risk of pollution reaching a sensitive watercourse or groundwater is: an annual probability of less than 1%; or a return period of 1 in 100 years.

B4.2 Results

Table 20 Results of the Accidental Spillage assessment. Undertaken using the Method-D approach detailed in HD45/09 based on traffic flow in design year 2051.

Location	Road Reference	Start chain age (m)	End chainage (m)	Length (km)	Receiving reach	Table D1.1 Road Category	2-way AADT	%HGV	%HGV factor	Factored %HGV	Pspl	P_{pol} (table D 1.2)	P_{inc}
Basin A	Penblewin Roadabout			0.10		3.09	13090	8	1	8	0.012%	0.6	0.007%
	A40 trunk road	0	1150	1.15		0.29	12060	8	1	8	0.012%	0.6	0.007%
Basin B	A40 trunk road	1150	2450	1.30		0.83	11960	8	1	8	0.038%	0.6	0.023%
	A40 Junction to old A40			0.04		0.93	600	8	1	8	0.000%	0.6	0.000%
Basin C	A40 trunk road	2450	3786	1.34		0.29	12020	8	1	8	0.014%	0.6	0.008%
	Bethel Chapel Roundabout W			0.10		3.09	11810	8	1	8	0.011%	0.6	0.006%
	A40 slip road to Bethel Chapal Roadabout			0.13		0.83	590	8	1	8	0.000%	0.6	0.000%
Basin D	A40 trunk road	3786	4306	0.52		0.29	11790	8	1	8	0.005%	0.6	0.003%

B5 Assessment of potential impact of dewatering and excavation works associated with construction of cuttings

B5.1 Penblewin Roundabout

Baseline conditions review identified a number of features that are reliant on groundwater (such as wells) and associated with shallow groundwater and surface water drainage features (such as issues or collects) within 500m of the proposed Penblewin Roundabout, as detailed in Table 21. The locations are shown on Figure 7.2A.

Table 21 Features identified within 500m of the proposed Penblewin Roundabout.

ID	Feature type	Approximate distance	Approximate ground elevation, mOD	Base flow	Surface water catchment
1	Headwater	200m W	94	Surface water run-off/ groundwater	Longford Brook
5	Well	350m N	75		
	Headwater				
3	Headwater	470m SW	80		Afon Marlais

B5.1.1 Impact on Groundwater Level/Flow

The review of published geology and results of ground investigations completed in the area of the proposed cutting, indicate the presence of mudstones of the Slade and Redhill Formation. The bedrock dip is shown to be 15° to the north.

Construction of Penblewin Roundabout would require generally shallow excavations, up to 2-3m deep to achieve construction depth of approximately 90 mOD. As shown on a long geological cross section (Drawing A40LVP-ARP-VGT-SWI-SK-C-0003 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III), the excavations would be undertaken primarily within the mudstones. The 2016 ground investigations recorded groundwater strikes at 75-76 mOD in that part of the scheme with the monitored levels at 76 mOD and therefore no dewatering is likely to be required. Consequently no impact on the groundwater flow/levels is anticipated.

B5.1.2 Impact on Surface Water Catchment Area

The watershed between the Longford Brook and the Afon Marlais is located to the north of the proposed roundabout and the proposed cutting is unlikely to impact the catchment area of the watercourses associated with the Longford Brook (i.e. Feature ID 1 and 5). The proposed roundabout is also located outside the catchment of Feature ID 3 and therefore is unlikely to impact it. Consequently, construction of the Penblewin Roundabout is unlikely to impact the surface water flows.

B5.2 Cutting 1

Baseline conditions review identified a number of features that are reliant on groundwater (such as wells, springs) and associated with shallow groundwater and surface water drainage features (such as issues or collects) within 500m of the proposed cutting 1, as detailed in Table 22. The locations are shown on Figure 7.2B.

Table 22 Features identified within 500m of the proposed Cutting 1.

ID	Feature type	Approximate distance to Cutting 1	Approximate ground elevation, mOD	Base flow	Surface water catchment
13	Well	250m W	74	Groundwater	Longford Brook
18	Start of a land drain	100m W	82	Surface water run-off/ groundwater	
19	Well/	60m W	94	Groundwater	
	Start of a land drain			Surface water run-off	
20	Collects	60m N	92	Groundwater/ Surface water run-off	
25	Spring	440m S	105		
21	Issues	150m E	94		Afon Daulan
22	Issues	250m E	105		
23	Issues	400m NE	70		

B5.2.1 Impact on Groundwater Level/Flow

The review of results of ground investigations completed in the area of the proposed cutting, indicate the presence of interbedded mudstones, sandstones and conglomerates of the Portfield and Haverford Mudstone Formation rather than the Slade and Redhill Formation as shown on published geology plans. This is presented on Figure 05 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III. The bedrock dip is shown to be 30° to the north and 25° to the south in the vicinity of the cutting, in line with a syncline nature of the bedrock formation. A fault crosses the proposed alignment at approximate scheme chainage 2+000. The bedrock dip and fault are shown on A40LVP-ARP-VGT-SWI-SK-C-0003 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III.

Construction of Cutting 1 would require up to 6m deep excavations to achieve construction depth of approximately 99 mOD. As shown on a long geological cross section (Drawing A40LVP-ARP-VGT-SWI-SK-C-0003 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III), the excavations would be undertaken primarily within the mudstone and may slightly extend into the underlying sandstones of the Portfield and Haverford Mudstone Formation. The excavations are unlikely to encounter the conglomerates of that formation. This may result in groundwater contained within the sandstone strata draining into the cutting, potentially creating a gradient into the cutting, locally impacting groundwater flows within the sandstones.

Considering the elevation of Feature ID 22, there is a potential for that feature to be impacted. The geological plan indicates that it is associated with the conglomerates of the Portfield and Haverford Mudstone Formation. Although the construction of the cutting is unlikely to impact these strata, it is likely that the sandstones and conglomerates are in hydraulic continuity and therefore draining of the sandstones may locally impact groundwater regime within both water bearing strata. Groundwater strike was recorded in BH101 at approximately 100 mOD, just slightly above the proposed construction depth and therefore no significant lowering of a groundwater level will be required. Considering a distance to Cutting 1 (approximately 250m) the impact on Feature 22 is unlikely to be significant.

Features ID 13, 18, 19, 20 and 23 are located at lower elevation than the construction depth and therefore any dewatering activities or drainage are unlikely to impact the groundwater regime within which these features are set. Considering the distance from the cutting, Feature ID 25 is also unlikely to be impacted by the cutting.

B5.2.2 Impact on Surface Water Catchment Area

The proposed Cutting 1 is unlikely to have a significant impact on surface water catchment areas of Feature ID 18, 21, 22 or 23. Construction of Cutting 1 is likely to significantly reduce the catchment area for Features ID 19 and 20.

Feature ID 19 and 20 both minor watercourse, direct tributaries to the Longford Brook, which discharges to the Eastern Cleddau River. These watercourses are likely to be associated with surface water drainage /shallow subsurface groundwater flows and therefore a review of potential impact on a catchment area for these watercourses is undertaken. These watercourses are located to the south of a ridge presenting a watershed between two minor watercourses and are within the Longform Brook catchment area. The reduction in the catchment area may result in lower flows within both watercourses, however, it is unlikely to significantly impact the Longform Brook catchment area as a whole, and also Feature ID 19 is likely to be more reliant on groundwater due to the well presence. This is because the proposed scheme drainage, as shown on Drawing W-ARP-HDG-B15-20-SK-CX-000001, would collect that water and discharge into another tributary of the Longford Brook via Basin B.

B5.3 Cutting 2

Baseline conditions review identified a number of features that are reliant on groundwater (such as springs), and associated with shallow groundwater and surface water drainage features (such as issues or collects) within 500m of the proposed Cutting 2, as detailed in Table 23. The locations are shown on Figure 7.2B.

Table 23 Features identified within 500m of the proposed Cutting 2.

ID	Feature type	Approximate distance to Cutting 2	Approximate ground elevation, mOD	Base flow	Surface water catchment
19	Well/ Start of a land drain	500m SW	94	Surface water run-off/ Groundwater	Longford Brook
20	Collects	300m W	92		
21	Issues	70m SW	94		Afon Daulan
22	Issues	70m SW	106		
23	Issues	300m NW	70		
24	Issues	430m NW	65		
26	Collects	60m NE	80		
27	Spring	150m SE	89		
28-33	Collects	250-380m SE	102-110		
35	Collects	320m E	87		
36-38	Collects	450-490m E	85		
39	Collects	250m NE	65		

B5.3.1 Impact on Groundwater Level/Flow

The review of published geology and results of ground investigations completed in the area of the proposed cutting, indicate the presence of mudstones of the Slade and Redhill Formation with conglomerates of the Portfield and Haverford Mudstone Formation present in the western part of the cut footprint. The Slade and Redhill Formation bedrock dips 15^{o} to the north-west and the conglomerates to the south (dip not provided), in line with a syncline nature of the bedrock formation.

Construction of Cutting 2 would require up to 14m deep excavations to achieve the construction depth of approximately 95 mOD in the east and 90 mOD in the west. As shown on a long geological cross section (Figure 05 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III), the excavations would encounter both formations. This may result in groundwater contained within the conglomerate strata, encountered during the ground investigations at approximately 101 mOD, draining into the cutting, potentially creating a gradient towards the cutting, locally impacting groundwater flows. Groundwater strikes were also recorded within the mudstones at approximately 93-94 mOD in the eastern part of the cut, at or below the proposed construction level.

All identified features to varied extent are likely to be dependent on groundwater flows. Features ID 23, 24 and 26 are located at lower elevation than the construction depth of the cut and therefore groundwater flows are unlikely to be significantly impacted. Features ID 19, 20, 35 to 38 are located at a similar elevation as the base of the proposed cutting and therefore considering the distance to the cutting, it is unlikely that the Proposed Scheme would impact groundwater level or flow associated with these features.

Features ID 28 to 33 are all located in the area underlain by the mudstones of the Haverford Mudstone Formation. The collects are likely to be fed by shallow groundwater flows within the weathered zone. The proposed Scheme is unlikely to impact these strata and therefore it is unlikely that the Proposed Scheme would significantly impact groundwater level or flow associated with these features

There is however a potential that the Proposed Scheme could impact Features ID 21, 22 and 27. As shown on Figure 7.2B, these features are located within or near the outcrop of conglomerates of the Portfield and Haverford Mudstone Formation and it is likely that their flows are associated with groundwater contained within these deposits. Ground investigations undertaken within the area of Cutting 2 recorded water strikes within the Slade and Redhill Formation at approximately 94 mOD and in the conglomerates of the Portfield and Haverford Mudstone Formation at approximately 100 mOD. Considering the construction depth of the excavations, dewatering is likely to be required to the formation level in that section of the cut to approximately 92 mOD. All three considered features are located at similar depth or higher than the proposed cut. However, based on the estimated elevation (at approximately 89 mOD) and distance to the cut (150m), Feature ID 27 is unlikely to be significantly impacted by the construction of the cut. This is also likely to be the case for Feature ID 21. Feature ID 21 is located at the western end of the cutting section, where formation levels are at a higher elevation of 95 mOD. Considering the elevation of Feature 21 at 94 mOD and distance to the cutting section of 70m, Feature ID 21 is unlikely to be significantly impacted by the construction of Cutting 2.

There is however a potential risk of impacting the flows of groundwater which provide the base flow to a stream associated with Feature ID 22. The dewatering during construction and the applied drainage system for the scheme is likely to locally lower groundwater levels to below the spring (Feature ID 22) elevation and create a gradient towards the cutting and away from the spring, which potentially would impact the flows in the area of Feature ID 22. The groundwater intercepted by the cutting drainage/dewatering works, would be discharged into the attenuation Basin C. This basin discharges into a stream (associated with Feature ID 26 marked on Figure 7.2A). The affected stream, for which Feature ID 22 provides a base flow and the stream receiving the outflow of the attenuation basin C, are both in the catchment of Afon Daulan. Therefore the impact on the surface water would only be localised to a minor watercourse, and is unlikely to have an impact the wider catchment of Afon Daulan or Afon Taf.

B5.3.2 Impact on Surface Water Catchment Area

All identified features are associated with surface water drainage/ shallow groundwater flows within associated catchment areas. Catchment areas of all these features, except for Feature ID 26, are located away from the proposed cutting and therefore no impact is anticipated. A significant part of the catchment area of Feature ID 26 would be impacted by the cutting by intercepting the water that otherwise would have discharged into Feature ID 26. However, the proposed scheme drainage, as shown on Drawing W-ARP-HDG-B15-20-SK-CX-000001, would collect that water and discharge into the affected watercourse via Basin B. Therefore, no impact on Feature ID 26 is likely to occur.

B5.4 Cutting 3 and Llanddewi Velfrey Roundabout

Baseline conditions review identified a number of features that are reliant on groundwater (such as springs), and associated with shallow groundwater and surface water drainage features (such as issues or collects) within 500m of the proposed Cutting 3, as detailed in Table 24. The locations are shown on Figure 7.2B.

Table 24 Features identified within 500m of the proposed Cutting 3.

ID	Feature type	Approximate distance to Cutting 3	Approximate ground elevation, mOD	Base flow	Surface water catchment
26	Collects	470m NW	80	Surface water run-off/ Groundwater	Afon Daulan
27	Spring	260m W	89		
28-33	Collects	330 - 350m SW	102-110		
34	Spring	370m SW	130		
35	Collects	150m NW	87		
36-38	Collects	130 - 150m N	85		
39	Collects	300m NW	70		
44	Spring	95m NE	90		Afon Taf
45	Collects	240m NE	70		
46	Spring	270m NE	105		
61	Private water supply	150m N	102		
47	Spring	490m NE	55		
48	Spring	300m E	96		
53	Headwater	290m E	95		Afon Marlais
54	Issues	250m SE	95		
55	Collects	260m SE	97		

ID	Feature type	Approximate distance to Cutting 3	Approximate ground elevation, mOD	Base flow	Surface water catchment
56	Issues	280m SE	96		
52	Issues	360m SE	95		
57	Issues	400m SE	60		
59	Collects	400m S	100		
58	Issues	370m S	95		
43	Collects	400m S	85		

B5.4.1 Impact on Groundwater Level/Flow

The review of published geology and results of ground investigations completed in the area of the proposed cutting, indicate the presence of mudstones of the Slade and Redhill Formation with conglomerates and sandstones of the Portfield and Haverford Mudstone Formation present in the western link road footprint. The Slade and Redhill Formation bedrock dips 30-35° to the north and 60° to the south, and the conglomerates/sandstones to the south (dip not provided), in line with a syncline nature of the bedrock formation. Refer to the Arup GIR, enclosed in Appendix 6.3, Volume III.

Construction of Cutting 3 would require up to 15m deep excavations to achieve the construction level of approximately 106 – 112 mOD; and approximately 6m on the proposed link roads with the existing A40 to achieve the construction level of approximately 112 mOD to the east and 130 mOD to the west. As shown on a long geological cross section (Figure 06 presented in the Arup GIR, enclosed in Appendix 6.3, Volume III), the excavations would encounter the mudstones within the main cutting area. No groundwater was encountered during the ground investigations within the cutting area. Therefore no significant dewatering is likely to be required during the construction works and consequently no impact on groundwater flows or levels is anticipated.

Construction of the eastern link road, however may encounter conglomerates, which may contain water. This may result in groundwater contained within these water bearing strata draining into the cutting, potentially creating a gradient towards the cutting, locally impacting groundwater flows. However, no features associated with conglomerates strata have been identified with 500m of the cutting.

B5.4.2 Impact on Surface Water Catchment Area

All identified features are associated with surface water drainage/ shallow groundwater flows within associated catchment areas. Catchment areas of all these features, except for Features ID 36 to 38, and 44 to 45, are unlikely to be impacted by the construction of Cutting 3 and Llanddewi Velfrey Roundabout.

A significant part of the catchment area of Features ID 36 to 38, and 44 to 45 would be impacted by the cutting. The drainage associated with the cutting would intercept the water that otherwise would have been discharged into these features.

These features provide base flow to a tributary to the Afon Daulan (Features 36 to 38) and to a tributary to the Afon Taf (Features ID 44 and 45). The proposed scheme drainage, as shown on Drawing W-ARP-HDG-B15-20-SK-CX-000001, would collect the drainage water from Cutting 3 and discharge into another tributary to the Afon Daulan via Basin C. Drainage water from the access route would be discharged to the Afon Marlais catchment via Basin D. The construction of the cutting may result in decrease in flows within the impacted minor surface water courses. However, it is considered that this would be a localised issue, and is unlikely to have a significant impact on the overall catchment of the Afon Daulan or Afon Taf.

B5.5 Summary

Construction of the cuttings has a potential to locally impact hydrogeology by influencing groundwater levels, gradient and flow rates as a result of either dewatering works or drainage. The cuttings may also reduce the catchment areas for water courses where a base flow is dependent on surface water run-off and flows within shallow subsurface.

The assessment identified nine features that may be impacted by the construction of the cuttings (Table 25); the impacts are likely to be localised and affect the minor watercourses by reduction in base flow. In the majority of the cases, the flows intercepted by the highway drainage would be returned into the affected catchments via attenuation basins and therefore the overall impact on hydrogeological and hydrological setting of the scheme area is unlikely to be significant.

Table 25 Identified features potentially impacted by cutting construction and/or operation

ID	Feature type	Approximate distance to cutting causing potential impact	Approximate ground elevation, mOD	Base flow affected	Direct surface water catchment
19	Start of a land drain	60m NE of Cutting 1	94	Surface water catchment	Longford Brook
20	Collects	60m N of Cutting 1	92		
22	Issues	70m S of Cutting 2	105	Groundwater	Afon Daulan
26	Collects	60m NE of Cutting 2	80	Surface water catchment	
36-38	Collects	130 - 150m N of Cutting 3	85	Surface water catchment	
44	Spring	95m N of Cutting 3	90	Surface water catchment	Afon Taf
45	Collects	240m NE of Cutting 3	70	Surface water catchment	

Welsh Government

A40 Llanddewi Velfrey to Penblewin Improvements

Appendix 7.2 Flood Risk Note

A40LVP-ARP-HDG-SWI-FN-D-0001

P04 | S4
18/01/19

Contents

1 Introduction

The Welsh Government appointed Carillion to Design and Construct the Llanddewi Velfrey to Penblewin section of the A40 Improvements. In January 2018, Carillion went into liquidation and so Welsh Government awarded a contract to Arup supported by RML to complete the contract.

The need for the improvement of the A40 arose in December 2004 when the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study came about as a result of a number of previous reports that all concluded that the A40 needed improvement.

2 Technical Note Purpose

This note aims to identify the risks imposed by the Scheme in relation to flooding. The following types of flooding have been considered:

- Fluvial Flooding
- Surface Water and Highway Flooding
- Ground Water Flooding

The risk posed, if any, from each type will be quantified using the relevant statutory guidance and any subsequent requirements for the Scheme will be identified.

3 Flood Risk

3.1 Fluvial Flooding

Technical Advice Note 15 (TAN 15) – Development and Flood Risk (2004) provides technical guidance which supplements the policy set out in Planning Policy Wales, November 2016 (PPW) in relation to development and flooding. This provides a framework within which risks arising from fluvial, tidal flooding, and runoff can be assessed.

The Natural Resources Wales (NRW) and TAN 15 Development Advice Maps (DAMs) identify areas of extreme flood risk categorised into three zones (A, B and C with subdivision into C1 and C2). An extract of the DAM is provided in Figure 1.

The entirety of the Scheme is located within Zone A and is considered to be at little or no risk of flooding. Therefore, in accordance with TAN 15 Figure 1, no further consideration of flood risk is required.

The NRW flood risk map (extract provided in Figure 2) also shows the Scheme is not located in an area which is at risk of fluvial flooding. There could still be minor/ordinary watercourses that have not been included within the NRW study, but consultation with Pembrokeshire County Council (PCC) has not raised any issue with flooding.

In accordance with Section 9 of TAN 15, no constraints relating to flooding are applicable, other than to avoid increasing risk of flooding elsewhere. In order to achieve this, the following principles will be followed:

- If possible, the highway runoff will be infiltrated into the ground. This can be achieved through the use of attenuation/ infiltration basins.
- If infiltration is not possible, surface water runoff will be restricted to the 1 year return period Greenfield Runoff Rate (GRR). This will be determined from a hydrological assessment and is to be confirmed with PCC.
- Attenuation will be provided in ponds/infiltration basins, with a maximum storage depth of 2m with 0.5m freeboard to the top of the pond. The ponds will be sufficient in size to accommodate the 1 in 100 year event with an allowance for climate change.
- Where a new drainage system is to be provided, or where an existing drainage network is to connect into the proposed network, the restricted flow will include the 1 in 1 year flow from the existing highway as well as the GRR from the new highway. This will be basis for calculating the required attenuation volumes, subject to confirmation from PCC.
- Several watercourses/streams cross the route of the proposed Scheme. The flows in these watercourses will be maintained within their catchment through culverts.
- The proposed cross drainage culverts will be designed to convey the 100 year event flows beneath the proposed highway with an allowance of 30% for climate change. There will be a freeboard of 300mm or a quarter of the diameter, whichever is greater. The culverts will be designed in accordance with the requirements of the DMRB, CIRIA Report 689, PCC, and may require a 150mm embedment for environmental reasons.
- Where the catchment area draining to the cross drainage culvert is not readily defined, the minimum culvert diameter will be 1200mm in accordance with the Design Manual for Roads and Bridges (DMRB).

3.2 Surface Water and Highway Flooding

The NRW surface water flood risk maps identify areas which are likely to be at risk of surface water flooding as shown in Figure 2. The Scheme crosses some areas which have been identified as at risk of surface water flooding. These areas correspond to low spots in the existing topography where existing watercourses are present. In particular the area to the south of Ffynnon Woods is shown as being at high risk of surface water flooding, which is defined by NRW as being greater than 1 in 30 year return period. This area currently has a meandering smaller watercourse running through it and culverts which mean that a pooling of surface water will be avoided. Generally across the site, the use of culverts at identified low points will mitigate any risk of surface water flooding.

Some low-lying sections of the existing A40 are shown to be at risk however the maps do not take into consideration existing positive drainage networks. As the existing highway is known to have a positive drainage network, this risk is considered negligible.

In addition to the principles outlined in Section 3.1, the following principles will be followed to mitigate the impacts of surface water flooding.

- The highway drainage will be designed in accordance with the requirements of the Design Manual for Roads and Bridges (DMRB), in particular HD33/16 which considers surface water/ highway flooding.
- A positive drainage system will be provided for the Scheme which will ensure that there is no surface water flooding for a 1 in 5 year return period event.
- No surcharge will be present in the drainage network for a 1 in 1 year event.
- The peak rainfall intensity will be increased by 30% to account for the effects of climate change.

3.3 Groundwater Flooding

no groundwater flooding currently occurring at the site.

Where changes are being made which will impact on groundwater levels, the principles outlined in Sections 3.1 and 3.2 and the following will be applied:

- In cuttings, the surface runoff will be drained to combined surface water/ ground water filter drains in the verge.
- Lined cut-off ditches at the top of cuttings and unlined cut-off ditches at the bottom of embankments will intercept natural runoff. If the natural topography falls away from the road alignment, cut-off ditches will not generally be provided other than to mitigate local flooding risk.
- Any existing land drains encountered will be intercepted and diverted to cut-off ditches.
- Attenuation ponds/infiltration basins will be designed to ensure that ground water will not impede their performance.

4 Conclusions

As the Scheme is located within Zone A, a Flood Consequences Assessment (FCA) is not required.

In accordance with TAN 15, no constraints relating to flooding are applicable, other than to avoid increasing risk of flooding elsewhere. All types of flooding will be suitably managed through the principles outlined in Section 3.

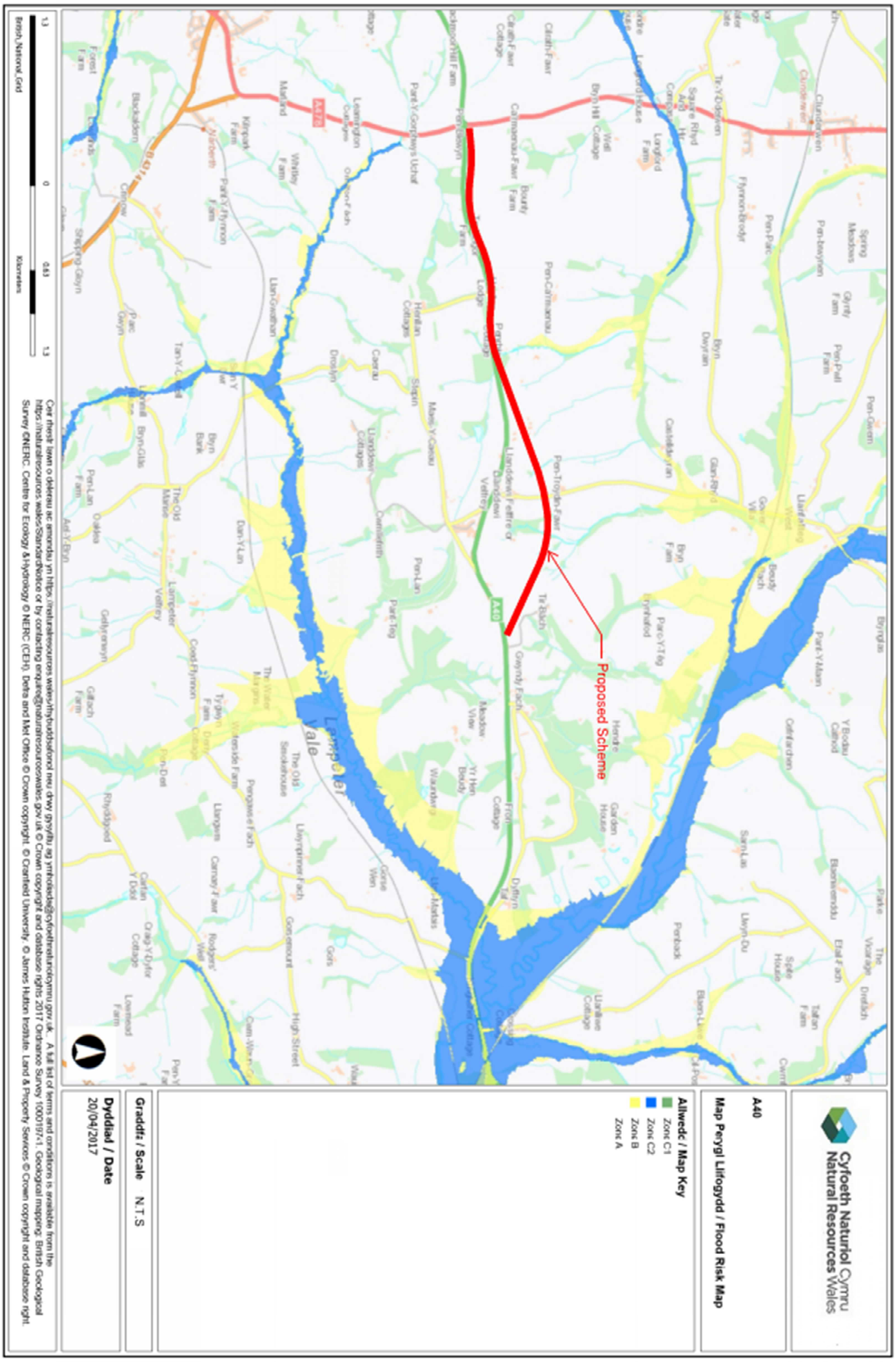

Figure 1 – NRW/ TAN 15 Development Advice Maps

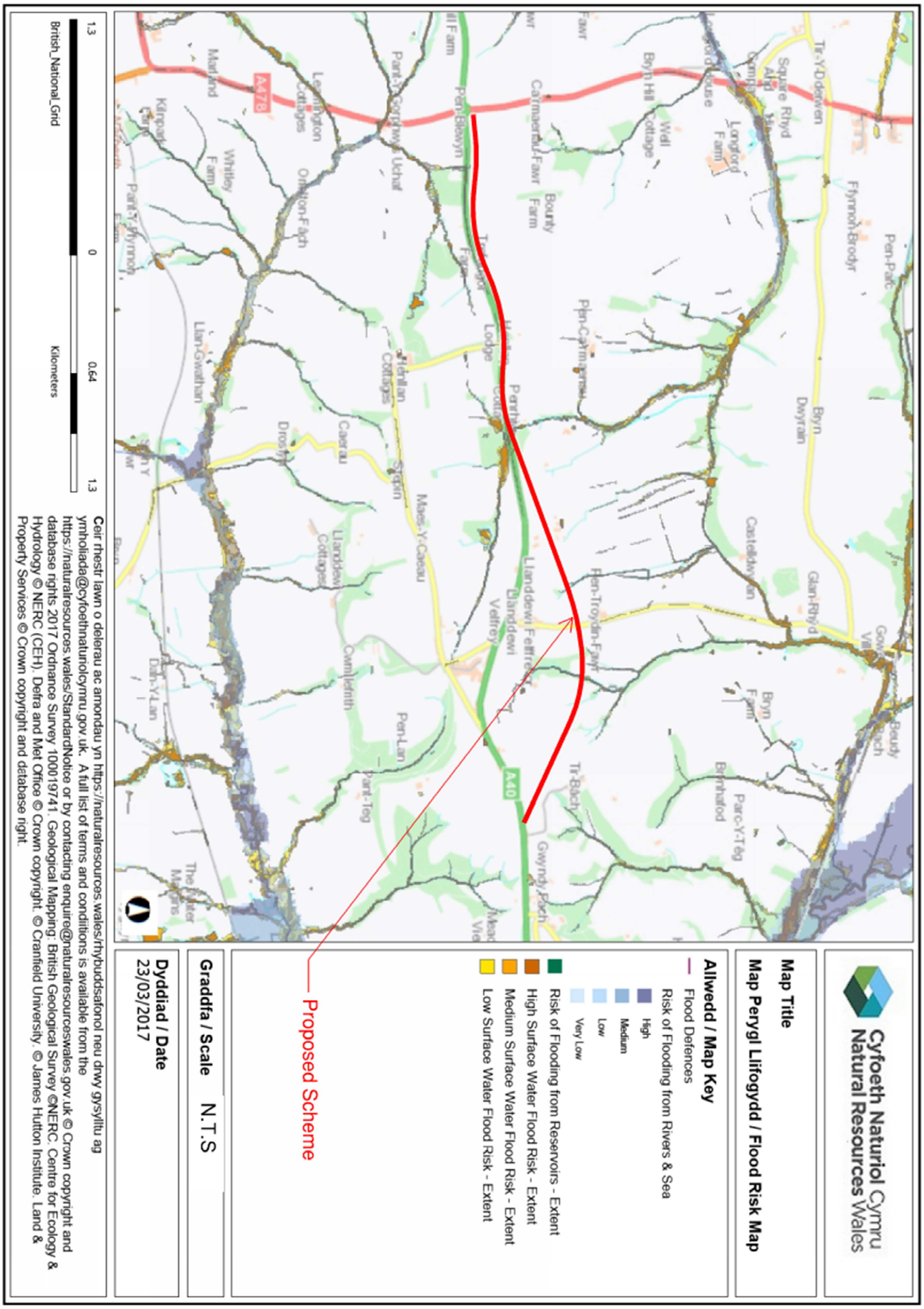

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Figure 2 – NRW Flood and Surface Water