7. Geology and Hydrogeology

7.1 Study Methodology

This section of the report describes the geological and hydrogeological constraints within the study area.

The assessment comprised initial roadside site visits, and a desk study of available published information which is included as a list of references in Appendix A.

The information outlined in this section is presented graphically on Figures 5A and 5B.

7.2 Bedrock

7.2.1 Introduction

The bedrock in the southern part of the constraints study area changes from granites (igneous rocks) and surrounding metamorphic deposits (Leinster batholith) along the eastern part of the area, north of New Ross, to Ordovician slates and shales in the south-east (Thomastown to New Ross). Carboniferous limestone rocks underlie the section of the study area north of Thomastown.

In the southern part of the study area, south of Ballyhale, the bedrock is mainly composed of Devonian sandstone with an occurrence of limestone in the southwest corner near Kilmacow.

7.2.2 Sedimentary rocks

The main geological formations occurring in the constraints study area are described, starting with the oldest sequence, in Table 7.1.

Some of the Carboniferous limestone formations identified may be associated with Karst features (Ballyadams Formation, designated Rck-3 on the geotechnical figures, 5A and 5B, and the Waulsortian Formation, designated Rck-4). The dolomitised Limestone rocks may also prove hard to excavate.

The sandstone rocks encountered, during a site visit, in the vicinity of Thomastown, were massive and blocky and could also therefore prove hard to excavate.

7.2.3 Granite Complex

A granite complex known as the Tullow granite extends in a broad zone to the east of Gorebridge-Carlow (Rck-5) and along the eastern part of the constraints study area, northeast of Mullinavat. The granites are igneous rocks and the resulting heat and deformation has created the surrounding metamorphic rocks. The Tullow granite is the largest granite pluton in the Leinster Batholith and is mostly of medium-grained texture but some coarse and fine veins cut the mass. The granites can be very hard and difficult to excavate although, along the joints, the granite is often deeply weathered to sand with solid blocks in-between. This deep weathering can also result in a highly or completely decomposed granite structure.

Table 7.1: Geological formations occurring in the constraints study area.

Period	Formation	Rock Types	Excavatability	Cutting Stability	Map Symbol (where used)
Ordovician	Maulin	Slatey mudstones. Mudstones altered to phyllites and schists where they lie close to the granite	Generally rippable	May have instability problems along planes of weakness	Rck-1
	Browsford	Schists	May prove hard to excavate	As above	Rck-1
Devonian	Carrigmaclea	Conglomerates, sandstone and shales	Sandstones may prove hard to excavate	Bedding planes tend to be gentle and therefore fairly stable.	Rck-2
	Kiltorcan	Sandstones and mudstones	As above	As above	Rck-2
Carboniferous	Ballymartin	Interbedded muddy limestone and shaly mudstone	Generally rippable	Fairly stable	
	Ballysteen	Muddy limestone	Generally rippable	Fairly stable	
	Waulsortian reef Limestone	Massive, unbedded fine-grained limestone	May prove hard to excavate	Fairly stable, except for karstified zones	Rck-4
	Kilsheehan	Limestone occasionally cherty	Generally rippable. Hard in zones	Fairly stable	
	Butlersgrove	Argillaceous limestone	Generally rippable	Fairly stable	
	Ballyadams	Shelf Limestone, potentially Karstic	Generally rippable, may prove hard to excavate where the rock is massive	Stable except for karstified zones	Rck-3

7.3 Glacial Soils

7.3.1 Gravels

Thick gravel deposits occur within the constraints study area, mainly along the major river crossings. The main gravel areas identified are as follows: -

- Gravel deposits along the River Nore south of Kilkenny City. The major gravel aquifer within this area is designated G-3 on Figure 5A
- Gravel deposits along the River Barrow.

These materials do not present problems for road construction, provided the road alignment is kept above the water table. Generally, gravels provide good formation for pavement construction and are generally suitable for reuse. Water bearing sand and silt layers where encountered can be problematic.

7.3.2 Clayey Till

Glacial tills dominate much of the constraints study area. These glacial deposits are mainly deposits of the 'Midlandian' ice sheet with the coarse fraction dominated by cobbles and boulders of limestone with lesser proportions of sandstone, slates and shales.

The depth of till occurring within the constraints study area is not known, and is likely to vary. Depths of 0m to 5 m were reported in the vicinity of Thomastown . Elsewhere the depth of the till is likely to vary considerably.

The geotechnical properties of Irish glacial tills are well-documented These soils are generally well graded, variable with gravel lenses, with quite an absence of clay minerals. The clay fraction (rock flour) typically amounts to about 15% and the fines fraction (clay and silt) is about 30 to 40%. The glacial tills are generally over-consolidated, and therefore are of a low compressibility. These soils are usually firm to stiff, however due to their low plasticity they are very susceptible to softening and deterioration in wet weather, especially if heavily trafficked. When the clayey tills are kept dry, they present relatively little difficulty to road construction.

7.4 Soft Ground

The main soft soils occurring within the constraints study area are as follows: -

7.4.1 Peat deposits

- Small deposits occurring to the east of Kilmacow and north east of Mullinavat (P-3).

Based on available Geological Survey of Ireland (GSI) information there are relatively few areas of peat within the study area.

Peat soils are considered to be problematic for construction work owing to their high organic content, high compressibility and low shear strength. When loaded, these soils usually exhibit large immediate and primary settlement followed by a very pronounced long-term creep settlement. These soils are also known to exhibit a differential settlement due to their high variability within the same location. Peat soils could present problems for embankment stability as a result of the shear failure of the subsoil during construction. Special measures for embankment construction are usually required including piling, excavate-and-replace and preload with vertical drains, etc.

7.4.2 Alluvium

Alluvial materials are deposited by river action or the action of melting glaciers. The following major alluvial tracts cross the constraints study area:

- Along the basin of the River Barrow from Carlow town to Goresbridge (AL-2). These soils are poorly drained and have a slightly peaty clay loam texture. The organic content can reach up to 20%. The depth of the alluvium is usually greater than 1m. The depth of the alluvial sands/gravels occurring in river valleys can typically be 9 m to 12 m.

- Along the River Nore (AL-3).

These soils are normally consolidated (i.e. they have not been previously compressed by glaciers) and thus are moderately to highly compressible, though not as severe as peat soils. Special measures for embankment construction over alluvial materials include preloading, with or without vertical drains, and piling.

Table 7.2 presents a summary of the properties of the soils discussed in Sections 7.3 and 7.4.

Table 7.2 : Soil Properties within the Study Area

Soil Type	Strength	Compressibility	Use as Earthworks
Gravel	Good	Low	Good
Glacial Till	Variable	Low-medium	Variable
Alluvium	Poor	High	Poor
Peat	Very poor	Very high	Not suitable

7.5 Unstable Ground

7.5.1 Karst Solution Features

Some of the Carboniferous limestone formations occurring in the constraints study area are reported to have potential karst solution features. The formations most associated with solution features are known as ‘Ballyadams’ and ‘Clogrenan’ and occur in a broad band between Bennettsbridge and Carlow Town. The massive reef limestone (Waulsortian Formation) is also prone to karstification. The most exposed areas to Karst are those where the limestone is present near the surface or lies near a catchment area. The area near Kilmacow appears to be exposed to Karst because of the water discharge in this area coming from the surrounding hills.

The Karst database held by the GSI was consulted. This database holds records of locations and types of reported Karst features. The location and features of the reported Karst areas are presented in Figures 5A and 5B with details provided in Table 1 of Appendix A

The occurrence of sinkholes under a roadway can lead to depressions or collapse in the pavement. Specific areas prone to Karst should be identified at the aerial photograph interpretation and site investigation stages. Depending on the risks, it may be prudent to adopt design measures to control water discharge, which can re-activate solution features, and to incorporate measures which will protect the roadway from potential collapse.

7.5.2 Slope Stability

In order to assess the stability of rock cuttings, it is important to identify the orientation of present discontinuities, their condition and also the extent of weathering. Steep ground should also be identified during move detailed assessment of route options. A survey of any previous cases of slope failure in the area of study would prove very useful. Areas of instability along potential route options may be revealed by examination of aerial photographs.

The rocks associated with the Ordovician period may be susceptible to cutting instability because of the complex geological structure characterising these rocks (i.e. folds, faults and variable dip). This may also be due to the presence of frequent mudstone horizons, which can lead to low strength zones (i.e. residual strength) following the bedding pattern due to strain slip during folding. Cutting stability in Limestone rocks would need careful consideration where Karst weathering is present and also in the granites where deep weathering can occur.

7.5.3 Mining Areas

The GSI minerals inventory database records were also consulted and indicated that no recorded coal mines, former pits or natural outcrops of coal are present within in the study area.

7.6 Man-made Features

A list of pits and quarries within the study area are given in Table 2 of Appendix A. The location of the main quarries and pits in the constraints study area are shown on Figures 5A and 5B. At this stage no major landfill areas have been identified in the constraints study area. However the search was not exhaustive as it was based on limited historical data. The GSI are presently updating their records of pits and quarries. It is anticipated that updated records will be available in May 2001.

7.6.1 Pits

The geotechnical constraints mapping (Figures 5A & 5B) shows many gravel pits, both in-use and disused, within the gravel strata that occur within the constraints study area.

7.6.2 Quarries

The locations of quarries prove a good way of verifying locations where the rock is close to the surface. There are many quarries, mostly disused, noted in the southern portion of the southern section of the constraints study area, north of Waterford City. Anecdotal evidence also suggests that an in-filled landfill site exists to the north of Bennetsbridge.

7.6.3 Landfills

A list of landfill sites compiled by the Environmental Protection Agency (National Waste Database 1998) was consulted for identifying any landfill sites occurring within the constraints study area. Based on the EPA list there are no major landfill sites within the constraints study area. According to the GSI data there appears to be an old landfill located just north of Waterford City.

7.7 Groundwater

The southern constraints study area is drained by two main rivers - River Nore, River Barrow and their tributaries. Low-lying areas prone to flooding should be identified in more detail during the evaluation of the feasible route options.

The GSI were consulted about the locations of public well supplies in the constraints study area, and were able to provide data on wells in County Kilkenny only. These are plotted on the geotechnical constraints figures. Further detailed investigation of wells will be necessary at route selection stage wherever the routes are likely to impact on the groundwater supply.

7.8 Resources

7.8.1 Aquifers

Consolidated Sediments (Bedrock)
The main bedrock aquifers identified are:

- Sandstone aquifer of the Kiltorcan formation. This formation may contain aquifers of regional importance.

- Karstified limestone: Ballyadams formation. This formation contains an aquifer of regional importance. A large spring located in the south of Paulstown is the source for a regional water supply in a part of Co Kilkenny.

- Dolomitised limestones, Waulsortian and Butlersgrove formations. A substantial part of this aquifer drains in the River Nore. This aquifer has been developed for industrial water supply in Carlow town and for municipal supply in Bagenalstown.

- Ballysteen Formation: can contain aquifers of regional importance (3).

- Ballymartin Formation: only contains aquifers of minor importance (3).

- Maulin Formation: These rocks contain only minor aquifers (3).

The constraints to route selection posed by bedrock aquifers are not likely to be as significant as sand and gravel aquifers, so they have not been plotted on the geotechnical constraints maps.

Unconsolidated Sediments (sands and gravels)
There is a thick deposit, mainly of sand and gravel, which occurs in the constraints study area as follows:

- Major aquifer along the River Nore south of Kilkenny city (10 m to 30 m), designated G-3.

- Other gravel aquifers identifed stretching along the main rivers occurring in the constraints study area are considered to be minor aquifers (5).

Aquifer Vulnerability and Protection

Draft groundwater vulnerability mapping was provided for County Kilkenny by the GSI. The data available was examined to identify any major vulnerable aquifers occurring within the constraints study area. Some extremely vulnerable aquifers were reported in areas where the shallow rocks lay within 0 m to 3 m from the surface as follows:

- Rock aquifer between Thomastown and Kilmacow
- Rock aquifer between the north-east of Thomastown and Dungavan
- Rock aquifer at the north-east and north-west of Gowran.

Where the water table would be lowered as a result of excavation for road cutting, the potential effects on local wells would need to be assessed. Lowering of the water table, potentially could reduce or eliminate the well yields.

Road drainage as well as accidental spillages could also potentially have an impact on the quality of the local groundwater. In areas of road crossings through zones of high aquifer vulnerability, specific design measures for road drainage may be required to prevent surface activity from polluting the underlying groundwater.

7.8.2 Mineral Resources

There are numerous active and disused sand and gravel pits within the constraints study area, many of which are identified on the geotechnical constraints figures. The locations of rock quarries identified on the GSI maps, which are fewer in number are also shown on the geotechnical constraints figures. Some of these pits and quarries may also provide a source for road construction materials.

As specific routes could impact on the viability of open cast mining, the potential for mineral resources along specific routes will be considered at route selection stage. It may be possible to identify these potential mineral resource areas in consultation with the Department of the Marine and Natural Resources, the County Councils, as well as the minerals section of the GSI.

The only mine identified in the constraints study area was an active dolomite mine near Bennettsbridge.

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