

# Memorandum



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<b>To</b>	<b>From</b>	<b>Our reference</b>
Stephen Carpenter	Gareth Mason	IJD/GJM/261552
<b>Office</b>	<b>Date</b>	<b>Your Reference</b>
Bristol	16 December 2009	261552
<b>Subject</b>	<b>South Bristol Link - Geotechnical input</b>	

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Further to a request dated 23 September 2009, we have undertaken a brief desk study review of the proposed South Bristol Link route as shown on Drawings Nr. MMD-262581-C-DR-00-XX-1000 to 1003 (P3 revision).

The review has been limited to desk based appraisal only and has used the following sources of information: -

- Outline Planning Application for Ashton Park, including Environmental Statements and Phase 1 & 2 Geo-environmental Assessment by Carl Bro.
- British Geological Survey Mapping, Sheet Nr. 264, Bristol (2004), Solid and Drift Geology.
- Environment Agency (<http://www.environment-agency.gov.uk/default.aspx>).

The following information is presented: -

1. Description of Route
2. Geology
3. Landfills and Made Ground
4. Earthworks
5. Mining
6. Flooding
7. Geochemistry
8. Pavement
9. Preliminary engineering considerations and recommendations

## 1 Description of Route

A brief description with respect to topography and water features is given of the route as shown on the provided drawings.

The highway route begins at a proposed roundabout on the A370 (10 m AOD) and the bus route begins at the Ashton Vale Park & Ride Car Park (8 m AOD). This area is low-lying open fields with numerous small streams and drains which generally flow towards the River Avon to the northeast. These two roads join at approximately Chainage 700 m and continue south where it crosses a railway line at Chainage 900 m (15 m AOD).

The road continues south for a further 300 m along the low-lying area (20 m AOD). At Chainage 1200 m the road climbs a ridge of land along the valley of a stream. The route reaches the top of this ridge at Chainage 2000 m where it crosses Bridgewater Road (50 m AOD). The route continues to climb across open fields, small streams and ditches to Chainage 3000 m (70 m AOD), where it enters the built up area of Highridge and Bishopsworth. It descends gently from this point to its termination at Chainage 5200 m (40 m AOD). The route follows roads and service corridors (namely a water main).

## 2 Geology

### 2.1 Superficial Deposits

The low lying parts of the route (northern section) are overlain by alluvial deposits associated with the streams and rivers in the area. It is likely that the remaining areas are covered in a small layer of colluvium (downslope movement of material) and possibly completely weathered bedrock.

**Table 1 – Superficial Deposits**

Superficial Deposits	Description	Chainage (m)	
		From	To
Alluvium	Alluvium associated with the watercourses that traverse the site. It typically comprises normally consolidated gravels, sands, silts and clays, possibly organic matter.	0	350
Terrace Deposits	It typically comprises normally consolidated gravels and sands, but may also contain areas of silt and clay.	350	1700
Possibly colluvium deposits and/or weathered bedrock	Highly variable weathered material.	1700	5200

BGS Borehole ST57SE/105 is located 100 m northeast of Chainage 0 m within the Park & Ride Car Park. This indicates that there is approximately 3 m of alluvium described as soft dark clayey silt and peat which is underlain by 1 m of gravel and sand.

## 2.2 Solid Geology

The route is underlain by solid geology of Triassic and Jurassic Age, which unconformably overlies coal measures of Carboniferous Age. The underlying coal measures have been mined to the north of the Yanley Fault in this area (further described below). The Triassic and Jurassic strata are described in Table 2.

**Table 2 – Triassic and Jurassic Geology**

Solid	Description	Chainage (m)	
		From	To
Mercia Mudstone	Red mudstone with greenish grey sandstone.	0	1800
Rhaetic Succession from the Mercia Mudstone Group to the Lias Group (i.e. Penarth and Blue Lias Group)	Mudstone, shale and limestone including: Blue Anchor Formation Westbury Beds Lilstock Formation Blue Lias Formation	1800	2150
Charmouth Mudstone Formation	Grey mudstone of the Lias Group.	2150	4450
Rugby Limestone Member of the Blue Lias Formation	Limestone and mudstone	4450	5200

It is likely that the Mercia Mudstone is highly to completely weathered and is therefore relatively impermeable and therefore gives rise to poor drainage.

Slips can also be seen in the surrounding area in many of the steep valley slopes where the Keuper Marl (now known as Mercia Mudstone) is capped by the White and Blue Lias. An area of slipped material is noted on the geological map within the Colliters Brook stream cut valley immediately adjacent to the proposed route. The brook has been culverted and the valley has subsequently been infilled (Yanley 1 Landfill).

Above the Mercia Mudstone the thin Rhaetic beds have two main lithologies which will affect slopes due to interbedded low and high permeability rocks. At the base the thinly laminated mudstones of the Westbury Beds form a very low permeability blanket and cause seepage discharge along hillsides. At the top of the Rhaetic moderately spaced discontinuities in the thinly bedded White Lias limestones make it a permeable horizon.

## 2.3 Structural Geology

The Yanley Fault (reverse type with downthrow to the south) trends east west across the route at approximately Chainage 1300. This large fault occurred during the Variscan Orogeny and therefore before deposition of the Triassic and Jurassic rocks. There is evidence for reactivation of this fault following deposition of the Triassic rocks. Consequently the rocks and strata around this fault zone are probably highly fractured and therefore permeable due to prolonged movement.

The Triassic and Jurassic strata are relatively flat lying with no major dips.

The underlying coal measures dip approximately 20 degrees to the southeast to the north of the Yanley Fault. The coal measures are highly faulted and fractured to the south of Yanley Fault.

## 3 Landfills and Made Ground

The route crosses close to or through several areas of landfill and Made Ground. A summary of these derived from the Phase 1 & 2 Geo-environmental Assessment for Ashton Park is included in Table 3. The Environment Agency website has also been consulted for information on registered landfill sites, which is presented in Table 4.

**Table 3 – Landfills and large areas of Made Ground**

Feature	Description	Chainage	
		From	To
Parsonage Farm Landfill	Completed and restored landfills	0	50
Made Ground	Associated with the construction of the Park & Ride Car Park	0	50
Kennel Farm Landfill	Located to the west of the proposed road	100	200
Railway Embankment	Contaminated material associated with construction and operation of railway line.	900	900
Yanley 3 Landfill	Operational landfill	900	1100
Yanley 2 Landfill	Completed and restored landfills	1400	1550
Yanley 1 Landfill	Located greater than 150 m to the west of the route	1600	1800
Stones Landfill	Completed and restored landfills	1650	1850
Infilled Quarry	Located to the northeast of the proposed road. Actual extent not known. The quarry is no longer in use but it contains a large quantity of tipped material this includes; rubble, sleepers, a tank and topsoil.	2050	2050
Made Ground	Associated with construction of water main, services, road, etc.	3000	5200

**Table 4: Summary of historical landfills on the area as listed on the Environment Agency website (consulted December 2009)**

Site name (with name given by Phase 1 & 2 Geo-environmental Assessment Report for Ashton Vale)	First waste received	Last waste received	Type of waste						Waste control measures	
			Inert	Industrial	Commercial	Household	Special	Liquids/ sludge	Gas control	Leachate control
Land at Parsonage Farm and Phase 2 (P&R Car Park)	14/06/1981	31/12/1988	Y	Y	Y			Y		
Phase 2 Of Landfill Site At Parsonage Farm (P&R Car Park)	37/10/1983	25/06/1991	Y	Y	Y					
Phase 3 Landfill Site At Ashton Vale (P&R Car Park)	13/11/1985	31/12/1991	Y	Y	Y					
Viridor Long Ashton (Kennel Farm Landfill)	29/07/1992	-	Y	Y	Y	Y				
Land Adjacent to BR Railway Embankment (Yanley 3)	18/02/1991	10/02/1994	Y			Y	Y			
Land Adjoining The Railway Embankment (Yanley 3)	31/12/1960	-		Y	Y	Y	Y		Y	Y
Yew Tree Farm (Yanley 2)	-	-	Y							
Land Adjoining Yew Tree Farm (Yanley 2)	30/06/1984	31/12/1987	Y	Y	Y	Y				Y
Land to the Rear of Yew Tree Farm (Yanley 2)	31/07/1983	31/07/1986	Y							
Castle Farm (Stones)	18/12/1979	19/05/1987	Y	Y	Y			Y		
Yanley Lane (Yanley 1)	31/12/1975	22/07/1988	Y	Y				Y	Y	Y

Development over existing landfills will require consideration of the landfill gas regime and the attendant mitigation measures. Mitigation measures may include membranes, dig out & replace and passive or active venting.

The boundaries of the landfills will require definition in relation to the proposed route. This may include the requirement for geophysical investigation and intrusive investigation to confirm locations.

The potential for landfill leachate impacting on groundwater and off-site migration requires consideration as does the potential for off-site to on-site migration of leachate and gas. Groundwater / ground gas monitoring wells should be installed along the boundaries and appropriate sampling and analysis undertaken to determine the groundwater quality, soil gas concentrations and flow regime.

The Made Ground associated with the landfills and developed land will require characterisation to determine the likely waste classification for disposal of arisings resulting from excavations. The initial stage of assessment requires the material to be assessed in terms of hazardous or non hazardous waste.

The following information was taken from the Phase 1 & 2 Geo-environmental Assessment Reports for Ashton Vale.

### **3.1 Kennel Farm Landfill**

Kennel Farm Landfill was operated by Viridor Waste Management as an inert landfill site. Part of this landfill was previously used as a sewage works. The waste management licence was surrendered on 27th February 2004 indicating that the site restoration was acceptable to the Environment Agency.

Authorised Wastes - Empty used containers, ferrous metal scrap, foundry sand (from Avon), highway gully emptyings, house clearance waste, ind./com. waste, plastic/polythene waste, road sweepings, rubber waste

Prohibited Wastes - Clinical wastes, difficult wastes not specified, liquid/sludges not specified, special wastes waste, Not Otherwise Specified.

### **3.2 Yanley 3 Landfill Site**

A large landfill named Yanley 3 is located to the west of the proposed route, with the railway line forming the north boundary and reaching south as far as Hanging Hill Wood.

Authorised Waste - Asbestos, ceramic waste, concrete waste, construction, demolition, inert / non-hazardous / non-toxic, excavated natural materials, ferrous metal scrap, foundry, sand, general factory waste, glass, paper, plastics, road sweepings, sawdust, textiles and wood.

Prohibited Waste - Biodegradable/putrescible waste, liquid wastes, poisonous, noxious and polluting wastes.

Yanley 3 landfill site is presently operated under an IPPC permit by Viridor Waste Management.

The site appears to have been first registered in 1988. It is a modern containment landfill with active gas and leachate management systems. Landfilling has progressed across the site from the west, the shallower part of the landfill that is now restored, to the east. According to a previous report on the site, 'Environmental Review of Existing and Closed Landfills' (Aspinwall & Company, 1997), four former mine shafts have been identified in preparation of the site base and these have been treated in accordance with the conditions of the licence.

The Aspinwall & Company (1997) report also explained that since 1991 the site has been permitted to landfill household waste in addition to inert and non-hazardous industrial and commercial waste. From 1994 the site's licence permitted the deposition of household, industrial and commercial and specifically itemised difficult and special wastes. A trade effluent discharge consent was issued to Terry Adams Ltd in 1989 by Wessex Water permitting the discharge of leachate to sewer subject to conditions. Historically there have been some minor problems experienced with complying consistently with the sulphide content, and elevated zinc readings above the consented limits have been detected on occasions.

### **3.3 Yanley 2 Landfill Site**

The site is located in a former dry valley to the west of Yewtree Farm. The site has been restored to agriculture.

There are numerous licences referring to landfilling activities at the grid reference of Yanley 2, however, as reported in 'Environmental Review of Existing and Closed Landfills' (Aspinwall & Company, 1997), these refer to Yanley 2 landfill and the proximate Stones Landfill site. It is thought that a Waste Management Licence for Yanley 2 was issued to Terry Adams Ltd in 1983 for landfilling of inert materials only.

A wider variety of controlled wastes were permitted at the site under a later licence dated 1984. This permitted waste tyres and fragmentation wastes. These licences are no longer valid. A licensed discharge consent to permit a discharge to Colliter's Brook, subject to conditions, was revoked at the request of Terry Adams Ltd in 1992.

There is no landfill gas, leachate or groundwater monitoring conducted at the site. The presence of a 1m thick cap will limit the ability for gas to disperse to the atmosphere.

It is not known if any mine shafts are located under the landfill area.

### **3.4 Stone's Landfill Site**

Located to the south west of Yanley 2, close to Castle Farm, is the restored Stone's Landfill site. Little is documented on the site but it was thought to have been registered to S & A Stone Ltd in 1979, with permitted waste of dry commercial and industrial waste, asbestos, construction and demolition wastes and excavated natural materials. It was reported to have been completed and closed by 1981.

### **3.5 Construction on Landfills**

Some considerations for road construction across the landfills include the following:

- CCTV survey to determine condition of existing culverts / services and likely alignment and depth.
- Excavate waste, segregate, improve and replace with compacted engineering fill. This may result in high costs associated with the following; release of asbestos fibres or gas, explosions of built up gas, possible subterranean fires, contaminated groundwater control and waste disposal.
- Pre-loading surcharge to compress and improve the bearing capacity characteristics of any compressible waste within the landfill beneath the proposed road construction. It is recommended that such works are undertaken in advance of adjacent development to remove possible concerns regarding displacement of landfill gas into surrounding properties.
- Dynamic compaction of waste mass. This may prove problematic due to high groundwater levels and clayey nature of waste mass and the underlying culvert.

Sufficient time is required to reduce the rate of primary settlement to acceptable levels. However, continued long-term secondary settlement is likely if there is a significant amount of decomposable material within the landfill.

## **4 Earthworks**

### **4.1 Geometry**

There are very few major earthworks along the proposed route due to the flat lying nature of the area crossed. However, there is one exception between approximately Chainage 1250 m and 1750 m. At this location, the proposed road leads from the Mercia Mudstone basin at ~15 m AOD, up a ridge formed by the Blue Lias Formation / Penarth Group to the Charmouth Mudstone plateau at ~40 m AOD. Over this distance the road crosses sidelong ground and two infilled valleys with culverted streams. The former valleys have been used as landfills (Yanley 2 and Stones).

The cross sections provided show the existing slope to be at approximately 1 in 3. It is not known whether this slope represents the natural slope angle or an artificial slope angle due to landfill operations (placement of fill material).

Typical sections at 100 m intervals from Chainage 1100 m to 2200 m have been provided. These indicate that the maximum cutting depth between these chainages is approximately 10 m (Chainage 1400 m) and the maximum embankment height is approximately 2.5 m (Chainage 2000 m). There may be greater slopes located between the 100 m sections provided.

There may be opportunity to create a split level carriageway. This will have the benefit of reducing the height of potential earthworks and also reduce the amount of requiring excavation.

### **4.2 Proposed Slope Angles**

The proposed slopes are shown to have a slope angle of 45 degrees (1 in 1), which is considered to be excessively steep, and will likely lead to failures of the cutting and embankments slopes unless they are strengthened. Strengthening works could include; soil nailing, retaining walls, reinforced earth, etc.

Several boreholes, located within the direct vicinity of the proposed road, indicate that these cuttings and embankments will either be within landfill material (unknown and highly variable geotechnical properties) or weathered Mercia Mudstone (Ref. Ashton Park, Environmental Statement).

TRL Research Report 199 (1989) gives maximum allowable slope angles to restrict the percentages of failure to below 1 % within 25 years of construction for various geological materials. This information is based on a survey of the motorway embankments and cuttings. A summary of this is provided in Table 5.

It is likely that drainage will be required within the large cutting slopes. These will either comprise counterfort or herringbone type drains.

**Table 5 – TRL RR 199 maximum allowable slope angles to restrict the percentages of failure to below 1 % within 25 years of construction**

	Maximum slope angle (vertical to horizontal)		
	Height of slope		
<b>Embankments</b>	<b>0 to 2.5 m</b>	<b>2.5 to 5.0 m</b>	<b>&gt;5.0 m</b>
Lower Lias	1 : 5	1 : 5	1 : 5
Mercia Mudstone	1 : 1.5	1 : 1.5	1 : 1.75
<b>Cuttings</b>	<b>0 to 2.5 m</b>	<b>2.5 to 5.0 m</b>	<b>&gt;5.0 m</b>
Lower Lias	1 : 4	1 : 5	1 : 5
Mercia Mudstone	1 : 1.5	1 : 1.75	1 : 1.75

For preliminary design purposes it is recommended that the slope angles provided in Table 5 are used. Where these angles can not be accommodated due to space constraints, then retaining walls, reinforced slopes, etc should be considered.

There are several complications associated with drilling / excavating through landfills (obstructions, release of ground gas, explosions, contamination materials, etc) which need to be considered when choosing the type of construction.

### **4.3 Excavations**

Generally, the ground conditions encountered during the initial ground investigations and recorded on the BGS maps indicate that the majority of excavations will be possible with normal earthmoving machinery, and blasting should not be required (some limestone or siltstone beds may require ripping or a pneumatic drill to break them up).

Special measures will probably be required when excavating material from landfills.

### **4.4 Re-use of excavated material**

It is not anticipated that landfill material will be suitable for re-use.

The limestone, mudstones and siltstones from the cutting excavations within natural rock should be suitable for constructing embankments, provided that appropriate suitability and contamination testing is carried out. However, care needs to be taken that water is not added to the mudstone and siltstones as it will quickly become unworkable.

## 5 Mining

The Phase 1 Geo-environmental Assessment for the Ashton Park indicates the locations of three mine related features close to the route. The grid references and locations presented in Table 6 are approximate.

British Coalmining Archives Ltd produced a report for the site in 1997. It provides further detail on Gore's Old Pit, stating that other published material gives the total depth of workings as approximately 18 m. The Old Engine Pit records indicate that the coal seams are greater than 73 m bgl.

**Table 6 – Mine related features**

<b>Name</b>	<b>National Grid Ref.</b>	<b>Chainage (m)</b>	<b>Approximate position relative to route</b>
Gores Colliery	355890, 170150	850	50 m west
Gores Old Pit	355620, 170060	850	350 m west
Old Engine Pit	356100, 169990	950	100 m east

As part of the Phase 1 Geo-environmental Assessment for Ashton Park an investigation was performed in order to prove the location of the two Gores mine entrances consisting of 5 Nr. window samples at each feature. This investigation was unsuccessful in proving the location of either mine entrance.

The report also highlights the possible presence of old abandoned and flooded shallow workings on the site, interpreted to be the barrier to working imposed by the Ashton Vale Company in the mid 1700s. However, this is not confirmed and plans of the workings are not available. If these are in the vicinity they are likely to be bell pits or pillar & stall type workings.

A full assessment of the risk posed by workings should be made and is beyond the scope of this brief desk study. Although many of the deeper workings and the three recorded mine entrances may not impact on the proposed road, the shallower unrecorded workings could have a significant impact. This will be especially significant where there is a small thickness of overlying Mercia Mudstone.

## 6 Flooding

According to Environment Agency flood mapping, the site is located within an area of 'extreme' flooding from rivers or sea without defences (Zone 2) and the north-western end of the site is within an area of flooding from rivers or sea without defences (Zone 3).

It may be that the site levels have to be increased to mitigate this risk. Alternatively flood defences may need to be constructed.

## **7 Geochemistry**

According to BRE Special Digest 1 (2005), Mercia Mudstone and Charmouth Mudstone Formation is one of the principal sulphate bearing strata in England. Under the right environmental conditions sulphate ions are known to react with susceptible concrete and result in either a conventional form of sulphate attack leading to the formation of ettringite and gypsum or in a Thaumasite form of sulphate attack.

The geochemistry of the ground will need to be determined in order to select an adequate design class for any underground concrete or steel elements of the proposed structures.

## **8 Pavement design**

Considering the variability and unknown compaction of the materials underlying the route, it is recommended that the strength of the near surface material is tested. Conservative values of California Bearing Ratio should be adopted for preliminary design. Improvement of the formation will probably be required in several areas. Expansion of sulphate rich materials need to be considered, if materials are to be reused.

The requirements of the Design Manual for Roads and Bridges, including sub-base and capping depths, should be followed.

## **9 Preliminary Engineering Considerations and Recommendations**

Based on the information reviewed and the summary data provided in this document, the following preliminary engineering issues should be considered: -

1. Mudstones and limestones are the predominant strata on the area. These materials are normally fractured and therefore tend to have high leaching potentials, i.e. can readily transport any pollutants encountered in the ground. This characteristic is of great significance considering the historical land uses e.g. landfills, sewage works.
2. Alluvium is identified on the geological map and hence there is the potential for soft ground. This could lead to settlement and/or potential failure in both the short and long term for earthworks. These areas need to be positively identified.
3. Made Ground is normally encountered on historical areas of works, e.g. collieries, quarries, sewage plants, landfills. The thickness and nature of this Made Ground will need to be adequately assessed as it will impact on the local ground conditions and can lead to foundation issues such as differential settlement.
4. Construction of landslip materials may lead to ground instability which will affect both the design and construction of these routes. Excessive long term settlement may occur. Measures are needed to address cracking in the pavement.
5. Geogrids could be used beneath roads and possibly lightly loaded structures to reduce the amount of unsuitable material requiring removal and to span obstructions or soft zones.
6. Groundwater control will probably be required within the cuttings due to the interbedded high and low permeability strata.
7. Allowance for extending watercourses that pass beneath the scheme should be made. Environment Agency discharge consent is likely to be required for any alterations to watercourses/drainage outfalls.

8. The presence of woodland adjacent to the scheme may be a constraint to the construction works.
9. A walkover survey should be undertaken to identify any geomorphological features.
10. The precise location of all services should be determined, as these will probably impact on the proposed routes (i.e. several culverts at unknown depth below proposed earthworks).
11. There is a high risk of migration of voids from mining to the surface resulting in subsidence or collapse settlement. A more in depth desk study review should be made to identify further information on the potential mining beneath the proposed road. This should locate previous ground investigation data, historical information from local records offices, aerial photographs, walk over survey. A soil stripping exercise can be used to identify the location of any shafts. Permission to carry out any works associated with coal workings must be agreed with the Coal Authority.
12. It is recommended that suitability testing is carried out to determine whether the material will be suitable for reuse on site.
13. The self-weight settlement of any fill and the settlement of underlying material need to be considered at this site.
14. It is important to note that the detailed geotechnical design for the proposed road will have to be carried out in accordance with BS EN 1997 (Eurocode 7) as this new standard will become mandatory in 2010. This also has significant implications on the nature of the additional ground investigation that will be required.
15. Landfill materials, Mercia Mudstone and Charmouth Mudstone can create an aggressive chemical environment. Sulphate and other chemical attacks on buried concrete/steel will need to be tested for and considered in the design. Additionally, sulphate related expansion of re-used fill will need to be considered.

**KEY**

- Approximate location of Landfills
- Proposed Route
- Known mine entries
- Alluvium

