



St. Athan Northern Access Road Preliminary Sources Study Report

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Preliminary Sources Study Report – St. Athan Northern Access Road

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Drawings

AECOM Alignment Drawings:

60509148-SHT-30-0000-CT-0601
60509148-SHT-30-0000-CT-0602
60509148-SHT-30-0000-CT-0603
60509148-SHT-30-0000-CT-0604
60509148-SHT-30-0000-CT-0605

AECOM St. Athan Proposed Exploratory Hole Plans:

60509148-SHT-30-0000-CT-0652
60509148-SHT-30-0000-CT-0653

Appendices

Appendix A – Previous Ground Investigation Information:

Historical Ground Investigation Information Northern Link Road – Logs (Capita Gwent Consultancy, 2003)

St. Athan Defence Technical College Factual Report on Ground Investigation Volume 2/C: Tremains Farm and Eglwys Brewis Road Area, 400& EB Series (Zone H&J) (Soil Mechanics, 2009)

St. Athan Geo-Environmental Validation Report (Pell Frischmann, 2010)

Defence Estates Proposed Service Family Accommodation at Picketston South West, RAF St. Athan Ground Conditions Assessment Report (WYG, 2011)

Appendix B Site Walkover Photographs

Appendix C Envirocheck Report

Appendix D BGS Borehole Logs

Executive Summary

AECOM Limited has been commissioned by the Welsh Government to design a new access road to serve the Aerospace Business Park in St. Athan. The new road, which is referred to as the Northern Access Road, will provide a link from the B4265 near Llantwit Major in the west to Eglwys Brewis Road in Picketston in the east.

This Preliminary Sources Study Report (PSSR) has been prepared in accordance with the requirements of the Design Manual for Roads and Bridges (DMRB) Section 4.1.2, HD22/08 Managing Geotechnical Risk (Ref.1) in order to support the detailed design and construction of the St. Athan Northern Access Road.

This PSSR is based upon a review of documentary records and a preliminary site inspection. Ground conditions, historical use of the land and environmental factors, which may be relevant, have been examined and considered. The report contains a preliminary assessment of the ground conditions, an interpretation of the existing information received and an assessment of geotechnical and geo-environmental factors that may influence the scheme design and construction.

The scheme includes the provision of a 2.0km highway link (single two lane carriageway) with associated drainage features. The alignment includes the crossing of a small number of watercourses (Llanmaes Brook and Boverton Brook) with associated approach earthworks including embankments and cuttings up to 5m in depth/height. Other significant features along the scheme include two culverts and junctions with the existing road network at Eglwys Brewis Road.

The site is located in St. Athan, South Wales approximately 6.3 km west of Cardiff airport. It is accessed from the B4265 via Eglwys Brewis Road. The landscape is predominantly agricultural with the Llanmaes Brook running north to south through the scheme. Boverton Brook and Nant y Stepsau run along the northern and southern boundary of the proposed road respectively. The topography of the Scheme area generally falls towards Llanmaes Brook (Ch. 0 to Ch. 600) after which it is generally flat across the proposed alignment.

Geological maps indicate the site is underlain by the Porthkerry Member (Blue Lias Formation). The mapping does not show any Drift deposits on site. However, discrete deposits of alluvium may be present in the vicinity of the watercourses. Historical mapping shows the proposed alignment has remained largely in open pasture.

Significant Made Ground is not expected to be encountered along the proposed road corridor except in the vicinity of the existing highway network. Findings of the site walkover (including conversations with the tenant farmer at Plot 15 Milllands Farm) suggests there also may be Made Ground present in Plot 16 Tremains Farm in the vicinity of Llanmaes Brook.

A number of historical ground investigations have been carried out within in the vicinity of the St. Athan Northern Access Road. In general, these investigations confirm the information on the published geological maps.

A preliminary geotechnical risk register and geo-environmental risk assessment have been prepared. The risks presented may be reduced significantly during design following ground investigation and through the implementation of appropriate mitigation measures during construction.

1 Introduction

1 Introduction

1.1 Introduction

AECOM Limited has been commissioned by the Welsh Government to design a new access road to serve the Aerospace Business Park in St. Athan. The new road, which is referred to as the Northern Access Road, will provide a link from the B4265 near Llantwit Major in the west to Eglwys Brewis Road in Picketston in the east.

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A site location plan is presented in Figure 1. The current scheme proposals are shown on AECOM Drawings 60509148-SHT-30-0000-CT-0601 to 0605.

This PSSR is based upon a review of documentary records and a preliminary site inspection. Ground conditions, historical use of the land and environmental factors, which may be relevant, have been examined and considered. A Statement of Intent (SOI) for the current scheme was prepared by AECOM in August 2016 (Ref. 2).

This report contains a preliminary assessment of the ground conditions, an interpretation of the existing information received and an assessment of geotechnical and geo-environmental factors that may influence the scheme design and construction.

The report is limited to a geotechnical and geo-environmental assessment of the highway corridor and includes observation of and reference to the surrounding area.

1.2 Limitations

This report is a desk study report, which has been prepared using readily available information in accordance with the project stage requirements, budget and timescales. The opinions expressed in this report and the comments and recommendations given are based on the information obtained from desk assessment and an initial site reconnaissance. At this stage intrusive investigations have yet to be undertaken at site to establish actual ground and groundwater conditions and provide data for assessment of the geotechnical and geo-environmental status of the site.

The information, views and conclusions drawn concerning the site are based, in part, on information supplied to AECOM by other parties. AECOM has proceeded in good faith on the assumption that this information is accurate. AECOM accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to AECOM from others.

The geotechnical and geo-environmental walkover surveys consisted of a general inspection of the site aimed at identifying any obvious signs of geotechnical hazards affecting the site and potential sources of ground contamination. Any risks identified in this desk study are perceived risks, based on the information reviewed; actual risks can only be assessed following a physical investigation on site.

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2 Sources of Information and Desk Study

2 Sources of Information and Desk Study

2.1 Introduction

2.1.1 The following sources of information have been reviewed.

2.2 Topographical Maps

2.2.1 An AECOM scheme specific topographical survey has been prepared.

2.3 Geological Maps and Memoirs

2.3.1 The following British Geological Survey (BGS) map covers the scheme:

- 1:50,000 scale, Sheet 262, Bridgend (1990)

2.3.2 Further geological data was accessed on the BGS Geindex – <http://www.bgs.ac.uk/geindex/home.html> (Ref. 4). This index was checked for borehole records, water wells, geophysical logs, well water levels, faults and other linear features mass movement deposits, artificial ground, superficial deposits and bedrock geology.

2.3.3 Soil Survey and Land Research Centre (SSLRC) - <http://www.landis.org.uk/soilscapes/> (Ref. 5) - Soil maps and reports.

2.4 Mines and Mineral Deposits

2.4.1 The BGS recorded mineral sites database was reviewed which is encapsulated within the Envirocheck report.

2.5 Archaeological and Historical Investigations

2.5.1 Historical Ordnance Survey maps (1: 2,500 and 1:10,560 scales) for the period 1877 to 2006 (Appendix C).

2.5.2 The Zetica portal <http://www.zetica.com> for Unexploded Ordnance data and military history (Ref. 8).

2.5.3 A Heritage Assessment including archaeological investigations are being reviewed by the AECOM Heritage team and will be reported separately.

2.6 Environmental Data and Land-Use Data

2.6.1 A number of information sources have been investigated to determine the general environmental setting of the site, including the following:

- Environmental disclosure report (Ref. 8);
- Department of Environment, Food and Rural Affairs (DEFRA): Agricultural land classification maps, locations of carcass burial pits and notifiable diseases (Ref. 9 and 10).

2.7 Flood Records and Groundwater Vulnerability

2.7.1 Environment Agency, Policy and Practice for the Protection of Groundwater, Groundwater vulnerability 1:100,000 Map series, Sheet 36, Gwent, South and Mid Glamorgan (Ref. 11).

2.8 Other Relevant Information

2.8.1 The relevant desk study and geotechnical/geo-environmental factual and interpretative reports that have been reviewed in preparing this PSSR are listed in Table 2.1.

Table 2.1: Existing Reports

| Title | Report Type | Author | Date Issued | Reference |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------------------|---------------|----------------------------------------|
| St. Athan Defence Technical College Factual Report on Ground Investigation Volume 2/C: Tremains Farm and Eglwys Brewis Road Area, 400& EB Series (Zone H&J) | Factual Report | Soil Mechanics | November 2009 | Report No H9069 |
| Historical Ground Investigation Information Northern Link Road | Logs | Capita Gwent Consultancy | August 2003 | - |
| Defence Technical College and Aerospace Business Park – St. Athan Environmental Statement | Environmental Statement | Entec UK Ltd. | May 2009 | SA-C1XXX-XX-XXX-EN-X-0210 |
| St. Athan Geo-Environmental Validation Report | Validation Report | Pell Frischmann | March 2010 | SA-C100E-RP-XXX-PC-X-3129 |
| Defence Estates Proposed Service Family Accommodation at Picketston South West, RAF St. Athan Ground Conditions Assessment Report | Ground Conditions Assessment Report | WYG Environment | January 2011 | - |
| Defence Estates Service Family Accommodation – St. Athan Tremains Farm Site Ground Conditions Assessment Report | Ground Conditions Assessment Report | WYG Environment | January 2011 | A038833-9/Tremains Farm/PV/Jan 2011/V1 |
| Defence Estates Proposed Service Family Accommodation, North of West Camp, RAF St. Athan | Ground Conditions Assessment Report | WYG Environment | January 2011 | - |
| RAF St. Athan: Explosive Clearance & Development Desk Study | Explosive Clearance & Development Desk Study | Parsons Brinckerhoff | February 2008 | - |
| St. Athan Northern Access Road Phase 1 Geo-Environmental Assessment | Desk Study | AECOM | December 2016 | 60509148 / CFRP0006 |

3 Field Studies

3 Field Studies

3.1 Site Walkover

- 3.1.1 A geotechnical site walkover of the route alignment was undertaken by AECOM on the 28th July 2016. The walkover was undertaken over plots 6 (Great House Farm), 9 (Great House Farm), 14 (Millands Farm) and 16 (Tremains Farm). The tenant farmers for the other plots (12 Froglands Farm, 17 Boverton Court Farm and Rose Cottage) could not be contacted and as such a walkover was not possible over these areas at that time. Walkovers have since been completed across the entire site.
- 3.1.2 The purpose of the site walkover survey was to assess the condition of the site, observe any geotechnical important features and to identify any potential sources of contamination.
- 3.1.3 Generally, the site is predominantly located within an agricultural context. Due to the presence of horses, cattle and arable crops and the inability to contact some landowners, the majority of the site visit was conducted by observing the site from viewpoints along the Elgwys Brewis Road and unnamed farm roads.
- 3.1.4 Site photographs are presented in Appendix B with locations shown on Figure 3.
- 3.1.5 From west to east the site comprises the following areas:
- B4265 located west of the site (Ch.0)
 - Llanmaes Brook is in the western extent of the site and passes through the riding school where there were horses in the fields. It will cross the proposed alignment between Ch. 400 – 420m. At the time of survey the water level in Llanmaes Brook was relatively high which was anticipated due to heavy rainfall on the day. The water was clean and the stream bed was visible.
 - Millands Caravan Park is located approximately 30m north of the proposed road (Ch. 900m).
 - Boverton Brook runs south of the alignment from Ch. 0 – Ch.1570 where it also crosses the proposed alignment Ch. 1520 – Ch1570m.
- 3.1.6 During the initial walkover the Fire Training area and Nant y Stepsau brook were not observed due to hedgerows along Elgwys Brewis Road and locked access gates belonging to the St. Athan MoD site.

4 Site Description

4 Site Description

4.1 General

This section describes a range of geographical, topographical, geological and geo-environmental aspects of the site and includes a review of historical maps of the area.

4.2 Geography

The Scheme corridor is located near the village of St. Athan and crosses a number of parcels of land, currently agricultural land, and adjacent to a number of farm buildings in the western section of the Scheme. The site layout is presented in the scheme alignment drawings in the Drawings Section of this report.

The Scheme area is bounded by agricultural land to the north and south, the B4265 to the west and Eglwys Brewis Road to the east.

4.2.1 Sensitive Land Uses

The Sensitive Land Uses Map of the Envirocheck® Report indicates the Scheme is not in a Nitrate Vulnerable Zone.

4.3 Topography

The topography of the Scheme area generally falls towards Llanmaes Brook (Ch. 0 to Ch. 600) after which it is generally flat across the proposed alignment.

At Ch.0m (B4265) the ground level falls from 44.7m AOD to 35.47 at Llanmaes Brook. The relief then increases from 35.47m AOD to 42.97 at Ch. 600 after which the relief generally remains constant (circa 42.0m AOD).

4.4 Geology

4.4.1 Geological Information from Published Information and Maps

The geological maps, together with the BGS borehole logs indicate that the geology beneath the site consists of the Jurassic Porthkerry Member (Blue Lias Formation); comprising interbedded limestone and calcareous mudstone or siltstone. During the site walkover the tenant farmer for Plot 14 (Millands Farm) indicated that the land was built up in plots 14 (Millands Farm) and 16 (Tremains Farm) and as such Made Ground is anticipated in these areas.

Drift Deposits

The published 1:50,000 scale geological map (Sheet 262 "Bridgend", 1990) indicates there are no superficial deposits on the site. There are localised deposits of alluvium within 60m of the site which were predominantly mapped along Boverton Brook.

Solid Geology

Porthkerry Member (Blue Lias Formation)

The underlying Porthkerry Member can be in excess of 140m thick and comprises limestone, calcareous mudstone and siltstone. Individual limestone beds are usually between 0.1 – 0.3m thick.

4.4.2 Geological Information from BGS Records

The BGS holds an archive of historical borehole logs throughout the UK. The database of borehole logs was searched for any records which would provide useful information on the ground profile at the site. A total of eight exploratory hole logs were obtained from the BGS.

With reference to the BGS mapping, the Scheme is underlain by the Porthkerry Member (Blue Lias Formation). Made Ground is also present across the proposed road alignment. A summary of a selected number of borehole logs representing typical conditions in each locality are described below in Table 4.2. The exploratory hole logs are presented in Appendix D.

Table 4.1 Exploratory Hole Log Data from BGS

| Borehole reference NGR Distance From Site Year | Borehole Type | Stratum ¹ | Description | Depth to Top of Stratum (m bgl) | Level of Top of Stratum (m AOD) | Thickness (m) |
|---------------------------------------------------------------------------------|------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------|-------------------------|
| SS96NE50 (299244, 169080) 180m south of site 2004 No GW | RC | Fill | Boulder clay and fill | G.L. | 43.43 | 1.3 |
| | | Porthkerry Member (Blue Lias Formation) | Limestone, broken bands | 1.3 | 42.13 | 0.7 |
| | | | Slightly weathered, generally strong to very strong, grey blue, smeared light brown fine to medium grained limestone. Sub-horizontal (0 to 5 degrees) and sub-vertical very closely to closely spaced, occasionally medium spaced, stepped and undulating, rough open with a light brown, slightly sandy silt infill (<5mm) | 2.0 | 41.43 | Proven to 12.65m depth. |
| SS96NE51 (299337, 169165) 150m south of site 2004 No GW | ROH | - | No description | G.L. | 42.22 | 1.3 |
| | | Porthkerry Member (Blue Lias Formation) | Boulder Clay (Driller's description) | 1.3 | 40.92 | 0.4 |
| | | | Broken limestone, clay bands. | 1.7 | 40.52 | 3.1 |
| | | | Limestone, broken bands, clay bands | 4.8 | 37.42 | Proven to 15.0m depth |
| SS96NE54 (299476, 169168) 80m south of site 2004 No GW | ROH | Porthkerry Member (Blue Lias Formation) | Boulder Clay (Driller's description) | G.L. | 42.79 | 1.25 |
| | | | Broken limestone (Driller's description) | 1.25 | 41.54 | 1.75 |
| | | | Limestone, clay bands, broken bands (Driller's description) | 1.75 | 41.04 | Proven to 15m depth |
| SS96NE71 (299659, 169091) 60m south of site 2004 | RC | Fill | Fill (Driller's description) | G.L. | 42.97 | 0.8 |
| | | Porthkerry Member (Blue Lias Formation) | Clay (Driller's description) | 0.80 | 42.17 | 1.0 |
| | | | Broken limestone, clay bands (Driller's description) | 1.8 | 41.17 | 0.7 |

| Borehole reference NGR Distance From Site Year | Borehole Type | Stratum ¹ | Description | Depth to Top of Stratum (m bgl) | Level of Top of Stratum (m AOD) | Thickness (m) |
|-------------------------------------------------------------------------|------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------|-----------------------|
| No GW | | | Moderately weathered, moderately strong to strong, grey blue, fine to medium grained limestone. Subhorizontal and subvertical, very closely to closely spaced, undulating and open with grey black clayey infill (<5mm). 5.5m – 15.32m –intermittent bands of moderately weak to weak grey black siltstone | | | Proven to 15.6m |
| SS96NE55 (299878, 169117) 40m south of site 2004 No GW | RC | Made Ground? | Clay (Driller's description) | G.L. | 40.79 | 1.6 |
| | | Porthkerry Member (Blue Lias Formation) | Limestone (Driller's description) | 1.6 | 40.19 | 0.4 |
| | | | Slightly weathered, moderately strong and very strong, grey blue and light brown, fine to medium grained limestone. Subhorizontal, very closely to medium spaces, stepped and undulating, rough, open with slightly sandy silt infill (<5mm) with very weak to moderately weak siltstone. 10.8m – 10.86m – with very soft, brown, very slightly sandy silt. | 2.0 | 39.79 | Proven to 11.0m |
| SS96NE17 (299890, 169210) 40m north of site 2002 GW: 1m bgl | RC | Made Ground | Soft grey black clay fill with cobbles of limestone Hydrocarbon odour from 1m | G.L. | 40.88 | 2.0 |
| | | Porthkerry Member (Blue Lias Formation) | Fractured dark grey crystalline limestone with mudstone and clay bands | 2.0 | 38.88 | Proven to 8.8m depth |
| | | | Heavily fractured light grey crystalline limestone stained orange brown in fractures | 6.6 | | |
| | | | Light grey crystalline limestone with mudstone bands | 7.2 | | |
| ST06NW54 (300100, 169400) 1992 GW:2.75m | RC | Porthkerry Member (Blue Lias Formation) | Brown clay | G.L. | - | Proven to 50.0m depth |
| | | | Weathered block limestone | 3.73 | | |
| | | | Limestone with thin clay bands | 12.12 | | |
| ST06NW122 (300800, 169238) | RC | Porthkerry Member (Blue Lias Formation) | Clay and boulders (Driller's description) | G.L. | 46.47 | Proven to 11.2m depth |
| | | | Limestone | | | |

| Borehole reference NGR Distance From Site Year | Borehole Type | Stratum ¹ | Description | Depth to Top of Stratum (m bgl) | Level of Top of Stratum (m AOD) | Thickness (m) |
|------------------------------------------------------------|------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|---------------------------------------|------------------|
| 200m east of site 2004 No GW | | | Slightly weathered, generally strong to very strong, grey white, fine to medium grained limestone. Sub-horizontal (0-5 degree) closely to very closely and occasionally medium spaced, undulating and stepped, rough with slightly sandy silt infill (<10mm). | | | |

Notes:

1. The geological classification is based on information available on the logs and is therefore indicative only.
2. Borehole type – RC: Rotary Core; ROH: Rotary Open Hole
3. GW – groundwater. In areas where groundwater is not listed no groundwater was encountered.

4.5 Hydrology

4.5.1 Surface Watercourses

During the geotechnical site walkover undertaken on the 28th July 2016 by AECOM the location and current condition of key surface water features was noted. The site walkover was carried out on a rainy day.

The surface water features are presented on the Site Sensitivity Maps shown in the Envirocheck® Report (Appendix C).

The site is mainly located in agricultural land and there are two brooks (Llanmaes and Boverton Brook) which intersect the site perpendicular to the alignment of the proposed road. Nant y Stepsau is located at the eastern extent of the site. The key hydrological features crossing or near the site are listed below:

- Llanmaes Brook flows south, crossing the site between Ch. 400 to Ch. 420m.
- Boverton Brook is generally located south of the alignment between Ch. 0 to Ch. 1570m. The proposed highway alignment crosses the brook in the vicinity of Ch. 1520 to Ch. 1570m.
- Nant y Stepsau flows along the northern and southern boundary of the alignment between Ch. 2175 to Ch. 2350.

4.5.2 Surface Water Abstractions

There are no surface water abstractions associated with the site. Abstractions of less than 20m³ per day do not require a license and therefore may not be identified in this search.

4.5.3 Flooding

The Envirocheck report (Appendix C) indicates that there are localised high risk areas of flooding from rivers and seas (Zone 3) along the scheme associated with the watercourses that either cross or are in the vicinity of the scheme namely Llanmaes Brook, Boverton Brook and Nant y Stepsau. The Environment Agency categorises Flood Zone 3 as “an area that could be affected by flooding, either from rivers or the sea, if there were no flood defences.” The area is anticipated to have a 0.5 per cent (1 in 200) or greater chance of flooding by the sea each year or a 1 per cent (1 in 100) or greater chance of flooding from a river each year.

4.6 Hydrogeology

4.6.1 General Characteristics

The BGS 1:625,000 Hydrogeology map (Ref. 4) describes the Lias Group as rocks with essentially no groundwater. The mudstone and limestone sequence is expected to form local aquifers which yield small supplies of groundwater attributed mainly to the movement of groundwater along discontinuities.

The BGS logs have identified groundwater at 1.0m bgl within the Made Ground and 2.7m bgl within the weathered Porthkerry Member. It is anticipated that the groundwater encountered within the Made Ground was perched water. It is expected that the groundwater encountered within the Porthkerry Member will yield small quantities of water.

4.6.2 Vulnerability of Groundwater Resources

The Groundwater Vulnerability Map of the area indicates that the Porthkerry Member (Blue Lias Formation) is classified by the Environment Agency (EA) as a Minor Aquifer, defined as: 'fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although these aquifers will seldom produce large quantities of water for abstraction, they are important for both local supply and in supplying base flow to rivers.'

4.6.3 Licensed Groundwater Abstraction

There are no groundwater abstractions within the site. However there is one recorded groundwater abstraction within 99m north east of the site. The site does not lie within a source protection zone.

4.7 Soil Survey

The 1: 100,000 scale Soil Survey of England and Wales (Sheet No. 36 Mid Glamorgan), indicates that the soils in the study area are of intermediate to high leaching potential which either has the potential to "transmit a wide range of pollutants (intermediate leaching potential) or readily transmit non-absorbed pollutants and liquid discharges but which have some ability to attenuate absorbed pollutants and liquid discharges but which have some ability to attenuate absorbed pollutants (high leaching potential)'.

4.7.1 Soil Chemistry

Widespread, naturally-occurring chromium (40-60 mg/kg) and nickel (15-30 mg/kg) (associated with the geological conditions (clays) in the St. Athan area, have been identified in the soils beneath the site.

4.8 Historical Development

4.8.1 Sources of Information

A review of the history of the site and adjacent area has been undertaken using historical maps dated between 1877 and 2016. The maps were obtained as part of an Envirocheck® Report.

Reference to historical Ordnance Survey (OS) maps provides invaluable information regarding the land use history of a site. However, it should be noted that historical evidence will be incomplete for the period pre-dating the first edition and between successive maps.

4.8.2 Historical Mapping

Historical Ordnance Survey maps (1:2,500 and 1:10,560) have been obtained and reviewed to establish the historical development of the site. It should be noted that any development occurring between map editions will not necessarily have been recorded and some mapping of the site for certain periods was unavailable.

Table 4.2 Site History

| Year [scale] | Features on-site | Features off site |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1877 (1:2,500) 1900 (1:10,560) | The site consists of agricultural land. Boverton Brook runs west to east and Llanmaes Brook runs north to south through the scheme. Boverton Brook labelled as Nant y Stepsau on 1:10,000 mapping. | Quarry is situated approx. 50m south of the site in the vicinity of western section of the proposed road. Spring is located approx. 40m and 210m south of the alignment Limekiln and Old Limekiln are identified 40m and 170m south of alignment respectively. Picketston Well is located approx. 70m north of site. |
| 1885 (1:10,560) 1899 (1:2,500) | Shingle heap on site (western section of proposed alignment) | Eglwys Brewis Farm is located approx. 50m south of site. Quarry and Limekiln are located approx. 120m south of proposed road (western section). Railway located approx. 200m south of proposed alignment. |
| 1919 (1:2,500) | No change. | No change. |
| 1943 (1:2,500) | No change. | Limekiln approx. 170m south of western road alignment no longer denoted on mapping. Limekiln approx. 40m south of site now denoted as 'Old Limekiln). Quarry and Limekiln no longer in use. |
| 1969 (1:10,000) (1971 (1:2,500) | No change | Previously undeveloped area east of site is now developed Increased residential development south of Boverton Brook. Artesian well located approx. 280m south of site in the vicinity of the B4265. Llanmaes Brook now labelled on mapping. A number of farms are located in the vicinity north and south of the site. |
| 1979 (1:2,500) | No change | B4256 constructed. |
| 1987 - 1989 | No change | Increased residential development south-west of site and south of Boverton Brook. |

4.9 Geomorphology

The geomorphology of the area is governed by the underlying Jurassic stratigraphy. The relief in this stage is very low and the topography is planar which reflects the lacustrine and mature alluvial origin of the upper sediments.

4.10 Mineral Extraction

There are two records of mining or quarrying within 100m of the site boundary. The Parwg (40m SE) and Great Farm (68m E) opencast quarries were registered limestone quarries (operations have ceased). The historical OS maps have also identified quarries in the vicinity of the site. The details are listed in Table 4.2.

4.11 Man-made Features

The known man-made structures present are at 1) Ch.0m - intersection of the B4265 with the proposed road; 2) Ch.1750m – tie in of the proposed road with Eglwys Brewis Road; 3) Between Ch.2090 - 2153m – second tie in with Eglwys Brewis Road.

4.12 Unexploded Ordnance

According to the Regional Unexploded Bomb Risk map for Glamorgan (Ref. 7), the St. Athan North Access Road is located in an area where the probability of encountering unexploded bombs is moderate. A previous explosive clearance and development desk study undertaken by Parsons Brinckerhoff classifies the site as low to moderate risk of encountering UXO. The UXO conditions should be considered at each phase of the project.

4.13 Services

Existing services within the site extents are as follows:

- Gas service from Ch. 30 to Ch.70
- Foul water service in the vicinity of Llanmaes Brook (Ch. 400m)
- Western Power overhead line (approx. Ch. 470m)
- Foul Water, Western Power (underground services and overhead line) between Ch.870-900m
- Western Power underground services, Gas service, BT service, electric service, Virgin service between Ch. 1560 to Ch. 1580
- Gas, Western Power, Western Power underground service between Ch. 1580 to end of alignment

A number of services are recorded in close proximity to the alignment including BT service Electric HV services, gas and foul water service.

A thorough utility search will be undertaken and the results reviewed. Utilities, including overhead cables, will be included on all design drawings.

4.14 Information from Statutory Authorities Records, etc

Information from the walkover reconnaissance and desk study has identified the following areas of potential sources of contamination that may impact the proposed scheme.

- In vicinity – Fire Training Area (Ch. 1900m)
- In proximity – St. Athan MOD site
- The Envirocheck report details the on-site and off-site potentially contaminative sources is provided as Appendix C.

In addition any Made Ground has the potential for natural/landfill gases and other mobile contaminants and may also present an aggressive chemical environment to concrete structures.

4.15 Geo-environmental and Possible Contamination Issues

Information from the desk study has identified the following potential sources of contamination that may impact the proposed scheme.

Potential on site sources of contamination include:

- Made Ground – possibly present and containing contaminants including asbestos;
- Roads – fuel leakage from vehicles and run off; and
- Unexploded ordnance – there is potential for ordnance to be present due to the proximity to a military facility.
- Potential off site sources of contamination include:
 - Made Ground – present off site as a feature of historical stages of redevelopment of the MOD site;
 - Fire Training Area – present directly north of the site at Ch. 1900m;
 - Fuel Tanks – unknown contents related to the historical air field to the north of the route at approx. Ch.2000m;
 - Unexploded ordnance – potential for ordnance to be present due to the proximity to a military facility; and
 - Radioactive material – radium has been previously identified in the Picketston area north of the site.

MOD St Athan is located both south and north of the site. Previous environmental investigations carried out across the MOD St Athan site by Enviros Aspinwall, Parsons Brinkerhoff (PB) and WS Atkins between 2002 and 2009, as detailed by Entec 2009 (Ref. 6) identified localised contamination of metals, sulphates and petroleum hydrocarbons in soils across both West Camp (area extends from c. 100m - >1000m south of the site Ch.1600m) and East Camp (area adjacent to site extending approximately 1km south east of site Ch. 2700m).

Radiological contamination from the remnants of radium paint had been discovered in the Picketston area (area adjacent to the site's northern boundary) which has been removed in accordance with National Resources Wales (NRW) criteria in 2004. Locally elevated concentrations of metals, petroleum hydrocarbons and sulphate were also identified across the area.

In addition, Made Ground is anticipated on site associated with pre-existing roads (Eglwys Brewis Road and connecting roads) and as a feature of historical stages of redevelopment at the site and could potentially contain asbestos. Made Ground also has the potential for natural/landfill gases and other mobile contaminants and may also present an aggressive chemical environment to concrete structures.

5 Ground Conditions

5 Ground Conditions

5.1 General

Ground investigation data along and near the scheme corridor has been obtained from the reports listed in Section 2. The reports provide limited information regarding the ground and groundwater conditions along the route.

The reports including exploratory hole records are presented in Appendix A.

The ground model based on published information is presented in Section 4 (Table 4.1) with the information presented below supplementing this. An assessment of ground conditions has been carried out using the information available from these previous investigations, site walkover(s) observations and from review of other information detailed in Section 4.

5.2 Soil Mechanics Investigation

A ground investigation (Phase 1) was carried out in November 2009, undertaken by Soil Mechanics under the instruction of Capita Symonds (CS), comprising of machine excavated trial pits, hand dug trial pits, rotary drilled boreholes, handheld windowless sample boreholes, soakaway infiltration tests, in-situ testing/monitoring and a suite of geotechnical laboratory testing. An overview of the ground investigation is presented in Table 5.1.

Table 5.1 Summary of Ground Investigation – November 2009 (Soil Mechanics)

| Exploratory Hole Type | Exploratory Hole ID | Quantity | Maximum Depth (m bgl) |
|-------------------------------|---------------------------------------------|----------|-----------------------|
| Boreholes (Rotary Core) | BH450 and BH455 | 2 | 15 |
| Handheld Windowless Sample | WS01, WS01 and WS02 | 3 | 0.65 |
| Trial Pit (machine excavated) | TP-RP1, TP-402 SA, TP-403 to TP-414, TT-411 | 14 | 3.15 |
| Trial Pit (hand dug) | TP-EB1 to TP-EB8 | 8 | 1.3 |

5.2.1 Made Ground

Made Ground was encountered in most exploratory holes across the scheme. The Made Ground encountered was predominantly associated with the excavation of the exploratory holes within and in the vicinity of the existing road (Eglwys Brewis Road). The material was generally as either tarmacadam (wearing course) or as soft to firm light grey to brown silty sandy fine to coarse gravel of limestone with medium cobble content. Cobbles are limestone (sub-base).

5.2.2 Porthkerry Member (Blue Lias Formation)

The Porthkerry Member was encountered in most exploratory holes across the site. The Porthkerry Member typically comprised strong to very strong light grey limestone. Locally there is light brown staining penetrating up to 2mm and a slight loss of strength along fracture surfaces. Discontinuities are sub-horizontal closely and medium spaced planar and undulating locally with clay infill <2mm. A weathered zone is present which is generally described as firm dark brown slightly sandy gravelly silty clay with low cobble content. Gravel is fine to coarse limestone and cobbles are limestone. The top of the Porthkerry Member was encountered between ground level and 0.55m bgl. Generally, in areas where Made Ground

was absent it was encountered at ground level.

Four (4No.) Atterberg Limit Tests were undertaken on four samples collected from the weathered section of the Porthkerry Member between 0.2m bgl and 0.7m bgl. The plastic and liquid limits ranged from 27% to 44% and 51% to 98% respectively. The plasticity index ranged from 14% to 54%. These results classify the clay to be of high plasticity.

5.2.3 Groundwater

Three groundwater strikes were recorded during the investigation. One strike was encountered at 0.5m bgl in the Made Ground. The other two groundwater strikes were recorded within the weathered Porthkerry Member at 0.72m bgl and 0.8m bgl.

5.2.4 Geo-environmental

Environmental samples were taken during the investigation but the results were not listed in the report.

5.3 Apex Drilling Investigation

A ground investigation was carried out from January to February 2003, undertaken by Apex Drilling and Enviros, comprising of machine excavated trial pits, rotary drilled boreholes and in-situ CBR tests and testing/monitoring. A suite of geotechnical laboratory testing was also performed. An overview of the ground investigation is presented in Table 5.2.

Table 5.2 Summary of Ground Investigation – January-February 2003 (Apex Drilling and Enviros)

| Exploratory Hole Type | Exploratory Hole ID | Quantity | Maximum Depth (m bgl) |
|-------------------------------------|--------------------------------------|----------|-----------------------|
| Boreholes (Rotary air flush) | BH1-BH5, BH9 – BH10, BH17 – BH24 | 14 | 12 |
| Trial Pit (CGC) (machine excavated) | CGCTP1 – CGCTP12 | 12 | 1.9 |
| Trial Pit (machine excavated) | TP1 – TP14, TP17 – TP20, TP27 – TP46 | 36 | 2.2 |
| CBR | CBR1 – CBR16 | 16 | 0.75 |

5.3.1 Made Ground

Made Ground was encountered in two exploratory holes north of the proposed alignment. The material was generally described as firm dark brown clay with gravel and cobbles of limestone. Occasional fragments of blue plastic sheeting, brick and concrete were reported.

5.3.2 Porthkerry Member (Blue Lias Formation)

The Porthkerry Member was encountered in most exploratory holes across the site. The Porthkerry Member typically comprised very weak to strong dark grey thinly to medium bedded crystalline limestone with many large pockets of soft orange brown silty clay. A weathered zone is present which is generally described as firm orange brown very silty clay with low cobble content. Gravel is fine to coarse limestone and cobbles are limestone. Generally, the top of the Porthkerry Member was encountered at ground level. In the areas where Made Ground was present it was encountered between 0.45m and 0.6m bgl.

Atterberg Limit tests were undertaken on five samples collected from the weathered section of the Porthkerry Member between 0.2m bgl and 0.7m bgl. The plastic and liquid limits ranged from 20% to 40% and 50% to 66% respectively. The plasticity index ranged from 26% to 30%. These results classify the clay to be of high plasticity.

Sixteen (16 No.) CBR tests were performed within the Porthkerry Member. The results ranged from 0.9% to 2.1% (avg. 1.4%).

5.3.3 Groundwater

No groundwater information was recorded on the exploratory hole logs.

5.3.4 Geo-environmental

Environmental samples were taken during the investigation but the results were not listed in the report.

5.4 Pell Frischmann Investigation

A ground investigation was carried out from August to October 2009, undertaken by Soil Mechanics, comprising of machine excavated trial pits, windowless sample boreholes and rotary drilled boreholes including testing/monitoring. An overview of the ground investigation is presented in Table 5.3. The St. Athan NAR road lies with the Picketston and East Camp areas in the report.

Table 5.3 Summary of Ground Investigation – August – October 2009

| Exploratory Hole Type | Quantity |
|-------------------------------|----------|
| Boreholes (Rotary) | 17 |
| Trial Pit (machine excavated) | 169 |
| Windowless sample boreholes | 21 |

5.4.1 Made Ground

Made Ground was encountered during the investigation. It was generally thin and associated with the St. Athan MOD site.

5.4.2 Porthkerry Member (Blue Lias Formation)

The Porthkerry Member was generally encountered between 0.4 and 2m bgl. It comprised a weathered section described as sandy gravelly clay with gravel and bedrock. The bedrock was described as horizontally bedded strong to very strong light grey limestone with occasional fossil fragments. The rock is intermittently to regularly interbedded with a weak to medium strong dark grey siltstone or shale, as layers up to 0.35m thick.

5.4.3 Groundwater

The groundwater monitoring results obtained during the ground investigation indicated groundwater depths in the range of 0.32m bgl to 3.32m bgl (41.42m AOD and 42.59m AOD respectively) in Picketston and 3.2m bgl and 9.98m bgl in the East Camp site. The shallowest groundwater results were encountered in the areas of lowest relief along Boverton Brook and Eglwys Brewis Road. Geo-environmental

The results of the geo-environmental tests recorded exceedances of Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAH) and Perfluorooctane Sulphonate (PFOs) within the Made Ground. No contaminant exceedances were recorded within the natural strata.

5.5 WYG Investigation

A ground investigation was carried out between 8th and 13th October 2010, undertaken by White Young Green, comprising of machine excavated trial pits, rotary drilled boreholes, soakaway tests, in situ CBR tests and laboratory geotechnical and environmental testing/monitoring. An overview of the ground investigation is presented in Table 5.4.

Table 5.4 Summary of Ground Investigation – October 2010

| Exploratory Hole Type | Quantity | Depth (m bgl) |
|--------------------------------|----------|---------------|
| Window sample/rotary boreholes | 4 | 4.0 – 5.5 |
| Trial Pit (machine excavated) | 15 | 0.42 – 1.8 |
| Trial Pit (soakaway) | 2 | - |

5.5.1 Topsoil

Topsoil was encountered during the investigation. It generally comprised of firm to stiff clay and ranged in thickness from 0.1m to 0.25m.

5.5.2 Porthkerry Member (Blue Lias Formation)

The Porthkerry Member was generally encountered from ground level to 0.25m bgl. It comprised a weathered cohesive section described as sandy gravelly clay with occasional cobbles of limestone. The bedrock was described as strong grey slightly weathered limestone with closely spaced horizontal to vertical fractures with silt or clay infill.

5.5.3 Groundwater

The groundwater monitoring results indicated groundwater depths in the range of 1.1 to 2.0m bgl. It was concluded that the groundwater strikes were encountered at the interface between the weathered section and the bedrock within the Porthkerry Member.

5.5.4 Geotechnical Tests

A number of geotechnical tests were performed as part of the investigation. The results are summarised in Table 5.5.

Table 5.5 Summary of Geotechnical Test Results – October 2010

| Test | Number of Results | Range (min – max) | Average |
|--------------------------------------------|-------------------|-------------------|---------|
| Natural Moisture Content | 7 | 18 - 36 | 30 |
| Liquid Limit (LL) | 7 | 42 - 64 | 53 |
| Plastic Limit (PL) | 7 | 17 – 38 | 30 |
| Plasticity Index (PI) | 7 | 20 – 27 | 23 |
| Modified Plasticity Index | 7 | 19 – 25 | 21 |
| Undrained Shear Strength (hand shear vane) | 24 | 60 - >120 | 98 |
| CBR (In-situ: Mexe Cone) | 23 | 1 - 14 | 5.5 |
| CBR (laboratory derived) | 2 | 1.8 – 4.4 | 3.1 |



6 Preliminary Engineering Assessment

6 Preliminary Engineering Assessment

6.1 General

The current scheme proposal is shown on the AECOM alignment drawings (60509148-SHT-30-0000-CT-0601 to 0605).

6.2 Cuttings

There is one section of cutting identified along the scheme which is approximately 5m deep and is located between Ch. 0 to Ch. 410m which is illustrated on the AECOM alignment drawing 60509148-SHT-30-0000-CT-0601.

The historical ground investigation data and published geology suggests that weathered material comprising sandy gravelly clay with a low cobble content approximately 1.0m thick. This is underlain by strong to very strong light grey limestone interbedded with siltstone or shale as layers up to 0.35m thick. Shallow groundwater was encountered between 0.32m bgl to 0.8m bgl in the weathered Porthkerry Member. It is likely that groundwater will be encountered during construction of the cutting and appropriate groundwater control may be required.

It is likely that side slopes of 1 in 3 in the weathered cohesive overlying bedrock could be adopted. Below this depth side slopes could be steepened following an assessment using standard rock mechanics and rock slope engineering methods on the basis of discontinuity data from boreholes undertaken within the vicinity of the cuttings. However given the low cut depth a change in gradient is un-likely to be practical. It would be prudent to base assumptions as to what gradients should be adopted for any new rock slopes from observations made elsewhere in the surrounding area.

It is anticipated that most of the material excavated from the cuttings will be potentially acceptable as Class 1 general granular fill. It is likely that some of the rock will require treatment by crushing and screening to meet grading requirements. Any cohesive material encountered may be potentially acceptable as a Class 2 general cohesive fill.

An assessment of RQD and strength indicates digging will generally become progressively harder with depth. However, the use of pneumatic breakers may be required, particularly within fresh material, or where thickly bedded limestone is present locally.

6.3 Embankments

There are three sections of embankment identified along the scheme which are illustrated on the AECOM alignment drawings. The embankments are not expected to exceed 3m in height.

Embankment foundation soils are anticipated to be on the weathered Porthkerry Member (soft to firm clay with gravel) and the unweathered Porthkerry Member (moderately strong to strong limestone). Alluvium may also be present in the vicinity of the watercourses (e.g. Llanmaes Brook). Careful consideration of any cohesive material present will be required to ascertain the effects of loading as embankment construction proceeds and long term settlement effects. Additionally, consideration of the surcharge effect of the approach embankments to Llanmaes Brook will be required.

If Made Ground is identified in areas where embankment is proposed this is likely to require removal or treatment to avoid unpredictable settlement of the new carriageway.

For Class 1 material side slopes of 1 in 2 should be anticipated with side slopes of 1 in 3 anticipated for Class 2 material. In order to minimise land take it is anticipated that Class 2 material would be utilised for sections of embankment of low height. The unweathered excavated Porthkerry Member will require treatment such as crushing and screening to meet appropriate grading requirements. Slope stability analysis will be performed during detailed design to determine appropriate long term slope gradients.

6.4 Subgrade and Drainage

Two culverts are proposed for the scheme at Ch. 410m and Ch.1540m which are illustrated on the AECOM alignment drawings listed in Section 6.1.

Provision should be made for the drainage of the full thickness of the pavement construction. In addition drainage measures will be necessary along the crest and toe of cut slopes and along the toe of embankments to intercept surface and sub-surface water flowing towards and off the earthwork.

The impact of the construction proposals on hydrology and hydrogeology requires careful consideration. There are a number of surface water features in the vicinity of the scheme including the Llanmaes Brook, Boverton Brook and Nant y Stepsau. The local reduction in groundwater level due to the proposed cuttings should be considered and agreement sought from the Environment Agency as appropriate.

The previous ground investigations suggest that natural subgrade soils will be the Porthkerry Member. Groundwater strikes were recorded within the weathered Porthkerry Member at 0.32m bgl 0.72m bgl and 0.8m bgl respectively. One groundwater strike was recorded within the unweathered Porthkerry Member at 3.3m bgl. Groundwater strikes were also observed at shallow depths within the Made Ground at 0.5m bgl suggesting a perched water table within this unit.

Pavement design requires a prediction of long term stiffness of the sub-grade soils under proposed pavement loads and under equilibrium groundwater conditions. In order to avoid subgrade damage, the design shall be based on the lower value in comparison of the undrained in situ conditions and long term equilibrium values.

During the historical ground investigations CBR tests were performed within the weathered Porthkerry Member. The results ranged from 0.9% to 2.1% (avg. 1.4%). It is anticipated that much higher values will be recorded within the bedrock (>60%) which generally is below 1.0m bgl.

6.5 Structure Foundations

In view of the nature and thickness of the Porthkerry Member, traditional shallow spread footings should be suitable as foundations for the proposed culverts along the scheme. Should there be any foundations in the Alluvium then these are likely to be extended to a suitable founding stratum.

There may be Alluvium present in the vicinity of Llanmaes Brook (Ch. 410m) and Boverton Brook (Ch. 1540) which would be considered to be a low bearing capacity soil. This stratum would likely impact the design of road pavements and hardstanding areas.

Allowable bearing pressure for completely weathered bedrock comprising stiff clay is likely to be between 150kN/m² and 300kN/m², increasing to in excess of 400kN/m² for slightly or moderately weathered rock, dependent on the weathering profile at the structure location.

6.6 Contaminated Land/Soil Chemistry

Potential on and off-site sources of contamination have been identified at the site as detailed in section 4.14. Therefore, some limited areas of the ground have the potential to be hazardous to health, subject to further assessment. Appropriate health and safety measures will be needed to mitigate any identified risks.

Waste arisings along the proposed route are generally likely to be classified as non-hazardous, subject to further sampling, testing and assessment.

Llanmaes Brook and Boverton Brook, other minor ditch courses, and groundwater are receptors to contamination as a result of earthworks.

6.7 Effect of Man Made Obstacles/Site History

There are few anthropogenic features along and/or in the vicinity of the proposed alignment including the Fire Training Area and the existing Eglwys Brewis Road. The main existing feature is the tie-in with the existing Eglwys Brewis Road. However, the site is located on and in the vicinity of the St. Athan MOD base and as such some areas along the scheme may be potentially contaminated.

7 Comparisons of Project Options and Risks

7 Comparison of Project Options and Risks

7.1 General

A preliminary geotechnical risk register is presented overleaf highlighting the potential geotechnical risks of the project. The risk register shall be revisited and updated to take into account new information obtained during the design process. The risk scoring system detailed below has been adopted.

Table 7.1: Risk Scoring System

| Probability (P) | | Impact (I) | | | RISK (R = P x I) | Response to Risk | |
|-----------------|---|------------|---|------------------------------------------------------------------------------|--------------------------------------|------------------|----------------------------------|
| Very Probable | 5 | Very High | 5 | Potential to halt the project | Potential for major claim or similar | 17 to 25 | Unacceptable: act now to prevent |
| Probable | 4 | High | 4 | Significant delay on overall project | Major impact on cost | 13 to 16 | Unacceptable: act now to prevent |
| Possible | 3 | Medium | 3 | Major delay on this task, but significant impact on overall project unlikely | Significant impact on cost | 9 to 12 | Early attention required |
| Unlikely | 2 | Low | 2 | Minor delay on this task, but significant impact on overall project unlikely | Minor impact on cost | 5 to 8 | Regular attention required |
| Negligible | 1 | Very Low | 1 | No significant impact on task or project | Negligible impact on cost | 1 to 4 | Monitor |

7.2 Geotechnical Risks

The geotechnical risk register is presented overleaf.

| Identified Geotechnical Hazard/Risk | Cause | Risk before Control | | | Consequence | Feature Affected | Control Measures | Risk after Control | | |
|--------------------------------------------|----------------------------------------|---------------------|---|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---|---------|
| | | P | I | R (P*I) | | | | P | I | R (P*I) |
| GENERAL ROUTE AND STRUCTURES | | | | | | | | | | |
| Variable ground/variable strength material | Interbedded clay and limestone | 3 | 4 | 12 | Performance of road pavement compromised and/or deterioration of subgrade Reduced service life Maintenance costs Increased overall cost Commuter safety compromised Closure of road Potential instability of structures founded in Alluvium | Whole route | Remove, replace or otherwise enhance compressible/weak material Monitor settlement of road pavement Based on findings of monitoring, increase maintenance or design remedial solutions | 1 | 4 | 4 |
| | | | | | | | | | | |
| Encountering unexpected services | Inadequate/ no service or hazard plans | 3 | 4 | 12 | Injury to contractor's staff, AECOM personnel and the general public Potential prosecution and compensation claims Significant programme delays Disruption to service provided by statutory holders | Whole route | Appropriate surveys and searches to completed and made available to contractor prior to commencement of site works On site cable avoidance tools to be utilised in accordance with HS (G) 47 Inspection pits to be dug for any intrusive works | 1 | 4 | 4 |
| | | | | | | | | | | |

| Identified Geotechnical Hazard/Risk | Cause | Risk before Control | | Consequence | Feature Affected | Control Measures | Risk after Control | | |
|-------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------|---|------------------------------------------------------------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---|---|
| | | P | I | | | | R (P*I) | P | I |
| Injury to contractor's staff and AECOM personnel during construction | Soft ground | 2 | 3 | Injury to contractor's staff and AECOM personnel Delays to programme Compensation claims | Whole route | Utilise suitable site plant for ground conditions Shoring of excavations where appropriate Should unexpected groundwater be encountered due to localised pockets of more granular material or other unique site conditions work should cease and advice sought from a suitably qualified engineer All personnel should be suitably qualified for the respective tasks (minimum CSCS qualification for visitors on site) | 1 | 3 | 3 |
| | Inadequately trained staff | | | | | | | | |
| Presence of contaminated land | Unexpected site conditions | | | Injury to contractor's staff Delays to programme Increased project cost | Entire route | Assess potential for contaminated land prior to commencement of site works Ensure staff are adequately trained and informed Use appropriate PPE | 1 | 3 | 3 |
| | Prior/ current site use leading to the presence of contaminants on site | 3 | 3 | | | | 9 | | |
| Flooding (proposed road in the vicinity of Boverton Brook and Llanmaes) | Boverton Brook and Llanmaes Brook in vicinity and crossing road alignment | 3 | 3 | Flooding of excavations Damage to site machinery and equipment | Whole route | Monitor water levels in Boverton and Llanmaes Brook and check weather forecast daily to ensure safety of site staff | 2 | 3 | 6 |

| Identified Geotechnical Hazard/Risk | Cause | Risk before Control | | | Consequence | Feature Affected | Control Measures | Risk after Control | | |
|--------------------------------------------|------------------------------------------------------------------------------------|---------------------|---|---------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---|---------|
| | | P | I | R (P*I) | | | | P | I | R (P*I) |
| Brook) | | | | | Increased risk of water borne diseases Safety of site staff compromised Programme delays Increased cost | | Programming of works | | | |
| Unforeseen ground conditions | Error in geological mapping or unforeseen ground conditions due to history of site | 3 | 3 | 9 | Construction delays and redesign | Entire route | Undertake desk study and project specific intrusive ground investigation to improve the accuracy of ground models | 2 | 3 | 6 |
| Encountering unexploded ordnance | Encountering UXO due to site history | 3 | 4 | 12 | Delays caused by clearance works or initiation - endangering life | Whole route | Undertake UXO risk assessment and adopt appropriate mitigation measures | 2 | 4 | 8 |
| Encountering hard strata at shallow depths | Limestone (Porthkerry Member) anticipated at shallow depths | 4 | 3 | 12 | Delays as a result of difficulties with excavations using conventional means Increased cost associated with the use of specialist equipment | Entire route | Undertake desk study and project specific intrusive ground investigation to improve the accuracy of ground models Utilise suitable site plant for ground conditions | 4 | 2 | 8 |
| EMBANKMENTS/CUTTINGS | | | | | | | | | | |
| Slope instability/failure | Inadequate compaction, loose/soft deposits, collapse | 3 | 3 | 9 | Failure of slope construction Requirement for emergency works Damage to services and | All earthworks along scheme | Implement slope stabilising measures such as soil nailing, drainage and planting of vegetation Construct and adequately | 1 | 3 | 3 |

| Identified Geotechnical Hazard/Risk | Cause | Risk before Control | | | Consequence | Feature Affected | Control Measures | Risk after Control | | |
|---------------------------------------------|---------------------|---------------------|---|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------|---|---------|
| | | P | I | R (P*I) | | | | P | I | R (P*I) |
| | | | | | essential road furniture (e.g. safety barriers) Reduced service life Increased cost associated with maintenance Temporary road closure Delays to programme | | maintain slope drainage Allow for long-term monitoring of slopes | | | |
| Unacceptable of site won material for reuse | Soft deposits | 3 | 3 | 9 | Disposal off-site Earthworks cut and fill imbalance requiring importation of fill | Embankments and cuttings along scheme | Careful earthwork materials site management Materials conditioning | 2 | 3 | 6 |
| Presence of shallow groundwater | Shallow groundwater | 3 | 3 | 9 | Flooding of excavations Softening of surface material Programme delays | Cuttings along scheme | Evaluate findings of proposed GI Decide whether groundwater control may be required in advance of construction works | 3 | 2 | 6 |

7.3 Geo-environmental Risks

A preliminary risk assessment has been prepared to identify potential contamination sources, migration pathways and receptors that may affect the project. The purpose of the risk assessment is to demonstrate whether or not potential contaminant sources could cause harm to sensitive receptors including humans, animals, plants, properties or controlled waters.

The table below summarises the potential sources of contamination that may exist or are likely to occur with respect to the development area.

Table 7 – Potential Contaminants of Concern

| Source | Location | Potential Contaminants of Concern |
|----------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Made Ground | On site – possibly present as a feature of historical development | Asbestos |
| | Off site | Asbestos |
| Roads | On site | Petroleum hydrocarbons – fuel leakage from vehicles and run off |
| Unexploded ordnance | On site – potential due to proximity to military facility | Explosive residues |
| | Off site – potential due to proximity to military facility | Explosive residues |
| Fuel Tanks | Off site – unknown contents | Petroleum hydrocarbons |
| Radioactive Material | Off site – previously located and removed from the Picketston area north of the site | Radiological contamination from remnants of radium paint (used in luminised aircraft panels and instruments) |

7.3.1 Receptors

Identified receptors are as follows:

- Human Health (future site users, ground workers– proposed road network with limited exposure pathways);
- Off Site Receptors – the surrounding area includes a mixture of residential and military land use; and,
- Controlled Waters (Secondary Aquifers, Llanmaes Brook, Nant Stepsau, Boverton Brook).

7.3.2 Pathways

Potential pathways are as follows:

- Direct contact with contaminated soils and/or groundwater (limited post development);
- Inhalation/Ingestion of contaminated soils and/or groundwater (during construction);
- Leaching through soils;
- Lateral migration via groundwater; and,
- Surface water run-off.

7.3.3 Human Health – Preliminary Risk Assessment

Given the absence of significant sources of contamination at the site, limited plausible contaminant linkages and low sensitivity of the proposed highway infrastructure development, the risk to human health from levels of unacceptable contamination at the site is considered to be low.

7.3.4 Controlled Waters – Preliminary Risk Assessment

Given the absence of significant sources of contamination the risk to the controlled waters is considered to be low.

7.4 Other

Additional environmental risks include loss or reduction in diversity of flora, fauna and habitat for protected species. These risks are assessed separately as part of the environmental studies currently being undertaken by the project team.

7.5 Preferred Route/Options

A preferred route has already been identified.

8 References

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11. Environment Agency/DEFRA (2004) Model Procedures for the Management of Land Contamination, Contaminated Land Report 11.
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Figures

Figures

Figure 1 Site Location Plan

Drawings

AECOM Alignment Drawings:

60509148-SHT-30-0000-CT-0601
60509148-SHT-30-0000-CT-0602
60509148-SHT-30-0000-CT-0603
60509148-SHT-30-0000-CT-0604
60509148-SHT-30-0000-CT-0605

AECOM St. Athan Proposed Exploratory Hole Plans:

60509148-SHT-30-0000-CT-0652
60509148-SHT-30-0000-CT-0653

Appendices

Appendix A - Previous Ground Investigation Information

- Historical Ground Investigation Information Northern Link Road – Logs (Capita Gwent Consultancy, 2003)
- St. Athan Defence Technical College Factual Report on Ground Investigation Volume 2/C: Tremains Farm and Eglwys Brewis Road Area, 400& EB Series (Zone H&J) (Soil Mechanics, 2009)
- St. Athan Geo-Environmental Validation Report (Pell Frishmann, 2010)
- Defence Estates Proposed Service Family Accommodation at Picketston South West, RAF St. Athan Ground Conditions Assessment Report (WYG, 2011)

Appendix B Site Walkover Photographs





Photos 1 and 2 Llanmaes Brook looking South (photo 1) and west showing embankment along the brook (photo 2)



Photos 3 and 4 Millands Caravan Park approx. 30m south of and field in the vicinity of Ch. 900m



Photos 5 and 6 Proposed location of road alignment (Ch.1550m)



Photos 7 and 8 Eglwys Brewis Road in vicinity of proposed tie-in. St. Athan MOD base is located south of fence.

Appendix C Envirocheck Report

Appendix D BGS Borehole Logs



Record of Borehole BH10

Job No. : FSE98124A
 Site Name : RAF St Athan
 Client : Welsh Development Agency

| | | | |
|--------------|------------|---------------|------------|
| Easting | 300800.6 | Start date | 25/02/2004 |
| Northing | 189238.2 | End date | 25/02/2004 |
| Ground level | 48.47m AOD | Backfill date | 25/02/2004 |
| Final depth | 11.20m | Page | 2 of 2 |

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| Coring Details | | | | | | | | | | Strata | |
|----------------|---------------|------------------|----------|------------|----------|-----------------|--------|-------------------|-------------|--------------------|--|
| Progress | Coring run No | Flush returned % | T.C.T. % | S.S.C.R. % | R.O.D. % | Max No. of cuts | Legend | Depth (Thickness) | Level m AOD | Strata Description | |
| | 10.20 | | | | | | | | | | |
| | 10.20 | | | | | | | | | | |
| | 11.20 | | 100 | 90 | 75 | 270 115 | | 11.20 | 35.27 | | |

| | | | | |
|--------------|---------------|--------------|------------------------------------------------------------|-----------------------------------|
| Diameters | | | General remarks | Equipment and Methods |
| Depth (m) | Hole (mm) | Casing (mm) | | |
| | | | | |
| Groundwater | | | Notes: All dimensions in metres unless otherwise stated | Drilled by: APEX Logged by: ML |
| Depth struck | After 20 mins | Depth sealed | | |
| | | | | |
| | | | Checked by: | |

ST 06 NW 54

BOREHOLE LOG
PICKETSTON SITE

| Contract: RAF ST ATHANS | | Client: PSA | | Job Number: 54012 | | Date: 24:09 2012 | |
|---------------------------------|---------------------------------------------------------|-----------------------------|---------------------------------------------------------|----------------------------------|---------------------------------------------------------|-------------------------|---------------------------------------------------------|
| Borehole Number: PSA/125 | | Location: PICKETSTON | | Orientation: Ground level | | Remarks: | |
| Depth (m) | Remarks | Depth (m) | Remarks | Depth (m) | Remarks | Depth (m) | Remarks |
| 0.00 | Surface | 0.00 | Surface | 0.00 | Surface | 0.00 | Surface |
| 0.75 | 3.0m of 12.75 steel casing, 6.15 above B. 3.75 below C. | 0.75 | 3.0m of 12.75 steel casing, 6.15 above B. 3.75 below C. | 0.75 | 3.0m of 12.75 steel casing, 6.15 above B. 3.75 below C. | 0.75 | 3.0m of 12.75 steel casing, 6.15 above B. 3.75 below C. |
| 12.10 | Limestone with thin clay bands | 12.10 | Limestone with thin clay bands | 12.10 | Limestone with thin clay bands | 12.10 | Limestone with thin clay bands |
| 137.00 | End of borehole | 137.00 | End of borehole | 137.00 | End of borehole | 137.00 | End of borehole |

| | | | |
|------------|-----------------|--------------|------------------------|
| Key | Log-Data | Notes | General Remarks |
| S | Surface | 1 | 1 - Collar Data |
| C | Case | 2 | 2 - Motor Level n.s. |
| B | Borehole | 3 | 3 - Motor Level n.s. |
| D | Disturbance | 4 | 4 - Motor Level n.s. |
| P | Pit | 5 | 5 - Motor Level n.s. |
| V | Void | 6 | 6 - Motor Level n.s. |
| F | Flow | 7 | 7 - Motor Level n.s. |
| R | Recovery | 8 | 8 - Motor Level n.s. |

| | |
|------------------------------|---------------------------------|
| Scale: 1:50 | Sheet No. 1 of 1 |
| Scale: 0 to 20 metres | Sheet No. 0 of 20 metres |
| COMPILED BY: SMITH | DATE: 2012 |
| FIGURE NO. 1 | |



Job No. : FSE96124A
 Site Name : RAF St Athan
 Client : Welsh Development Agency

Record of Borehole BH36

| | | | |
|--------------|------------|---------------|------------|
| Easting | 299553.4 | Start date | 19/03/2004 |
| Northing | 189091.1 | End date | 18/03/2004 |
| Ground level | 42.97m AOD | Backfill date | 18/03/2004 |
| Final depth | 15.80m | Page | 1 of 2 |

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| Progress | Coring Details | | | | | FI | Log ₁₀ T | Depth (Theobalds) | Level m AOD | Strata | Strata Descriptions |
|----------|----------------|---------------|-------|-------|-------|-----|---------------------|-------------------|-------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Core run | Final returns | TCR % | RCR % | RCD % | | | | | | |
| | | | | | | | | 0.00 | | | FILL. (Drillers description). |
| | | | | | | | | 0.80 | 42.17 | | CLAY. (Drillers description). |
| | | | | | | | | 1.00 | | | |
| | | | | | | | | 1.20 | 41.17 | | |
| | | | | | | | | 0.70 | | | Broken LIMESTONE, clay bands. (Drillers description). |
| | | | | | | | | 2.50 | 40.47 | | |
| 2.50 | | | 58 | 16 | 9 | 200 | NI | | | | Moderately weathered, moderately strong to strong, gray blue, fine to medium grained LIMESTONE. Subhorizontal and subvertical, very closely to closely spaced, undulating and open with grey black clayey silt (<5mm). 3.00m to 3.05m with grey black clayey gravel. 3.15m to 3.20m Gravel is angular, fine to medium of limestone and siltstone. 4.14m to 4.35m with grey black, clayey gravel. Gravel is angular, fine to medium of limestone and siltstone. with soft, grey black clay. |
| 4.00 | | | 49 | 27 | 20 | 200 | NI | | | | |
| 4.00 | | | | | | | | | | | |
| 5.50 | | | | | | | | | | | 5.50m to 5.72m with moderately weak to weak, grey black siltstone. |
| 5.50 | | | 64 | 42 | 25 | 280 | 10 | | | | |
| 7.00 | | | | | | | | | | | 6.53m to 6.86m with moderately weak to weak, grey black siltstone. |
| 7.00 | | | | | | | | | | | 7.00m to 7.10m with moderately weak to weak, grey black siltstone. |
| | | | 77 | 46 | 25 | 280 | 10 | | | | 7.33m to 7.52m with moderately weak to weak, grey black siltstone. |
| 8.50 | | | | | | | | | | | 7.82m to 7.89m with moderately weak to weak, grey black siltstone. |
| 8.50 | | | 83 | 60 | 43 | 270 | 10 | | | | 8.78m to 8.84m with grey black, clayey gravel. Gravel is angular, fine to medium of limestone and siltstone. |
| | | | | | | | | 13.10 | | | 9.50m to 9.89m with orange brown discoloration of subvertical fractures. |
| 10.00 | | | | | | | | | | | |

| | | | | |
|------------------------------------------------------------|---------------|--------------|-----------------|-----------------------------------|
| Diameters | | | General remarks | Equipment and Methods |
| Depth (m) | Hole (mm) | Casing (mm) | | |
| | | | | |
| Groundwater | | | | |
| Depth struck | After 20 mins | Depth seated | | |
| | | | | |
| Notes: All dimensions in metres unless otherwise stated | | | Checked by: | Drilled by: APEX Logged by: ML |



Record of Borehole **BH20**

Job No. : FSE96124A
 Site Name : RAF St Athan
 Client : Welsh Development Agency

| | | | |
|--------------|------------|---------------|------------|
| Easting | 298878.3 | Start date | 27/02/2004 |
| Northing | 169117.0 | End date | 27/02/2004 |
| Ground level | 41.79m AOD | Backfill date | 27/02/2004 |
| Final depth | 18.00m | Page | 2 of 2 |

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| Program | Coring Details | | | | | | FI | Legend | Depth (7 thickness) | Level m AOD | Strata Descriptions |
|---------|------------------|-----------------------|---------|---------|----------|-----------------------|----|--------|------------------------|----------------|------------------------------------------------------------------------|
| | Core run m | Flush Returns % | TC % | SC % | RCD % | Max Min Cl % | | | | | |
| | 11.00 | | 68 | 25 | 23 | 220 NI | | | 11.00 | 30.79 | 10.80m to 10.85m with very soft, brown, very slightly sandy sil. |

| <table border="1"> <tr> <th colspan="3">Diameters</th> </tr> <tr> <th>Depth (m)</th> <th>Hole (mm)</th> <th>Casing (mm)</th> </tr> <tr> <td> </td> <td> </td> <td> </td> </tr> </table> | | | Diameters | | | Depth (m) | Hole (mm) | Casing (mm) | | | | General remarks Notes: All dimensions in metres unless otherwise stated | Equipment and Methods Rotary Cored |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------|-----------------------------------|--|--|-----------------|------------------|-----------------|--|--|--|--------------------------------------------------------------------------------------|-------------------------------------------|
| Diameters | | | | | | | | | | | | | |
| Depth (m) | Hole (mm) | Casing (mm) | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| <table border="1"> <tr> <th colspan="3">Groundwater</th> </tr> <tr> <th>Depth struck</th> <th>After 20 mins</th> <th>Depth sealed</th> </tr> <tr> <td> </td> <td> </td> <td> </td> </tr> </table> | | | Groundwater | | | Depth struck | After 20 mins | Depth sealed | | | | | |
| Groundwater | | | | | | | | | | | | | |
| Depth struck | After 20 mins | Depth sealed | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Checked by: | | | Drilled by: APEX Logged by: ML | | | | | | | | | | |



Record of Borehole **BH19A**

Job No. : FSE96124A
 Site Name : RAF St Athan
 Client : Welsh Development Agency

| | | | |
|--------------|------------|---------------|------------|
| Easting | 299478.8 | Start date | 18/02/2004 |
| Northing | 189168.2 | End date | 18/02/2004 |
| Ground level | 42.78m AOD | Backfill date | 18/02/2004 |
| Final depth | 15.00m | Page | 2 of 2 |

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| Progress | Coring Details | | | | | | Strata | | | |
|----------|----------------|-----------------|-------|-------|-------|-----------------|--------|------------------|-------------|---------------------|
| | Core run m | Flush returns % | TCR % | SCR % | ROD % | Max Min CL test | FI | Depth (Theobald) | Level m AOD | Strata Descriptions |
| | | | | | | | | 15.00 | 27.79 | |

| <table border="1"> <thead> <tr> <th colspan="3">Diameters</th> </tr> <tr> <th>Depth (m)</th> <th>Hole (mm)</th> <th>Casing (mm)</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table> | | | Diameters | | | Depth (m) | Hole (mm) | Casing (mm) | | | | General remarks Notes: All dimensions in metres unless otherwise stated | Equipment and Methods Rotary Open Hole |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------------|-------------|--|--|--------------|---------------|--------------|--|--|--|-----------------------------------------------------------------------------------|-------------------------------------------|
| Diameters | | | | | | | | | | | | | |
| Depth (m) | Hole (mm) | Casing (mm) | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th colspan="3">Groundwater</th> </tr> <tr> <th>Depth struck</th> <th>After 20 mins</th> <th>Depth sealed</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table> | | | Groundwater | | | Depth struck | After 20 mins | Depth sealed | | | | | |
| Groundwater | | | | | | | | | | | | | |
| Depth struck | After 20 mins | Depth sealed | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Checked by: | | Drilled by: APEX Logged by: APEX | | | | | | | | | | | |



Job No. : FSE98124A
 Site Name : RAF St Athan
 Client : Welsh Development Agency

Record of Borehole **BH16**

| | | | |
|--------------|------------|---------------|------------|
| Easting | 299244.8 | Start date | 28/02/2004 |
| Northing | 189088.1 | End date | 28/02/2004 |
| Ground level | 43.43m AOD | Backfill date | 28/02/2004 |
| Final depth | 15.00m | Page | 1 of 2 |

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| Coring Details | | | | | | | | | | Strata | |
|----------------|----------|---------------|-----|-----|-----|---------|-----|--------|-------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Progress | Core run | Flush returns | FCR | BCR | ROD | Max Min | FI | Legend | Depth | Level | Strata Descriptions |
| | m | % | % | % | % | CL | | | (Thickness) | m AOD | |
| | | | | | | | | | (1.30) | | Boulder CLAY and FLL. (Dillers description). |
| | | | | | | | | | 1.30 | 42.13 | |
| | | | | | | | | | (1.70) | | LIMESTONE, broken bands, odesx to 2m. (Dillers description). |
| | | | | | | | | | 2.00 | 41.43 | |
| 2.00 | | | 83 | 83 | 46 | | 140 | NI | | | Slightly weathered, generally strong to very strong, grey blue fine grained LIMESTONE. Subhorizontal (0-5 degree) very close, closely spaced, stepped and undulating, rough, open with a light brown, slightly sandy silt infill (<3mm). |
| 3.50 | | | | | | | | | | | |
| 3.50 | | | 75 | 48 | 32 | | 100 | NI | | | |
| 4.30 | | | | | | | | | | | 4.37m to 4.39m with a moderately weak and moderate strong, light brown, sandy siltstone. |
| 4.30 | | | 88 | 75 | 60 | | 210 | 30 | | | 5.45m to 5.55m with a grey black, moderately weak to weak, siltstone. |
| 5.80 | | | | | | | | | | | |
| 5.80 | | | 99 | 60 | 37 | | 310 | NI | | | |
| 7.30 | | | | | | | | | | | |
| 7.30 | | | 98 | 85 | 78 | | 200 | 80 | | | 7.83m to 7.85m with grey black, very weak, siltstone. |
| 8.80 | | | | | | | | | | | |
| 8.80 | | | 96 | 86 | 78 | | 180 | 20 | | | 8.70m to 8.80m with grey black, very weak, siltstone. |
| | | | | | | | | | | | 9.33m to 9.38m with grey black, weak and moderate weak, siltstone. |
| | | | | | | | | | | | 9.48m to 9.49m with grey black, very weak, siltstone. |

| | | | | |
|--------------|---------------|--------------|------------------------------------------------------------|-----------------------------------|
| Diameters | | | General remarks | Equipment and Methods |
| Depth (m) | Hole (mm) | Casing (mm) | | |
| | | | | |
| Groundwater | | | Notes: All dimensions in metres unless otherwise stated | Drilled by: APEX Logged by: ML |
| Depth struck | After 20 mins | Depth sealed | | |
| | | | | |
| | | | Checked by: | |

DRILLHOLE No. PI/BH7

| | | |
|--------------------------------|----------------------------------------------|------------------------------------------|
| Client : Delfera Estates | Ground Level m (A.O.D.) : 42.325 | Hole Type : Open Hole/Cored |
| Project : RAF ElAsha, Phase II | Hole Depth m : 8.75 | Co-ordinates : E 299898.854 N 163212.827 |
| Location : Pickerton | Well Height m (A.O.D.) : 42.365 | Logged By : Envtros |
| Date : 04.02.02 | Base of Exploratory Hole m (A.O.D.) : 44.325 | Sheet No : 1 of 1 |

| Depth (m) (sea level) Elevation | Geological Description (BS9930:1999) | Strata Type | Well Detail | Core Run Depth (m) | Total Core Rec. % | Solid Core Rec. % | RQD % | Discontinuities/Remarks |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|--------------------|-------------------|-------------------|-------|-------------------------|
| 49.00 | Soft clay fill with cobbles of limestone (MADE GROUND) | | | | | | | |
| 38.88 | Soft grey black clay fill (MADE GROUND) Hydrocarbon odour from 1m | | | | | | | |
| 34.28 | Fractured dark grey crystalline LIMESTONE with mudstone and clay bands at 3.1, 3.25, 3.6, 4, 4.6, 4.9, 5.25, 5.5, 5.85, 6.3 and 6.5m | | | | | | | |
| 33.63 | Heavily fractured light grey crystalline LIMESTONE stained orange brown in fractures | | | | | | | |
| 32.13 | Light grey crystalline LIMESTONE with mudstone bands at 7.55, 7.7, 8, 8.15, 8.25 and 8.5m | | | | | | | |

| | | |
|-------------------------------|------------------------------------|------------------------------------|
| Contractor : Apex Drilling | Hole Diameter (mm) : 105 | APEX DRILLING SERVICES LTD. |
| Drill Type : Rotary air flush | Casing depth (m) : 1.5 | DRILL THE WELL |
| Bit Type : P.C.D. | Core Diameter (mm) : 76mm (NO) 412 | DRILL THE WELL |
| Rig Type : Gryphon | Drilled By : MJ | |

