7.6 Soils and Geology

7.6.1 Introduction

The proposed N9 Kilcullen to Powerstown Scheme crosses generally low lying undulating relief, which is currently used for predominantly agricultural purposes. Desktop studies and a Preliminary Site Investigation have been carried out along the route of the proposed construction in order to determine the composition of the underlying sub-soils and hard rock geology of the area.

This section assesses the nature of the soils and geology and the scope of the earthworks construction activities and the consequential impacts. The impacts of the works on the hydrogeology in the vicinity of Narraghmore Bog and on the Narraghmore Group Water Supply are also discussed.

7.6.2 The Receiving Environment

Ground Conditions

The ground conditions along the route of the construction have been in the main influenced by the last major glaciations. The existing ground conditions are quite varied and comprise of typically 0.1 metres – 0.6 metres of topsoil overlying drift geology of glacial origin comprising mixed, glacial till material and granular deposits of generally between 1 metre and 20 metres in depth. During the preliminary ground investigation depths of granular material up to 37 metres in depth were identified at several locations. Localised peat, laminated clay and alluvium deposits also occur particularly in the vicinity of current watercourses. The nature of the glacial till is typically sandy gravelly clay with varying proportions of gravel, cobbles and boulders.

The bedrock geology along the route of the construction comprises a number of rock types. Silurian sandstone and siltstone rock are the oldest rocks encountered in the area and generally underly the mainline route, as far south as Mullamast. Lower Carboniferous limestones underly the Athy to R747 Link Road and the mainline area as far south as Coolane / Ballyvass which then extends onto granite. The nature of the limestone is a strong limestone, although it is interbedded with argillaceous layers and also shows localised weathering and potential for solution features in places. The Granite bedrock along the route of the construction is subject to deep 'onion skin' weathering to varied depths, with granite corestones surrounded by highly weathered residual granite sands. From Ballybar Upper, strong Lower Carboniferous limestone strata once again underlies the route south to Powerstown.

Landfill Site at Usk Little

An active landfill site is located in a disused quarry area situated at Usk Little between Ch. 71,740 – Ch. 71,820. Landfill operations under licence granted by Kildare County Council are still ongoing. Made ground is currently at a thickness of approximately 10.0 metres. During the Preliminary Ground Investigation, evidence of elevated levels of contaminants such as Heavy Metals and Polycyclic Aromatic Hydrocarbons (PAH's) were encountered at this site. Laboratory test results on samples from the landfill site indicate that the level of these contaminants exceeds the Dutch Standard Trigger levels. Further investigation will be required as part of the Detailed Ground Investigation to fully assess the implications of the presence of these contaminants.

Hydrogeology

The lands adjacent to the route are drained by the River Liffey and the River Barrow and its main main tributaries, the Rivers Burren. Lerr and Greese.

The main bedrock aquifers in the region are to be found in karsified limestones (Ballyadams and Clogrennan Formations), which lie to the east and south east of the route alignment, and the Dolomotised limestones (Ballysteen and Milford Formations).

The Leinster granite is considered to be an aquitard, most groundwater flow being concentrated in the upper weathered zones and along permeable zones of limited extent such as faults and fractures.

The bedrock is covered by a varying thickness of Quaternary deposits, whose hydro-geological significance is governed by their permeability, thickness and extent. High permeability Sand and Gravel deposits, where sufficiently thick, may be an aquifer in their own right. These deposits occur mainly to the north of the route. Additionally these deposits allow rapid recharge of underlying bedrock aquifers. The sand and gravel deposits can often be interbedded with less permeable material.

The low permeability Glacial Tills protect the underlying bedrock aquifers and may, in places, confine them and possibly produce artesian conditions under the correct topographic conditions.

During the Preliminary Ground Investigation groundwater was generally encountered at between 1 and 15 metres in depth. In localised areas low lying ground is prone to flooding.

The groundwater table is locally affected by drawdown associated with the sand and gravel pit in the area of Ballyvass, and by the limestone quarry at Clonmelsh. Dewatering is known to be in operation at Clonmelsh quarry, with the current floor level at least 30 metres below pre-existing ground levels.

A major group water scheme at Narraghmore has been identified and is discussed in more detail in the following sections.

Narraghmore Group Water Scheme

The Narraghmore Group Water Scheme is sourced from a shallow well on the east side of the road at Ch. 66,850. Water is pumped from the well to a reservoir at Nine Tree Hill, which then feeds to 330 houses in the vicinity of Crookstown and Mullamast.

The water supply is a shallow artesian well, fed from overburden soils consisting of sands and gravel, formed in what is probably an incised or channel feature. The well has a Source Protection Zone of 2.9 sq. kilometre, with a radial distance of 2 kilometres up-gradient of the well. An Inner Protection Area (SI) of 300m from the well and an Outer Protection Area (SO) of 1000 metres from the well have been identified from site specific investigations. See Figure 7.19 in Volume 2.

Narraghmore Bog

Narraghmore Bog is located approximately 8 kilometres south of Kilcullen in County Kildare, on the west side of the route between Ch. 69,200 and Ch. 70,600. The

bog covers an area of approximately 121 hectares, and is approximately 2 kilometres long and 0.5 to 1.2 kilometres wide.

The bog is described as a raised bog formed in a depression in the topography during the post glacial period. The bog is of high regional ecological importance, but has been significantly modified over recent years by drainage along it's eastern and southern boundaries, as well as part of the western boundary. The bog has also been used for forestation with conifers.

The waters in Narraghmore Bog are fed from the higher grounds to the east and west, and it discharges to the south. See Figure 7.20 in Volume 2.

7.6.3 Proposed Development / Site Investigations

The construction of the N9 Kilcullen to Powerstown Scheme includes the formation of nine major mainline road cuttings and six significant mainline road embankments. In addition, the earthworks on the Athy to R747 Link Road will be largely at grade or shallow earthworks, except at Mullamast and in the River Greese valley, where deeper earthworks cuttings and embankments will be formed.

Excavated materials are generally classified as being either rock or non rock, depending on the method of excavation required to form the cuttings. Rock generally requires blasting for its removal in large quantities. Excavated materials that are not suitable for re-use in structural embankments are defined as being unsuitable. Unsuitable materials fall into two categories, (U1 and U2). U1 materials are generally materials that are unsuitable due to the organic material content, high plasticity, high moisture content or a combination of these. U2 materials are materials having hazardous chemical or physical properties requiring special measures for excavation, handling, transportation or disposal. (Reference Series 600 of the NRA Specification for Roadworks)

Earthworks Quantities

The estimated earthworks quantities for the Dual Carriageway mainline and side roads are as follows:

- About 532,000 cubic metres (m^3) of topsoil is required to be excavated, of which about 182,000 m^3 will be re-used on grass verges and side slopes etc., and the surplus topsoil (about 350,000 m^3) removed from site.
- 2,950,000 m^3 of fill material is required to form the road embankments.
- 2,915,000 m^3 of clay / gravel / rock is to be excavated and re-used to form road embankments and 502,000 m^3 re-used in the capping layer.
- About 770,000 m^3 of poorer quality silty clay and peat are to be excavated. It is anticipated that some 500,000 m^3 of this material can be re-used in the formation of noise berms and landscape bunds with the rest of the material to be removed from site. However, some of this material, particularly at the southern end of the scheme, could be improved by mixing with lime for re-use as suitable fill material.
- About 502,000 m^3 of graded granular material will be required for the road capping layer, the majority of which is likely to be sourced from the sand/gravel cuttings and from the rock cuttings on site.

It is estimated that 350,000 m^3 of topsoil and 270,000 m^3 of poorer quality silty clay and peat will have to be removed from site, while some 35,000 m^3 of suitable fill material will have to be hauled to site from external sources.

The above scenario assumes that some 460,000 m3 of material will be hauled from the cuttings north of Ch. 41,000 to form the embankments at the southern end of the scheme between Ch. 32,300 and Ch. 33,500. If instead, fill material is imported from nearby sources, a similar quantity of surplus suitable excavated material will have to be exported to restitution of nearby disused quarries, or similar. In addition, the contractor would have flexibility in selecting some of the material excavated from rock cuttings for use in the sub-base layer. The most likely scenario is that the contractor will adopt a combination of importing suitable material to form the embankments at Clonmelsh, use of some excavated rock for use on the sub-base layer and removal of some suitable material off site, as well as the surplus unsuitable material. The earthworks design will be confirmed following the completion of the Detailed Main Ground Investigation Contract.

The estimated earthworks quantities for the Athy to R747 Link Road are:

- About 90,000 m^3 of topsoil is required to be excavated, of which about 28,000 m^3 will be re-used on grass verges and side slopes etc., and the surplus topsoil (about 62,000 metres^3) removed from site.
- 375,300 m^3 of fill material is required to form road embankments.
- 404,000 m^3 of clay / gravel / rock is to be excavated and re-used to form road embankments and the capping layer.
- About 50,000 m^3 of poor quality silty clay and peat are to be excavated. It is planned that most of this material can be re-used in the formation of noise berms and landscape bunds with the rest of this material be removed from site.
- About 60,000 m^3 of graded granular material will be required for the road capping layer, the majority of which is likely to be sourced from the rock cuttings on site.

It is estimated that 62,000 m^3 of topsoil will have to be removed from the site of the Athy to R747 Link Road.

The conclusions drawn from the earthworks review are that it is likely that 460,000 m^3 of fill material will be imported in the section from Ch. 32,300 to Ch. 33,440. This is in excess of the fill deficit for the whole of the route, ignoring logistical and economic problems of long hauls. The railway crossing at Clonmelsh, at Ch. 33,440, forms a barrier to haulage of earthwork materials from the north. The River Burren Crossing at Ch. 41,000 also forms a potential barrier to earthworks haulage.

The sources of imported fill material have not been specifically identified, but could come from the various quarries located close to the route. Prior to obtaining material from any borrow pit appropriate planning approval would have to be sought from the relevant planning authority. The potential environmental impact of the import of suitable fill material and any potential mitigation measures are discussed in Chapter 11, "Construction Phase".

The small shortfall of material for this scheme could alternatively be sourced by the improvement of U1 materials rather than import of materials. There is potentially approximately 800,000 m^3 of U1 material to be excavated during construction of the road. Some of this U1 material can be accommodated in landscaping and bunding along the route. However, some 270,000 m^3 of U1 material will need to be recovered to off site locations. There are a number of disused sand and gravel pits close to the road alignment that would be suitable for recovery using the U1 material.

The various alternative strategies for re-use of materials, and disposal of surplus materials as discussed above can only be finalised after receipt of the Detailed Ground Investigation data and receipt of the Detailed topographical Survey.

Excavations

At present, based on the findings of the Preliminary Site Investigation, it is believed that excavation of the sandstone / siltstone bedrock, to form the deep cuttings in the vicinity of Nine Tree Hill (Ch 64,460 – Ch. 65,150) and Mullamast (Ch. 8,700 – Ch. 9,100 on the Athy to R747 Link Road) and granite cuttings at Woodlands West (Ch. 52,500 – Ch. 53,200), Tinryland (Ch. 36,420 – Ch. 37,730) and Bennekerry (Ch. 41,200 – Ch. 42,890) will require pre-split blasting. The excavation of the granite bedrock, to form the cutting in the vicinity of Russelstown North (Ch. 45,940 – Ch. 46,300), may possibly be achieved by mechanical digging and ripping the rock using standard earth moving plant. A more complete understanding of the rock conditions and its variability with depth should be available once the Main Site Investigation has been completed.

Based on the findings of the Preliminary Ground Investigation the ground conditions are generally believed to be acceptable for forming the proposed earthworks at side slopes of one vertical to two horizontal with an adequate factor of safety in the sandy gravelly boulder clay / sand and gravels soil overburden.

During the course of the Preliminary Site Investigation a total of sixty-four standpipe monitoring points were installed in order to observe the levels of groundwater along the proposed route. It is anticipated that sections of the cuttings will be below the current groundwater level, and as a result water inflows are likely to occur during construction and operation.

It is anticipated that the flow of groundwater into the road cuttings would be controlled by the inclusion of a road drainage system comprising interceptor ditches, batter and filter drains and possibly slope drainage measures, to stabilise the cutting side slopes. Groundwater intercepted by this system would be collected and disposed through the road drainage system.

Embankments

Post construction settlements at embankments are anticipated to be up to 50 mm in places. A detailed assessment of embankment settlements will be carried out following the detailed design stage Main Ground Investigation to assess more fully the soil parameters and the depth of compressible material beneath the embankments.

Side slopes for embankment construction will depend on the quality of available fill material. It is expected that slopes of 1 vertical to 2 horizontal will be satisfactory given the likely materials excavated along this section of the route.

Landfill Site at Usk Little

Made ground at Usk Little is currently at a thickness of approximately 10.0 metres, and landfill operations are still ongoing. The road design at the landfill site assumes that the landfill material will be excavated down to the floor of the old quarry, and a shallow layer of granular fill material placed to construct the road formation.

The material placed in the landfill is generally a mix of soils and building waste, and it is considered that this material will not be suitable for incorporating into the road embankments. Furthermore, testing undertaken as part of the Preliminary Ground Investigation has indicated that the level of Heavy Metals and Polycyclic Aromatic Hydrocarbons contaminants in parts of the site exceed the Dutch Standard Trigger levels.

Narraghmore Group Water Scheme

The Narraghmore Group Water Scheme supply well is located on the east side of the proposed N9 Kilcullen to Powerstown Scheme at Ch. 66,850. The water supply is a shallow artesian well on the east side, sited approximately 200 metres to the east of the road, on the downhill side of the road at Ch. 66,850. At this location a stream crosses the road, falling from west to east.

The road drainage between Ch. 65,500 and Ch. 73,300 is carried in a closed drainage system in the verge where the road crosses this stream in order to protect the well from pollution and discharges into a more significant watercourse that flows parallel to the Local Road L8014 at Ch. 67,200. An attenuation pond and pollution control measures will be provided at this outfall. The potential impacts of the road scheme on the Group Water Supply Scheme are discussed in Section 7.6.4 below.

Narraghmore Bog

The proposed road runs adjacent to the eastern boundary of the bog over a length of 1.4 kilometres between Ch. 69,200 and Ch. 70,600. The road drainage between Ch. 70,500 and Ch. 73,300 discharges into the watercourse that runs along the eastern edge of the bog, while the road drainage between Ch. 69,200 and Ch. 70,500 discharges into a watercourse that crosses the proposed road alignment at Ch. 68,930, and then passes round the southern boundary of the bog. The potential impacts of the scheme on the hydrogeology of the bog are discussed in Section 7.6.4 below.

7.6.4 Predicted Impacts

Rock Cuttings

The excavation of the rock cuttings would generate additional environmental impacts in terms of noise, vibration and dust generation. The extent of these impacts would be controlled by the careful selection of appropriate method of excavation of the rock material. As the excavation effort increases so would the environmental impact in terms of noise, vibration and dust generation.

Landfill Site at Usk Little

The variable nature of the made ground at the landfill site at Usk Little suggests that the cutting side slopes should be constructed at one vertical to three horizontal through the landfill material.

During the Preliminary Ground Investigation the landfill site has been identified as being potentially contaminated. The extent of contamination is not known and a detailed environmental investigation will need to be undertaken during the Main Ground Investigation to assess the economic and environmental impact this material will have for the scheme.

The road vertical alignment requires that much of this material will need to be excavated to achieve road formation level and therefore classification of this

material as a hazardous waste will increase disposal costs and may require licensing by the Environmental Protection Agency.

Hydrogeology

Many of the cuttings occur in low permeability glacial till deposits which are not productive aquifers. It is anticipated that cuttings in these deposits will have minimal impact on the general groundwater regime, and any wells installed in proximity to these areas.

The installation of the anticipated drainage measures described above for the deep rock cuttings may lead to a localised lowering of the groundwater table in the vicinity of the cuttings. The deepest rock cutting sections occur in the sandstones of Nine Tree Hill where the preliminary ground investigation observed water to be below the level of the proposed cutting. No impact on the groundwater regime is anticipated here. Rock cuttings further south will cut through the Leinster granites, which are generally considered to be low permeability rocks which act as aquicludes.

Cuttings in the more permeable sand and gravel deposits, where groundwater tables are above the proposed cutting formation level, will impact on the groundwater regime of the surrounding areas. The lateral extent of the "potential drawdown" of the ground water table would be dependant on the permeability of the superficial soils and the existing groundwater levels. The deepest cutting occurring in this type of ground occurs to the east of Junction 2 on the R747 Link road. At this location preliminary observations indicate the groundwater levels to be below the proposed cutting formation levels, indicating minimal impact of the existing hydro-geological regime. The cutting north of Usk Little to Dalkinstown is to be excavated through permeable sands and gravels to depths of upto 10m. At this location, observations indicated groundwater to below formation level. It is also possible that the groundwater regime here has been affected by dewatering of the sand and gravels workings at Dalkinstown. The mineral extraction workings extend below proposed cutting formation level.

At Usk Little the preliminary groundwater observations indicate that the groundwater table is some 13 to 14m below the existing land fill level. Therefore the groundwater table is anticipated to be below the proposed carriageway levels. The road cutting by itself would not influence the ground water regime. However, because of the potential for contaminants within the existing land fill deposits, which will remain in place post road construction, there is potential for downward migration of leachable contaminants, should they be present, through the underlying permeable gravel deposits to the groundwater table. The potential for this migration of contaminants exists whether or not the road is constructed.

Narraghmore Group Water Scheme

A study of the well catchment has identified an Inner Protection Area (SI) of 300 metres from the well and an Outer Protection Area (SO) of 1000 metres from the well. The proposed N9 Kilcullen to Powerstown Scheme will intercept the SI over a length of approximately 130 metres and the SO over a length of approximately 1100 metres. This latter length of the road alignment, which extends from Ch. 65,850 to Ch. 67,850, has therefore been assessed to identify potential impacts.

Between Ch. 65,800 – Ch. 66,150 the road would be in cutting approximately 4 – 5 metres deep; then from Ch. 66,150 to Ch. 66,700 the cutting reduces to less than 3m deep. From Ch. 66,700 to Ch. 67,850 the road is on embankment except for a

short section of shallow cut through the rise at Ch. 67,000. The section of the Inner Protection Area (SI) affected by the road construction falls within the section of road on embankment.

The results from the Preliminary Ground Investigation conducted in 2002 indicate that the road cuttings will be formed in silty sandy clays, with the road formation level above the groundwater table throughout this section of road. Consequently, the road excavation should not intercept the aquifer feeding the well.

Narraghmore Bog

A study of the Narraghmore Bog has identified that the construction of the N9 Kilcullen to Powerstown Scheme will have only a minor impact on the groundwater regime that feeds the bog, as the scheme reduces the potential catchment area by only 3 – 5%. The proposed road drainage, which discharges into a ditch that runs along the eastern margin of the bog, was also reviewed and it was identified that the discharge from the road drainage at Ch. 70,500 should be attenuated to be compatible with the natural stream characteristics.

7.6.5 Remedial or Reductive Measures

Earthworks – General

In order to minimise the impact of material haulage on other road users and the population living along the roads leading to the site, the road construction contract would prohibit the use of certain roads by construction plant, and only those roads deemed suitable for access would be available to the contractor.

The mitigation of environmental impacts arising from the construction activities associated with the construction of the proposed scheme have been discussed more fully in Section 11.4, "Earthworks Operations". In brief, the mitigation measures proposed to minimise the environmental impact of the scheme during construction include:

- control of site working hours;
- specified maximum peak and average noise levels;
- restrictions on times and locations where rock excavations / blasting may be carried out;
- reference to best working practice in terms of selection of appropriate plant, maintenance and plant operation.

Landfill Site at Usk Little

Should the Made Ground at Usk Little landfill be classified, following further environmental investigations, as a hazardous waste, there will be significant economic implications for the scheme. The soils would require either on-site remedial treatment, containment or removal for off site treatment and disposal. There are no known landfills in Ireland at present currently licenced to accept hazardous waste, and therefore such waste would require treatment to reduce the contamination to non-hazardous levels or be exported for treatment / disposal. This will depend largely on the extent of the contamination within the landfill, the levels of contamination and whether or not these contaminants can readily migrate or leach from the excavated material to the surrounding ground and groundwater. Any form of onsite remedial treatment would require a waste license from the Environmental Protection Agency.

Hydrogeology

The anticipated mitigation of the environmental impacts of the reduction of the groundwater table in the locality of the cuttings may include the following:

- Minimising the depth of the drainage measures in the cuttings to ensure that the localised reduction in the groundwater table would be minimised.
- The introduction of appropriate planting to mitigate against the adverse effects of the localised lowering of the groundwater table on the existing flora.
- Where any cutting does impact on the ground water which would affect domestic water well abstraction, remedial measures would include the deepening or re-drilling of the well.

The full extent of the groundwater conditions, and hence the mitigation measures, required at the rock cutting locations cannot be determined until the Main Site Investigation has been carried out to enable a more complete understanding of the groundwater conditions at these locations to be established. Further long-term monitoring may be required to ensure that the groundwater table at the localities of the cuttings predicted during the design process agree with the conditions on site.

At Usk Little, the road drainage systems, and any slope drainage measures in the landfill materials, must consider the possible presence of contaminants. Any remediation or mitigation measures will depend upon the findings of the main environmental investigation to be carried out at the site. Mitigation measures may include isolating the runoff water and road drainage and containing them in a closed system. Capping or lining measures may be required above the existing landfill zones and on the cutting side slopes to prevent water permeation down through the landfill deposits into the gravels below.

Narraghmore Group Water Scheme

The construction of the new road through the catchment area of the well would potentially reduce the area of land feeding the well. However, this impact would be very minimal of the order of 1 – 5%.

The proximity of the proposed new road to the well is a risk to the water supply, due to the sensitivity of the shallow aquifer to pollution. Accordingly, the road drainage has been isolated from the source by piping the surface water run-off from the road carriageway between Ch. 65,500 and Ch. 73,300 to the outfall at Ch. 67,200.

There is also a risk, albeit very low, that the water supply could be polluted in the event of an accident taking place on the length of road between Ch. 66,600 and Ch. 67,000, which largely falls within the SI. However, the impact of any accident involving a petroleum / chemical transporter leaving the road immediately upstream of the well would be severe, due to the shallow nature of the underground feed. Such an accident could also pollute the well for a considerable period of time. Earth bunds have therefore been included in the design between Ch. 66,600 and Ch. 67,000 to ensure that vehicles cannot leave the road in the event of a major accident in this section of the route. Any spillage would therefore be taken to the closed road drainage system and would not infiltrate into the ground immediately upstream of the well.

During the construction stage, strict control will be imposed on all earthworks and drainage operations to prevent contamination of the water source. It is also recommended that the topsoil be retained under the road embankment between Ch. 66,800 to Ch. 66,940 to remove the risk of exposing the gravel aquifer that

feeds the well. Special embankment foundations, such as placing a geotextile layer under the embankment and use of fill materials excavated from the adjacent cuttings to form the body of the embankment, should be considered in the design of this section of the road.

Narraghmore Bog

It is recommended that the discharges from the road drainage at Ch. 70,500 into the stream that runs along the eastern edge of the bog be limited to c. 32 litres/sec. At this location, the proposed road drainage passes through a wetland attenuation pond / pollution control measure, with a 20-year storm discharge into the drain on the east side of the bog of 32 litres/sec. This would be considerably less during more frequent storm events.

Other recommended mitigation measures to protect the bog during the Construction Stage include installation of settlement ponds and pollution control measures.

7.6.6 Residual Impacts

General Impacts

Construction of the road scheme may cause long-term impacts on the hydrogeology of the area. Long term monitoring may be required at the locations of the rock cuttings to ensure that the predicted groundwater table behaviour at the cutting localities, developed during the design process, agree with the conditions on site. The potential impacts and mitigation measures are summarised in Chapter 13 "Mitigation Measures", 13.2.6 "Soils and Geology". It is anticipated that any impacts created can be controlled with relative ease by engineering design.

Chapter 11 discusses the possibilities of monitoring for noise pollution and other predicted nuisances during construction.

Landfill Site at Usk Little

Residual impacts may be incurred if the Made Ground at Usk Little landfill is classified as a hazardous waste and if these contaminants can readily migrate or leach from the excavated material to the surrounding ground and groundwater. Appropriate engineering design, remediation and long term monitoring must be implemented to ensure no residual impacts are incurred due to these activities. It should also be noted that these same impacts exist prior to construction of the road scheme and may already have impacted on the surrounding environments.

Narraghmore Group Water Scheme

The new road would potentially reduce the catchment area of the well by some 1 – 5%. This is considered to be a minor residual impact.

Narraghmore Bog

The new road would potentially reduce the catchment area of the bog by some 3 – 5%. This is considered to be a minor residual impact.

The pollution control measures installed at the road drainage outfalls would minimise the risk of any pollution from the road on the ecology of the bog.

Long term monitoring may be required to ensure that the predicted groundwater table behaviour in the bog agree with the conditions on site.