Chapter 6:

Geology and Soils in the Existing Environment

6 GEOLOGY AND SOILS IN THE EXISTING ENVIRONMENT

This chapter of the EIS presents available information on the soils and geology of the Study Area along and in the vicinity of the proposed Lower Lee (Cork City) Flood Relief Scheme. It investigates how the existing soil and geological environment may be altered in both the short and long-term by the construction and operation of the proposed scheme. Should significant impacts be identified on the soil and geology, mitigation measures are proposed insofar as practicable.

The Lower Lee (Cork City) Drainage Scheme construction phase will include the following:

- detailed site investigation;
- site preparation works including temporary fencing / hoarding;
- construction of culverts;
- rehabilitation of existing culverts;
- construction of reinforced concrete walls
- installation of sheet pile flood defences;
- construction of earthen embankments;
- construction of flood control system;
- services and utility diversions;
- re-instatement of footpaths / roadways / green areas;
- raising of roads and footpaths to minimise impacts of flood defences;
- Emergency Flood Response System;
- Changes to Dam Operations by ESB.

6.1 METHODOLOGY AND LIMITATIONS

This chapter was compiled in accordance with the EPA publication entitled 'Guidelines on the information to be contained in Environmental Impact Statements' along with 'Advice Notes on Current Practice in the preparation of Environmental Impact Statements'. The Institute of Geologists of Ireland also published a guidance that was consulted during the preparation of this Chapter, entitled 'Geology in Environmental Impact Statement – A Guide'.

A desktop study was carried out in order to ascertain a comprehensive baseline for the Study Area and give a description of the existing environment. This information was then used in assessing the potential impact the Flood Relief Scheme will have on geology and soils within the Study Area. It was then possible to propose practicable mitigation measures to ensure that any potential impacts identified will not have a significant impact on the environment during the construction and operational phase.

No difficulties were encountered in the compilation of this Chapter.

6.1.1 Published Material

The baseline study of the existing soil and geological environment throughout the proposed Study Area was prepared using the Geological Survey of Ireland's (GSI) online database and the GSI publication; 'Geology of South Cork' (1994), along with additional source material. A comprehensive list is included below;

- The Geology of South Cork (Sleeman and Pracht, GSI, 1994);
- The GSI online database;
- Cork City Development Plan (2015 - 2021);
- Cork County Council Development Plan (2014);
- Cork City Council Planning and Development (Applications for Registration of Quarries under Section 261, Planning and Development Act 2000);
- Cork County Council Planning and Development (Applications for Registration of Quarries under Section 261, Planning and Development Act 2000);
- Cork County Council Internal Geographical Information System (IGIS);
- Concrete Products Directory (Irish Concrete Federation);
- Aerial Photographs (2015);
- ENVision Mines Site, the EPA's online Historic Mines Inventory;
- General Soil Map of Ireland;
- Explanatory Bulletin to Soil Map of Ireland 1980.

A ground investigation contract was carried out which consisted of boreholes, trial pits and rotary core sampling throughout the Study Area. The recorded data was used to confirm and verify information obtained from the above sources.

A draft report prepared by JBA Consulting for the OPW in October 2013 entitled 'Hydromorphic audit of the Lower Lee watercourse' was also consulted.

6.1.2 Definitions

Environmental and agricultural scientists generally understand the word 'soil' to refer to the fertile, organic rich layer which occurs on the surface of the Earth and the underlying layers which interact with it in terms of nutrient, ion, water and heat exchange. Using this definition, the depth of the soil layer is typically 0.3m to 1.0m thick. Geologists and engineers, on the other hand, generally understand the word 'soil' to refer to all unconsolidated (non-lithified) organic and inorganic deposits which occur above bedrock.

For the purpose of this EIS, the term 'soil' refers to the unconsolidated, organic rich material closest to the Earth's surface ('topsoil), while the term 'subsoil' (Quaternary Geology) is used to refer to all other unconsolidated (non-lithified) materials which occur above bedrock.

6.2 GEOLOGY

6.2.1 Geomorphology

The topography of the South Cork region is controlled by its geological structure, with the anticlines forming upland areas and the synclines occupied by valleys. These valleys were formed during the Pleistocene glaciations, which occured 2 million to 10 thousand years ago. Prior to this, the regional topography sloped southwards and the region was drained by southerly flowing rivers. This Tertiary drainage was truncated by glaciers advancing outwards from the mountainous regions of western Ireland,

preferentially exploiting the weaker shales resulting in the development of a large number of broad u-shaped valleys, where previously there has only been north-south drainage patterns. Superimposed on these u-shaped valleys are a number of buried valleys infilled with sand and gravel.

At the peak of the last glaciation, 15,000 years ago, when much of Europe was covered in ice, sea levels fell to approximately 130m lower than present day. As a result the rivers eroded down to the new base level cutting new steep sided gorges. When temperatures subsequently improved the ice sheets receded, sea levels rose and the gorges rapidly became infilled with fluvioglacial sand and gravels as the rivers responded again to the changing base level. The south of Ireland continues to sink and so sea levels are still rising. Milenic & Allen, 2002, estimate this rise as being 16m over the past 8,000 years.

6.2.2 Bedrock Geology

The bedrock of South Cork is much less varied than in many parts of the country. With one exception all the rocks exposed are sedimentary and were deposited during the late Devonian and Carboniferous Periods, between about 310 to 370 million years ago.

Sedimentary rocks are deposited in beds or strata. For the purposes of description and mapping related beds of rocks are commonly grouped together into formations. These formations can then be sub-divided into members, which usually represent a distinctive feature or local variations.

The Geology of South Cork (Sleeman and Pracht, GSI, 1994) and the 'Geological Survey of Ireland Online Database' (GSI.ie) indicates that the area immediately north of the Lee River (centre of the Study Area) is underlain by Ballytrasna Formation purple mudstone and sandstone, Cuskinny Member Formation flaser-bedded sandstone and mudstone and Gyleen Formation sandstone with mudstone and siltstone. South of the Lee River lies an outcrop of Carboniferous Limestone comprising Waulsortian Limestone, Cork Red Marble Formation, Little Island Formation Limestone and Old Head Sandstone Formation.

The findings of the ground investigation (based on available results), which was carried throughout the proposed Study Area are broadly in line with the bedrock as described above. The ground investigation confirm the presence of sandstone within the study area.

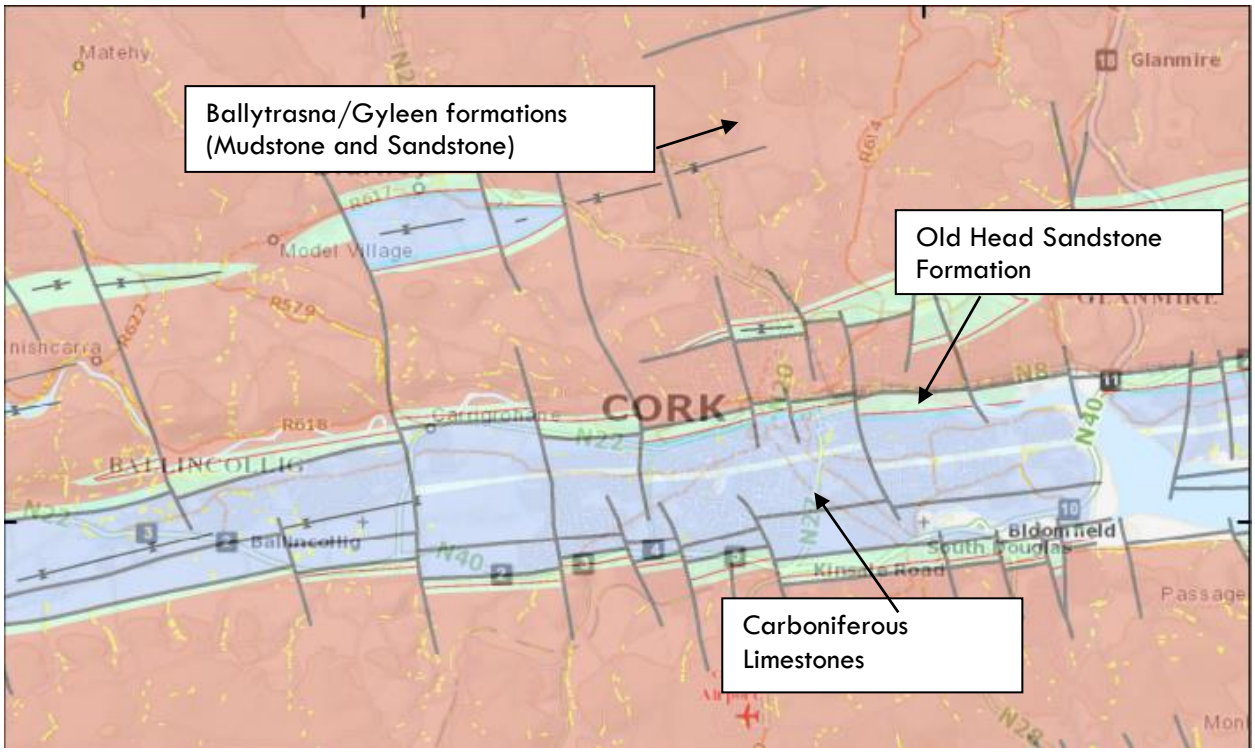

Figure 6.1 Bedrock Geology

6.2.3 Geological Heritage

Geological heritage encompasses the earth science component of nature conservation. This includes both bedrock and unconsolidated (soil) deposits close to the surface and processes (past and present) that shaped the land surface. The identification of geological heritage is achieved by finding sites or areas that best demonstrate particular types of geology, processes or phenomena that rank as noteworthy. A site selection process is being undertaken by the Geological Survey of Ireland (GSI), through the Irish Geological Heritage (IGH) Programme.

The IGH programme is a partnership between GSI and the National Parks and Wildlife Service (NPWS) and aims to identify and document the wealth of geological heritage, to protect and conserve it against threats through local authority planning and promote its value with landowners and the public. The primary national site designation for geological heritage (and nature conservation in general) is the Natural Heritage Area (NHA) designation. Designation of national sites is the responsibility of the National Parks and Wildlife Service (NPWS), working in partnership with the IGH programme. The second tier designation is that of County Geological Site (CGS). While a County Geological Site is not statutorily protected, the designation is intended to provide recognition for the site and there is some protection through incorporation in the County/ City Development Plan.

The Cork City Development Plan (2015 - 2021) states that the Council '*recognises the need to maintain and preserve important features of geological interest in the city and will work with the Geological Survey of Ireland, as appropriate, to conserve the sites identified as being of geological interest.* '

Similarly, the Cork County Development Plan (2014) states that the Council '*recognises the importance of geological heritage and to this end has listed in Volume 2, Heritage and Amenity Chapter 3 Nature Conservation Areas, of the plan the important geological features within the County with the intention of*

maintaining their possible conservation value. The list has been projected in consultation with the Geological Survey of Ireland and the Geology Department of the National University of Ireland, Cork'.

The Cork City Development Plan identifies 7 sites of geological and geomorphological interest in the city as proposed Natural Heritage Areas (pNHAs). One of the 7 sites are located within the Study Area which a second is immediately upstream of the Study Area.

Table 6.1 pNHAs within or in close proximity to the Study Area

pNHA	Site Code	Note	Description
Lee Valley	000094	Inside Study Area	A number of wetland bird species breed here, including Mallard, Heron, Sedge and Grasshopper Warblers and Reed Bunting and two rather locally distributed butterflies, the Small Blue and the Wood White occur.
Shournagh Valley	000103	Immediately upstream of the Study Area	Designation as a botanically diverse woodland of Oak, Beech and Hazel.

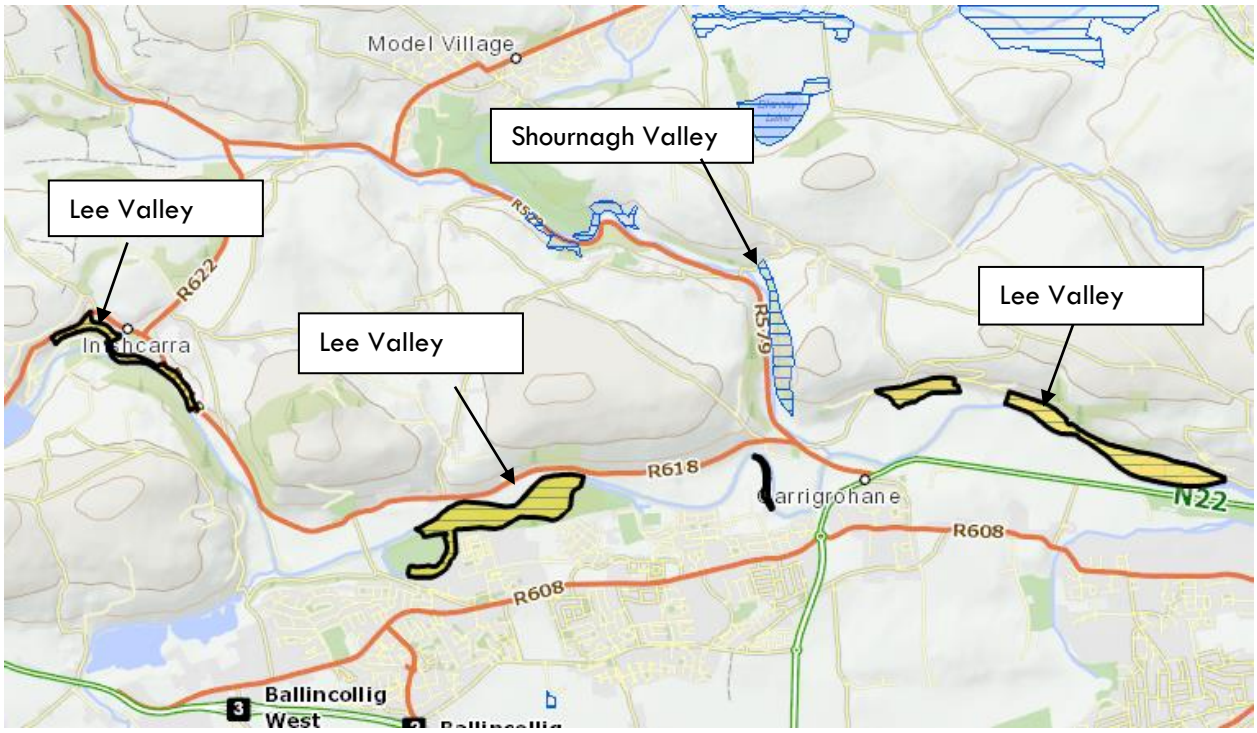

Figure 6.2 Proposed National Heritage Areas

In addition, the Cork County Development Plan 2014 lists the following CGS in the vicinity of the Study Area:

Table 6.2 Areas of Geological Interest County Cork

County Geological Sites	Description	Note
St. Joseph's section on Lee Road (Cork city)	Transition to Carboniferous	Adjacent to Study Area.
Blackrock Diamond Quarry	Amethyst; tarmac over - coal yard	Outside Study Area
Killumney Moraine	Major moraine and fluvioglacial terraces associated with local ice-cap expansion from the Cork/Kerry mountains. It may represent a retreat position rather than a discrete ice maximum limit.	Outside Study Area

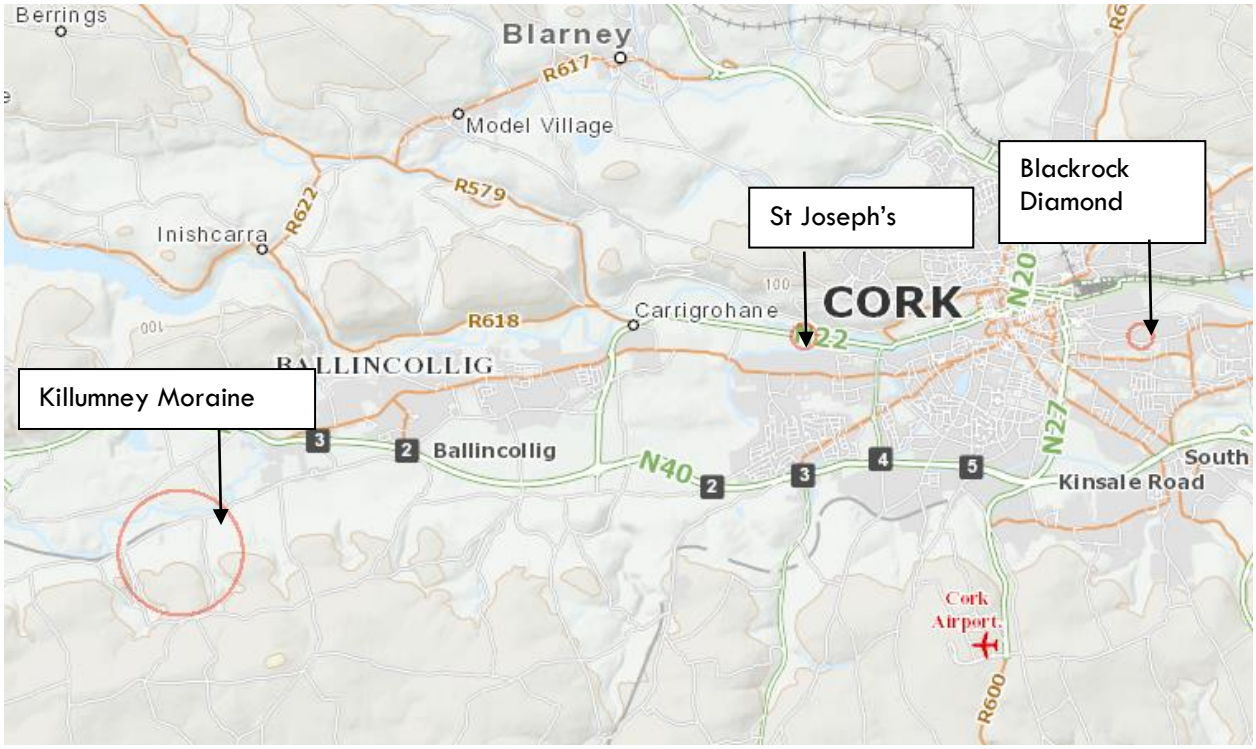

Figure 6.3 Geological Heritage Areas

6.2.4 Economic Geology

The term 'economic geology' refers to commercial activities involving soil and bedrock. The activities involved principally comprise aggregate extraction (sand and gravel pits and quarries) and mining. A number of sources were examined for information on such commercial activities within the Study Area, including:

- Cork City Council Planning Department (Application for Registration of Quarries under Section 261, Planning and Development Act 2000)
- Cork County Council Planning Department (Application for Registration of Quarries under Section 261, Planning and Development Act 2000)
- Cork City Development Plan (2015 - 2021)
- Cork County Council Development Plan (2014)
- Cork County Council Internal Geographical Information System (IGIS)
- Concrete Products Directory (Irish Concrete Federation)
- Aerial Photographs (2005)
- ENVision Mines Site, the EPA's online Historic Mines Inventory
- EPA Map Viewer

The sources consulted above indicate that there are two active quarries within the Study Area located approximately 2.5 km south East of Inniscarra Dam. The nearest active quarries are presented on Table 6.2:

Table 6.2 Quarries in closest proximity to the Study Area

Location	Status	Operators	Product summary
Classis Pit, c. within Study Area	Active	Roadstone Ltd.	Concrete sand, plastering sand, mortar, RMC, blocks, blacktop, aggregates and general fill.
Garryhesty Pit, within Study Area	Active	Roadstone Ltd.	Concrete sand, plastering sand, mortar, RMC, blocks, blacktop, aggregates and general fill.
Clashanure Quarry, adjacent to Study Area	Active	Finbarr O'Neill	Graded aggregate, sand, gravel, concrete, asphalt.

The locations of these quarries are shown in Figure 6.2.

As two of the quarries are inside the Study Area, the short and long term impacts of the proposed flood relief scheme on quarry activity is examined in this Chapter.

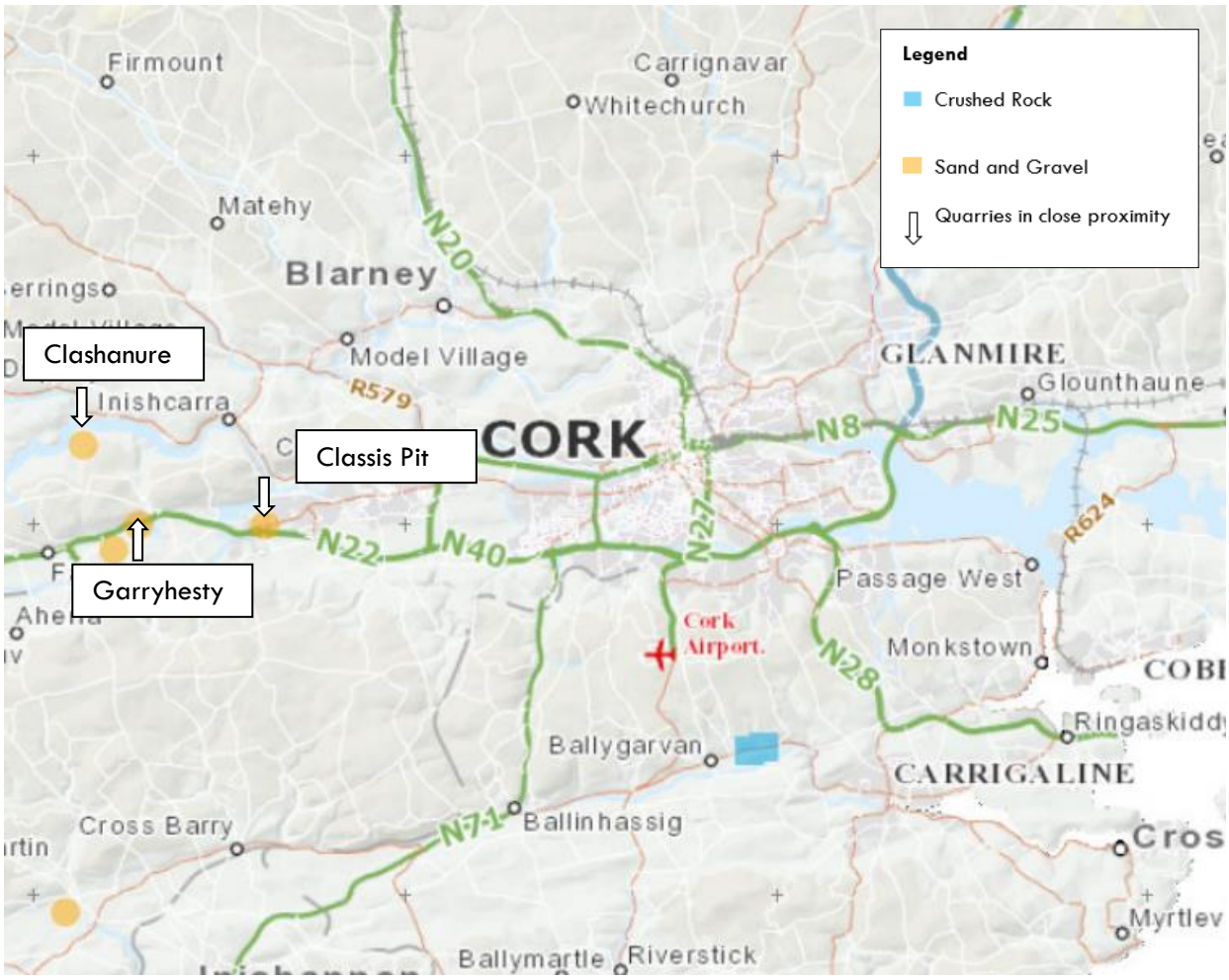

Figure 6.2 Quarry Locations

6.2.5 Geohazards

Upon consultation with the GSI National Landslide Database for Ireland, it was found that there are no recorded landslides in the area. There are no known geohazards within or in the immediate vicinity of the Study Area.

6.2.6 Quaternary Geology (Subsoil)

The Quaternary Period, which extended from the beginning of the Ice Age to the present day, is the final one of geological time scale. Most of the surface deposits of this area were deposited during the Quaternary Period, largely during the Ice Age itself. They were deposited either directly by glacier ice or by glacial meltwater. As the ice flowed over the underlying rock surface, pieces of protruding and loose rock became attached to its base. As these were carried along they both abraded the underlying rock and were ground down themselves. The rock that was picked up by the ice and partly ground down was later deposited either directly from the base or margin of the ice, or by meltwater flowing from the ice. In the former case it became Till and in the latter case it was separated out and deposited as gravel, sand, silt or clay. The composition of these sediments reflects the type of rock or substrate over which the ice flowed.

Subsoils deposited since the end of the last glaciation are typically referred to as 'recent deposits'. The most widespread recent deposits in Ireland is peat, which occurs both as upland blanket peat and lowland raised bog. Other recent deposits include silt and clay rich alluvium, typically deposited by and along rivers. According to the 'Geological Survey of Ireland Online Database' the Study Area is comprised of the following subsoils (Extract from GSI Database):

- Made Ground
- Alluvium
- Till Derived from Devonian sandstones
- Glaciofluvial sands and gravels

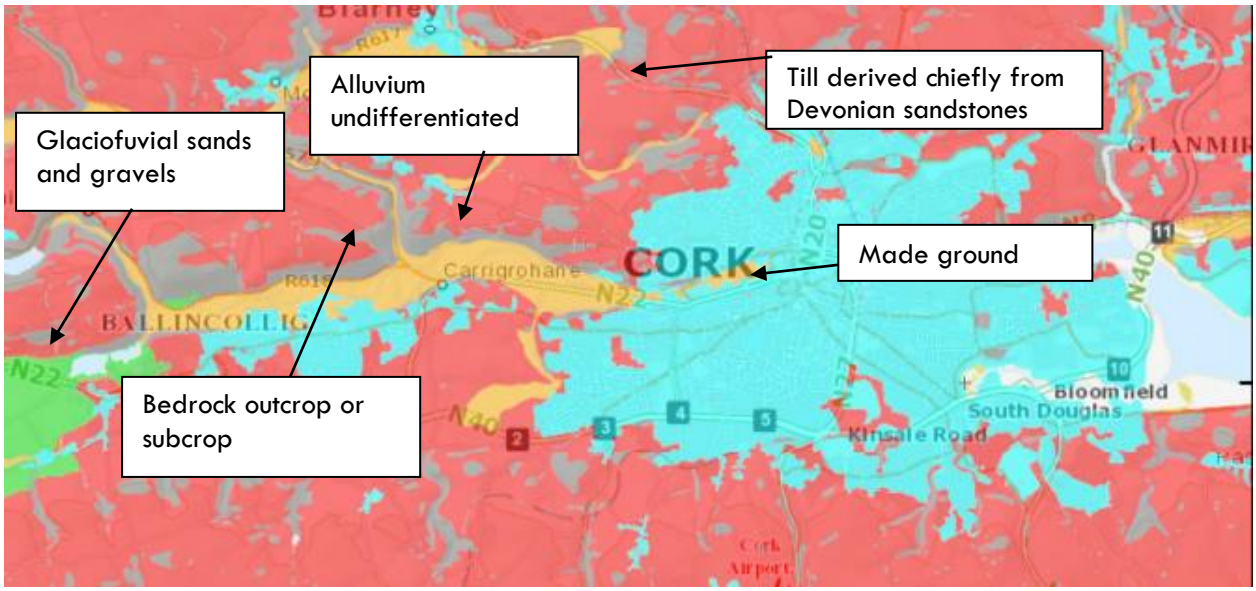

Figure 6.3 Subsoils

6.2.6.1 Bedrock Outcrop

These maps indicate that there are a number of bedrock outcrops in the centre of the Study Area (colour grey on map). This information is largely substantiated by the preliminary ground investigation that was carried out at regular intervals along the river bank. Silt/clay layers up to 1-3m thick were observed west of Cork City. Made ground 3-4m thick underlain sands and gravels was observed along the north mall.

6.2.6.2 Made Ground

Made Ground is defined as material, including soil, which has been deposited on land and/or altered by anthropogenic (human) activity. Made Ground is shown in the urbanised areas of the Study Area (colour turquoise on map).

The key risk associated with made ground is its uncertain origin and potential for contamination. However, no evidence of historical activities which could potentially have contributed to soil contamination was identified along or in the vicinity of the proposed scheme.

6.2.6.3 Alluvium

Alluvium is a young sediment that was recently eroded and carried off the hill side by a surface watercourse. It is ground into finer and finer grains each time it moves downstream, a process that can take thousands of years.

Alluvium soils are typically found at or in the vicinity of a surface watercourse and as such, a large stretch of the River Lee within the Study Area is situated within Alluvium subsoils (colour orange on Figure 6.3). As these subsoils are located in the immediate vicinity proposed works, it is likely that there will be an interaction with the proposed Flood Relief Scheme.

6.2.6.4 Glacial Till

Glacial till is a generic term which applies to glacially derived and/or transported soil which is deposited beneath or on the margins of a glacier or ice sheet. The Teagasc subsoil map, as presented on the Geological Survey of Ireland Online Database and Figure 6.3 of this report, indicates that glacial till is the predominant subsoil occurring in the south of the Study Area and is principally derived from Devonian sandstones (colour red on Figure 6.3).

Teagasc subsoil mapping indicates that glacial tills are present in areas to the south of the River Lee which is adjacent to proposed flood defences. The proposed scheme is concentrated around the River Lee, there was no ground investigation carried out within the area recorded as Glacial Till. As such there are no borehole records to confirm or deny the Teagasc Subsoil mapping as shown on the GSI Online Database. However, it is unlikely that the proposed scheme will impact on this Glacial Till.

6.2.6.5 Glaciofluvial Sands and Gravels

These Sands and Gravels are interpreted to be of glaciofluvial origin, deposited by glacial meltwater at the end of the last glaciation as the ice sheets retreated and formed outwash kame and terrace landforms. According to the Teagasc Subsoil Mapping there is an area of Sands and Gravels to the west of the Study Area (colour green on Figure 6.3). Although there was no ground investigation carried out in the area presented on the GSI Online Database as being Glaciofluvial Sands and Gravels, there were pockets of gravels discovered in close proximity to the Lee River. Given the complexity of the depositional environment around the ice margin, possibly associated with several phases of ice advance and retreat, this gravel would have been as a result of mixing of fluvial-glacial and/or glacio-marine deposits.

It is unlikely that the proposed works will have a significant impact on Glaciofluvial Sands and Gravels.

6.2.7 Potential Impacts on Geology

The key impact associated with the construction phase of the Lower Lee (Cork City) Drainage Scheme is the excavation, handling, storage, processing and transport of earthworks materials. The estimated volume of excavation anticipated during the construction phase is presented on Table 6.3.

Table 6.3 – Excavation Volumes

Origin of Excavation	Volume of Material
Wall Foundations	25,000m^3
Embankment Foundations	30,000m^3
Pipe Trenches	20,000m^3
Miscellaneous	2,500m^3
TOTAL	**77,500m^3**

There are a number of potentially negative environmental impacts associated with the handling of excavated materials. These impacts can arise directly as a result of on-site excavation and embankment construction activities or indirectly, due to placement of excess unsuitable materials at off-site locations.

Detailed site investigation works will also be carried out prior to the construction stage. These works will include intermittent coring of the bedrock, but impact is predicted to be imperceptible and as such has not been assessed below.

There was little evidence of large scale lateral movement of the channel observed during walkover study conducted as part of JBA Consulting Audit and only limited bank erosion.

6.2.7.1 Loss of Bedrock

Potential Permanent Slight Negative Impact

The majority of the Study Area is underlain by Gyleen Formation sandstone and carboniferous limestone, as described above in Section 6.2.2.

As the type of bedrock that will be excavated is abundant throughout the Study Area the portion to be removed will be imperceptible in comparison to the volumes retained and as such will not have a significant impact on the bedrock of the Study Area.

Mitigation Measures

Where it is necessary to remove bedrock to facilitate construction of the proposed scheme, suitable material will be reused elsewhere where possible. Material removed from site will be transported to the closest suitably licensed facility to be processed and used on other construction projects in the vicinity, where possible.

Residual Impact – Potential Permanent Imperceptible Impact

It is likely that, with the mitigation in place this impact will constitute a Permanent Imperceptible Negative Impact. This residual impact will be fully identified as the works method statement become finalised.

6.2.7.2 Loss of Geological Heritage

Imperceptible Impact

There is one proposed National Heritage Area (pNHA) within in the vicinity of the proposed works and a County Geological Heritage feature adjacent to the study area. As there no works prosed within the vicinity of the pNHA and it is not anticipated that significant volumes of rock will be excavated the potential impact is regarded as being imperceptible.

Due to possible exposure of bedrock as a result of proposed excavation works it is just as likely that the impact will be positive as negative. Should there be exposure of new geological surfaces, especially in bedrock, it may serve to facilitate greater understanding and appreciation of local geological heritage and earth science.

6.2.7.3 Loss of Quaternary Geology

Potential Permanent Slight Negative Impact

As described in Section 6.2.6 above, the Study Area is predominantly underlain by Made Ground, Alluvium, till derived from mixed Devonian Sandstone, Glaciofluvial sands and gravels. It is likely that the majority of excavations for flood defences are to be in Made Ground. The site investigation recorded that gravels are also present.

It may be possible to reuse excavated gravels, as recording during site investigation, as part of the fisheries mitigation measures recommended in Chapter 5. The impact of the removal of excavated material from the proposed works will be minimal as these subsoils are in abundance throughout the Study Area.

A large portion of the proposed flood defence measures are underlain by made ground and therefore there is a risk that contaminated material may be encountered. No evidence of historic activities which could potentially have contributed to soil contamination were identified in the immediate vicinity of the proposed scheme. Although the key risk with Made Ground is its uncertain origin, on the basis of available evidence and taking into consideration the small volume of made ground to be excavated, the potential impact is regarded as being imperceptible.

Mitigation Measures

Excavated subsoils will be reused as fill, or for the construction of flood defence embankments where possible. Any remaining volumes of unsuitable materials will be transported to the closest suitably licensed facility.

Residual Impact – Potential Permanent Imperceptible Impact

It is likely that, with the mitigation in place this impact will constitute a Permanent Imperceptible Impact. This residual impact will be fully identified as the works method statement become finalised.

6.2.7.4 Quarry

Potential Permanent Imperceptible Impact

During the construction phase there is potential that the proposed works may impact quarrying activities.

The following potential **positive impacts** have been identified:

- Local source of concrete/fill materials for construction for proposed works
- Possible disposal site for excavated material which is surplus to requirements or unsuitable for reuse in construction
- The following potential negative impact has been identified:
- Release of water from Innishcarra Dam may increase ground water levels resulting in increased risk of flooding or need for pumping.

Residual Neutral Impact

It is likely that this impact will constitute a Permanent Imperceptible Impact. This residual impact will be fully identified as the works method statement become finalised.

6.3 SOILS

Soil is the top layer of the earths crust. It is formed by mineral particles, organic matter, water, air and living organisms. It is an extremely complex, variable and living medium and its characteristics are a function of parent subsoil or bedrock materials, climate, relief and the actions of living organisms over time.

Soil can take thousands of years to evolve and is essentially a non-renewable resource. Soil performs many vital functions. It supports food and other biomass production (for example forestry and biofuels) by providing anchorage for vegetation and storing water and nutrients long enough for plant to absorb them. Soil also stores, filters and transforms other substances including carbon and nitrogen. It has a role supporting habitats and serves as a platform for human activity, landscape and archaeology.

6.3.1 Soil Formation

There are three principal soil formation processes that take place in Ireland, leaching, gleisation and calcification.

Through the *leaching* process, soluble constituents are carried down through the soil profile, the soil becomes progressively more acidic until relatively insoluble constitutes such as iron, aluminium and humus are washed deeper into the soil. Organic matter may accumulate on the surface and an iron pan may be formed at a lower level in the soil. At this point the leaching process may be referred to as podzolisation.

Gleisation is the soil-forming process resulting from the water-logging, possibly due to high water tables, or the impermeable nature of the soil itself. The movement of water through the soil is highly restricted and as a result leaching is very limited. Due to anaerobic conditions many soil constituents are converted by chemical processes into reduced forms. The soil usually takes a grey or blue colour as a result of the reoxidation processes.

C*alcification* is a process resulting in the redistribution of calcium carbonate in the soil profile without complete removal of it. Regions where rainfall is typically 750mm or less are affected by this process. Since the rainfall is low, the percolation of water through the profile is not sufficient to completely remove the calcium carbonate that existed in the parent material or that was produced by reaction between carbonic acid and the calcium hydrolysed from silicate minerals. Accumulation of carbonates at some point in the profile is typical of calcification. Calcium also tends to keep fine clay in a granular condition resulting in very little downward clay movement.

Due to the climate in Ireland, Leaching and Gleisation are the two most common soil formation processes.

6.3.2 Soil Associations

The General Soil Map of Ireland classifies the Study Area as Rolling Lowland. These lands have slopes between 2 and 6 degrees with soils typically derived from shales, sandstone, granite or mica schist.

The north of the Study Area comprises principally of Brown Podzolic soil (60%). Associated soil classifications are defined as Acid Brown Earths (20%) and Gleys (20%). These soils have been derived from sandstone and Lower Avonian Shale glacial till which is consistent with ground conditions as recorded in boreholes carried out as part of the site investigation. The south of the Study Area comprises principally of Acid Brown Earths (70%). Associated soil classifications are defined as Grey Brown Podzolics (15%) and Gleys (15%). These soils are derived from mixed sandstone and limestone glacial till. The Study Area was typically characterised by Made ground/Fill; topsoil, concrete, bitumen overlying Silt to depths of typically between 1.0 m and 4.0m to 5.7m bgl. These recent deposits were typically underlain by medium dense (becoming dense with depth) silty sandy Gravel with a variable cobble content, to depths of between 5.5m bgl and 16.0m bgl. The shallower gravel deposits also contain variable thicknesses of sandy gravelly Clay or Silt which varies in strength from generally soft to firm and occasionally stiff to very stiff.

Brown Podzolic soils have been formed through the leaching process as described above. They are less depleted than other soils formed through this process, and the profile usually consists of a surface in which organic matter is mixed with mineral matter. This overlies a reddish-brown layer in which iron, aluminium and sometimes humus have accumulated and there is no iron pan. Brown Podzolics have desirable physical characteristics and as a result are often devoted to cultivated cropping and pasture production. The low nutrient levels are easily overcome with the addition of lime and fertiliser.

Brown Earths are relatively mature, well drained, mineral soil with a relatively uniform profile. These soils have not been extensively leached with the result that there are no obvious signs of removal and deposition of iron oxides, humus or clays. In many cases a certain degree of leaching has taken place resulting in the translocation of soluble constituents, notably calcium and magnesium. The majority of Brown Earths result from lime deficient parent minerals and are therefore acid in nature. The desirable structure and drainage characteristics results in these soils being the most extensively cultivated soils, making up for a relatively low nutrient status by responding well to manorial amendments.

Gleys are soils in which the effects of poor drainage dominate and which have developed under the influence of waterlogging, characterised by the Gleisation process described above. Most gleys have poor physical conditions which make them unsuitable for cultivation or for intensive grassland farming. Their productive capacity is also affected by restricted growth in spring and autumn.

6.3.3 Potential Impacts on Soil

6.3.3.1 Loss of Soil

Potential Permanent Imperceptible Negative Impact

Any loss of soil, or other potential impacts will be during the construction phase and likely to be associated with excavation, handling, storage, processing and transport of earthworks materials. Where soils are disturbed, excavated and/or stored for re-use during construction, they are prone to erosion by surface water run-off. In-situ soils may be compacted by construction machinery, reducing their ability to store water, which in turn may lead to increased run-off and soil erosion.

As any soils underlying the proposed works are abundant on a local and regional scale, they are of relatively low environmental and/or ecological value. The volume of soils encountered throughout the

construction phase will be also be relatively small in comparison to the volume of excavated material generated.

Mitigation Measures

The construction and operation of the Lower Lee (Cork City) Drainage Scheme is not likely to have a significant impact on the soil in the area due to the small volumes, if any, of undisturbed soils that are likely to be encountered. Any excavated topsoil is likely to be reused in the construction of the flood defence embankments. It is necessary however to put in place mitigation measures in order to maximise the preservation of soil throughout the scheme.

In order to control the potential loss of soils as a result of erosion due to surface water run-off, a surface water management system will be put in place where necessary. As well as minimising soil erosion, a surface water management system will also minimise the volume of suspended solids transported by surface water run-off and discharged into local watercourses. The following measures will be implemented during the construction phase where applicable:

- Vegetation and soil should be left in place for as long as possible prior to excavation and stockpiling of soil to be minimised during wet weather periods.
- Soil stockpiles should be shaped so as to shed water.
- Surface water run-off from exposed soil surface should be intercepted and channelled to sumps and to silt traps thereafter.
- Granular materials should be placed over bare soil, particularly in the vicinity of watercourses, to prevent erosion of fines and/or rutting by construction machinery.

Residual Impact – Neutral Impact

Taking into account the relatively small volume of soil anticipated to be encountered throughout the construction phase, in conjunction with the mitigation measures as outlined above, the residual impact of the proposed scheme on the soil in the area is insignificant. This impact will constitute a **Neutral Impact**.

6.3.3.2 Contaminated Land

Potential Temporary Moderate Negative Impact

Potential impacts that may result from the improper management, storage and handling of fuels and lubricants for plant and machinery and of non-hazardous or hazardous liquid and solid wastes during the construction phase of the proposed scheme. Localised contamination of soils could result from an accident, spill or leak.

Mitigation Measures

In order to reduce the risk of soil contamination as a result of accidents spill or leaks the following measures will be implemented:

- Fuels, chemicals, liquids and solid wastes will be stored on impermeable surfaces.
- Plant refuelling should be undertaken on impermeable surfaces within a suitably constructed bund in accordance with best practice guidelines. No refuelling will be permitted in or near soil or rock cuttings.
- All hydrocarbons and other potential contaminants will be stored within suitably constructed bunds in accordance with best practice guidelines.

- Spill kits will be provided at refuelling areas and at high risk/sensitive sites.

Residual Impact – Potential Temporary Slight Negative Impact

It is likely that, with the mitigation in place this impact will constitute a **Potential Temporary Slight Negative Impact**. This residual impact will be fully identified as the works method statements become finalised.

6.4 HYDROMORPHOLOGY

Hydromorphology is similar to geomorphology in that it is the study of the structure, evolution and continued morphology of water courses over time. The hydromorphological characteristics of the River Lee are unlikely to be directly impacted due to the Flood Relief Scheme as dredging works are not proposed.

The material in this section is based on a draft report prepared by JBA Consulting for the OPW in October 2013 entitled 'Hydromorphic audit of the Lower Lee watercourse'.

6.4.1 Hydromorphological Characteristics

The Lower Lee catchment covers an area of approximately 420 km^2 extending from Innishcarra Dam to Cork Harbour. A large proportion of the catchment comprises agricultural land. Cork City extends for approximately 8km of the catchment.

The Lower Lee catchment is drained by a number of watercourses, the primary watercourse being the River Lee. The River Bride, Glasheen River and the Curraheen River drain the land to the south of the River Lee. The Shournagh River is the primary watercourse draining the north of the catchment and has two main tributaries; the Blarney River and the Owennagearagh River. Slower catchment runoff rates occur downstream due to the catchment topography and geology.

The Lower Lee Catchment terminates at Cork Harbour, and is therefore influenced by tidal conditions along the north and south channels of the Lower Lee through Cork City. Tidal influence is moderated by a number of weirs in the channels. Fine sediment dynamics of the Cork estuary result in the deposition of mud flats through Lough Mahon as far as Blackrock Castle and the Marina area. There is no significant deposition of tidally derived silts along the north and south channel of the River Lee through Cork City, suggesting that deposition upstream of the Marina is largely controlled by fluvial processes.

Drainage development and historic channel rationalisation have destroyed the original stable tidal marsh system that operated in the lower reaches of the River Lee. The main river has been rationalised into two heavily modified channels with lined banks with no natural flood plain or tidal marsh. The main river and tributary channels upstream of Cork City have been strongly impacted by rationalisation and multi-thread reaches are now absent from the watercourse. Channels have however, developed a functional pool-riffle-point bar in-channel morphology despite these impacts.

The watercourse through Cork City comprises a heavily modified bifurcated channel with splits at the Salmon Weir and flows as north and south channels down to the Tivoli Docks area. A fluvial audit of the Lower Lee indicated that the watercourses through Cork City have stable coarse gravel beds strongly indurated with fines filling the spaces between larger clasts. Smaller impoundments are not trapping significant volumes of coarse or fine sediment with is principally due to the impact of a low sediment supply. A lack of sediment was noted through Cork city with over-widened channel reaches remaining sediment free apart from occasional immobile low bar units.

There is a general absence of fine sediment deposits in the south channel and only limited mixed sediment bar deposits in the upper reaches of the north channel. This is primarily due to a reduced fluvial sediment supply and a low tidal fine sediment supply. The Waterworks Weir and the Salmon Weir split the flow among the north and south channels, impounding the watercourse for several hundred metres upstream and as such, have a strong influence on the watercourse. Historic gravel movement across the structure is evidenced by the presence of a large vegetated bar/ island downstream of the weir.

It was noted that small volumes of medium gravels are entering the active transport system from bar reworking and local bank erosion. Small loosely consolidated bars are seen along the river most noticeably downstream of the weirs.

The channel upstream of the Waterworks Weir is strongly ponded but relatively sediment free. Pool-riffle sequences develop further upstream where the main channel is joined from the north by the Shournagh River. Stretches of functioning pool-riffle-point bar morphology are interspersed between impacted reaches where impoundments have created extended ponded pool and glide biotopes. The lack of fluvial sediment is linked to the entrapment of sediment by the Carrigadrohid and Innishcarra Dam complex upstream. These engineered structures have also moderated the flow regime downstream releasing a controlled relatively constant base flow and moderating flood flows which allows the channel bed to slowly armour as constant flows transport finer material through the system. The fluvial audit indicated that there was little evidence of lateral movement of the channel and bank erosion was limited.

6.4.2 Potential Impacts on Hydromorphology

Potential Permanent Slight Negative Impact

The Lower Lee through Cork is presently an un-reactive channel displaying revetted channel margins and a stable armoured bed. Fine sediment being delivered from upstream is generally at a low level and this material appears to be moving through the North and South channels rather than accumulating as bar deposits. Tidal fine sediment inputs are similarly very low. Presently there is little risk of increased sedimentation unless the fine and medium sediment supply from the Lower Lee upstream of the Shournagh River confluence increases significantly beyond the present transport capacity of the watercourse downstream. Alterations to the flow regulation regime at the Carrigadrohid and Innishcarra Dam complex upstream, particularly an increased frequency of flood releases, would change the sediment balance that exists at present, potentially disrupting the bed and causing more widespread sediment transport. Such an occurrence could lead to coarse sediment build up across bar surfaces through Cork which would impact on the flood capacity in the long term as intermediate gravel transporting flows are unlikely to be released from the dams.

Mitigation Measures

The geomorphological assessment indicates the proposed works would not have a significant impact on sediment transportation in the channel.

Residual impacts – Permanent Slight Negative Impact

It is not possible to carry out the proposed flood relief scheme without impacting on the existing hydromorphology of the Lee River, however it is noted that the existing flow regime is artificial, controlled by existing dams, and has undergone significant changes from its natural state. The impact of the scheme on hydromorphology of the Lower Lee resulting from this scheme will therefore be insignificant in comparison with the effects of previous human interventions such as dam and weir construction.

6.5 IMPORT OF MATERIALS

Sourcing and Importing of Concrete and Fill Materials

There will be a requirement to import suitable fill materials for embankments, RC wall foundations, culverts, trenches and reclaimed land. In addition concrete will be required. In so far as is possible it is desirable that these materials be sourced locally to reduce environmental impacts associated with transport.

Surplus excavated materials may be used in earthworks provided that they satisfy certain acceptability criteria detailed in the NRA (TII) Specification. In general these criteria relate to moisture content, plasticity, density, CBR, strength and grading. The Sand and Gravels will be classified for re-use as General Granular Fill, Class 1A, 1B or 1C, depending upon the actual grading of the materials. Some of these deposits may also be suitable as selected granular fill to structures and possibly for capping and road sub-base materials. Sandy Gravely Clays will be classified for re-use as General Cohesive Fill, predominantly as Class 2C. These Class 2 materials will be susceptible to deterioration due to increases in moisture content and poor handling. Made Ground encountered along the route will most probably be classified as U1 unacceptable material. However, much of the made ground may be suitable for use as general fill if it meets the acceptability criteria specified by the NRA (TII) in the 'Specification for Road

Works Series 600 – Earthworks' (CC-SPW-00600). It should be noted that the above recommendations are an assessment based upon the ground investigations carried out to date and used to inform the Preliminary Design process for the Scheme. The results of the ground investigation are sufficient to make a reasonable assessment on the extent of re-use of earthworks materials and the resulting overall earthworks balance which is anticipated for the scheme. Some adjustments to the balance may occur during construction. However these adjustments will not generate a significant environmental impact.

Any topsoil stripped from the site will need to be stored in suitable areas before deposition on the completed earthworks slopes and verges. Any surplus material from the scheme can be disposed of appropriately off site.

There is a shortfall of available fill material for the embankments to be constructed on the Lower Lee (City Centre) Drainage Scheme. The availability of these materials within the locality should be accessed as part of preliminary site investigation works. In addition to meeting NRA (TII) specifications the following must be considered when selecting materials:

- Potential for spread of invasive species
- Potential destruction of cultural heritage features at source (if soils taken from agricultural lands)

Mitigation

The site will be subject to ecological assessment with particular regard for the presence of invasive species prior to the works commencing.

Residual Impact – Potential Temporary Imperceptible Impact

It is likely that, with the mitigation in place this impact will constitute a Potential Temporary Imperceptible Impact. This residual impact will be fully identified as the works method statements become finalised.