6 GEOLOGY AND SOILS IN THE EXISTING ENVIRONMENT

The Study Area, for the purposes of this Chapter, covers 18km of the Bandon River, extending from 4km upstream of Bandon Bridge, to 5.5km downstream of Inishannon town centre and covers an area of 18km^2. This Study Area is shown on Drawing SG001 in Appendix 6A.

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 Drainage 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 will be proposed insofar as practicable.

The Bandon River (Bandon) Drainage Scheme construction phase will include the following;

- detailed site investigation
- site preparation works including temporary fencing / hoarding
- dredging of approximately 150,000m^3 of material from riverbed
- construction of reinforced concrete walls
- construction of earthen embankments
- replacement of an existing culvert
- services and utility diversions
- re-instatement of footpaths / roadways / green areas

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 Drainage Scheme will have on the geology and soils within the Study Area. It was then possible to propose practicable mitigation measures to ensure that any potential impacts identifies will not have a significant impact on the environment during the construction and operational phase.

No significant 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 County Council Planning and Development (Applications for Registration of Quarries under Section 261, Planning and Development Act 2000)
- Cork County Development Plan (2009)
- Cork County Council Internal Geographical Information System (IGIS)
- Concrete Products Directory (Irish Concrete Federation)

- Aerial Photography
- ENVision Mines Site, the EPA's online Historic Mines Inventory
- General Soil Map of Ireland
- Explanatory Bulletin to Soil Map of Ireland 1980

A preliminary ground investigation contract was carried out which consisted of boreholes, dynamic probes and sampling spread throughout the Study Area. The recorded data was used to confirm and verify information obtained from the above sources.

A study carried out by JBA Consulting entitled 'Baseline Hydromorphological Assessment of the River Bandon through Bandon County Cork' 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. Igneous rocks are only known from one small intrusion near Bandon and a few occurrences of tuffs.

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' (shown on Drawing SG001 in Appendix 6A of this document) indicates that the majority of the Study Area is underlain by the carboniferous Kinsale formation which is a grey mudstone with subordinate sandstone. This formation is defined overall as a mud-dominant succession. The formation is divided into three members, the Castle Slate, Narrow Cove and Pig's Cove Members. These three members are not always mapped separately, however Narrow Cove and Pigs Cove have been identified in the northerly region of the Study Area.

A portion of the Study Area to the south east and a very small portion to the north is underlain by Old Head Sandstone Formation which comprises a thick succession of grey sandstones and heterolithic bedded sandstones and mudstones. The type section is at the Old Head of Kinsale where the sequence has been divided into two members, the Bream Rock Member and the overlying Holeopen Bay Member.

The findings of the ground investigation, which was carried throughout the proposed Study Area are broadly in line with the bedrock as described above. Twelve rotary core boreholes were carried out with bedrock encountered in eight of these. In each case the bedrock was described as highly weathered shale and ranged in depth from 1.8m to 6.8m deep. Shale is a sedimentary rock which is fine grained and composed of mud that is a mix of flakes of clay and tiny fragments of other minerals.

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 currently being undertaken by the Geological Survey of Ireland (GSI), through the Irish Geological Heritage (IGH) Programme.

The IGH operates a two-tier site designation. 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 some protection through incorporation in the County Development Plan.

The Cork County Development Plan (2009) states that the Council *'recognises the importance of geological heritage and to this end has listed in this plan the important geological features within the County with the intention of maintaining their possible conservation value. The list has been produced in consultation with the Geological Survey of Ireland and the Geology Department of the National University of Ireland, Cork.'*

The County Development Plan identifies 103 sites of geological and geomorphological interest in the county which could potentially become proposed Natural Heritage Areas (pNHAs). None of the 103 sites are located within the Study Area.

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 County Council Planning Department (Application for Registration of Quarries under Section 261, Planning and Development Act 2000)
- Cork County Development Plan (2009)
- 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

The sources consulted above indicate that there are only three quarries in the vicinity of the Study Area are presented on Table 6.1:

Location	Status	Operators
Dromkeen, Inishannon, within Study Area	Active	Keohane Readymix Ltd
Rockhouse, Inishannon, Just outside Study Area	Active	Finbarr Deasy
Brinny, Inishannon, outside Study Area to the North	Inactive	Cemex Ltd.

Table 6.1 Quarries in the vicinity of the Study Area

The locations of these quarries are shown on Drawing SG001 in Appendix 6A.

The abovementioned quarries are within the Study Area, but are not located in the vicinity of the proposed scheme. As such it is not envisaged that there will be any impact on these facilities from the proposed scheme.

6.2.5 Geohazards

Upon consultation with the National Landslide Database for Ireland (Landslides Working Group, 2006) 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 presented in Appendix 6B);

- Made Ground
- Alluvium
- Till derived from mixed Devonian Carboniferous rocks
- Glaciofluvial Sands and Gravels
- Marine/Estuarine Silts and Clays

There are also a number of bedrock outcrops and subcrops throughout the Study Area. This information is substantiated by the preliminary ground investigation that was carried out at regular intervals along the river bank.

6.2.6.1 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 at Bandon town and Inishannon town, the urbanised areas of the Study Area.

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.

6.2.6.2 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 Bandon River within the Study Area is situated within Alluvium subsoils. As these subsoils are located in the immediate vicinity of the Bandon River, and surrounded by the Made Ground of Bandon town, it is likely that there will be an interaction with the proposed scheme.

6.2.6.3 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, indicates that glacial till is the predominant subsoil occuring in the Study Area and is principally derived from sandstones and shales.

As the proposed scheme is concentrated around Bandon town and the Bandon River, 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.

6.2.6.4 Glaciofluvial Sands and Gravels

According to the Teagasc Subsoil Mapping there is an area of Sands and Gravels to the East of Bandon town, to the South of the Bandon River. 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.

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 Bandon 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.

6.2.6.5 Marine/Estuarine Silts and Clays

A deposit of silts and clays is recorded as being located downstream of Inishannon, in the vicinity of the Bandon River. These deposits are characterised by very fine grained subsoils. The Teagasc subsoil mapping as presented on the Geological Survey of Ireland Online Database shows these deposits are located outside of the area of proposed Flood Relief Measures.

As no works are proposed within the area denoted as Marine/Estuarine silts and clays no ground investigation was carried out at these locations to confirm or deny these findings. However, clays and silts were recorded further upstream where investigation was carried out. These deposits, similar to above, are likely due to the complexity of depositional environment around the ice margin.

It is unlikely that the proposed works will have a significant impact on Marine/Estuarine Silts and Clays.

6.2.7 Potential Impacts on Geology

The key impact associated with the construction phase of the Bandon River (Bandon) 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 6.2;

Origin of Excavation	Volume of Material
River Dredging	150,000m^3
Wall Foundations	3,000m^3
Embankment Foundations	4,000m^3
Pipe Trenches	3,000m^3
Miscellaneous	10,000m^3
TOTAL	**170,000m^3**

Table 6.2 – Excavation Volumes

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.

It is not anticipated that the proposed works will increase the velocity of flow in the Bandon River. As such, an increase in bank erosion is not anticipated. This is discussed further in Chapter 7.

6.2.7.1 Loss of Bedrock

Potential Permanent Slight Negative Impact

The vast majority of the Study Area, and the entire area covered by the proposed works, are underlain by Old Head of Kinsale bedrock, as described above in Section 6.2.2. It is envisaged that a large portion of the excavation required will include excavating bedrock from the river bed. Although this excavated material will be reused where possible, the volume of excavated material is likely to be greater than can be reused in the proposed works and as such this broken bedrock will be removed from the proposed scheme.

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 Negative 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

Neutral Impact

There are no sites in the vicinity of the proposed works of sufficient geological or geomorphological importance on a national or county scale to merit consideration for designation as an Natural Heritage Area (NHA) or designated as a County Geological Site. Due to possible exposure of bedrock at times of low flows as a result of proposed dredging work on the Bandon River, 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 underlain by a number of different classifications of subsoil, however proposed works will be predominantly underlain by Alluvium and Made Ground. It is likely that Alluvium will be affected as a result of proposed river dredging works with excavations for flood defences likely to be in Made Ground. The preliminary site investigation recorded that gravels are also present.

Soft silts and alluvium likely to be excavated as a result of river dredging are unlikely to be suitable for reuse elsewhere on the project. The volumes to be excavated will also far exceed those that would be required as fill on site and as such these subsoils will be removed from site. It may also be possible to re-use excavated sub-soils for construction of flood defence embankments, but more detailed site investigation is required to determine how appropriate the subsoil is for this purpose.

It may be possible to reuse excavated gravels, as recording during site investigation, as part of the fisheries mitigation measures recommended in Chapter 5. With the unpredictable nature of made ground, however, it is unlikely that it will be suitable for this use.

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, and the county as a whole.

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. Remaining volumes of unsuitable materials will be transported to the closest suitably licensed facility to be processed and reused in other construction projects in the vicinity, where possible.

Residual Impact – Potential Permanent Imperceptible Negative 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.

6.3 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.

Calcification 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 which occupies approximately 1.75million hectares. These lands have slopes between 2 and 6 degrees with soils typically derived from shales, sandstone, granite or mica schist.

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 and described in the above sections of this chapter. Site Investigation records suggest that the soils in the area are shallow, with the deepest level recorded being 1 metre below ground level. Made Ground from the surface was recorded in a number of locations.

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

As the proposed scheme does not traverse large tracts of agricultural land, and soil was not encountered in all boreholes carried out to date, it is unlikely that the scheme will have a significant impact on the soil in the area. Considering that the majority of the proposed works, aside from the proposed dredging, are to be carried out to existing structures or in urban areas the loss of soil will be minimal. No soils will be encountered where dredging is proposed.

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 Bandon River (Bandon) 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 excavated 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 stoned 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 statement 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 Bandon River are particularly important in relation to the proposed Bandon River (Bandon) Drainage Scheme as dredging constitutes the majority of the work proposed. As such the hydromorphological conditions will be altered, and will also directly affect the maintenance frequency during the operational phase.

The material in this section is based on a report prepared by JBA Consulting entitled 'Hydromorphological Assessment of the River Bandon through Bandon, County Cork'.

6.4.1 Hydromorphological Characteristics

The catchment of the Bandon River has a number of potential sediment sources in the upper, central and tidal catchments which include bank erosion, remobilisation of stored in-channel sediment, bar remobilisation, supply from tributaries and tidal sources. Overall the sediment supply within the catchment is low, slow and relatively constant.

The upper reaches of the River Bandon are bedrock controlled and have undergone little lateral movement over historic timescales. The main river has moved laterally over the Holocene period to create an often well developed floodplain. Historic channel movement has, however, been limited. Comparison of the present river planform with the 1837-1842 historic mapping for the river reveals only minor migration (in the Balineen area), chute channel meander cutoff (around Enniskean and Dromidiclogh West) and localised multi-channel rationalisation (at Mawbeg East and Nelinagh East).

Overall sediment supply within the catchment is low, slow and relatively constant. It is coming from a variety of natural sources including the upper catchment, middle reach tributaries and direct bank and bar erosion. As such, catchment gravel inputs to the study reach at Bandon would not be controllable without significantly disrupting the present hydromorphology of the river.

Sediment transfer along the Bandon River can be broadly split into coarse bedload and fine suspended load. Suspended load studies have shown a strong link between the volume of material moved and the river discharge with higher flows carrying a disproportionately large volume of suspended material particularly during the rising limb of a flood. Bed load transport is less well linked to discharge as the process of entrainment and transport is more complex and sediment supply from the catchment is less uniform. Transport is correspondingly sporadic and temporary increases and decreases in local storage may occur as sediment waves pass a point. Despite this, zones of sedimentation tend to remain fairly fixed in the system, particularly where low energy zones have been engineered.

The main channel through the town of Bandon has been significantly changed in order to utilise the energy of the water and to reduce the risk of flooding to the town. Channel dimensions have been significantly altered, artificially high vertical banks constructed, disconnecting the river from its floodplain, and a 2m high weir constructed across the bedrock rapid in the town. This weir will be disrupting sediment transport at lower magnitude events but is drowned out during large floods and gravels are able to continue their passage downstream.

The primary change has been to the width of the channel which in the reach below Bandon Bridge is of the order of 35 m. This compares with a more natural channel width of between 25 and 30 m upstream of the town. The result of this has been to generate artificially low energy conditions through Bandon town as flood flows recede promoting gravel deposition to restore a more natural channel width. Gravels shoals and bars have accumulated downstream of the bridge with extensive shoaling on the southern bank slightly further downstream. Gravels are also accumulating in the outer bridge arches, away from the main central flow.

6.4.2 Potential Impacts on Hydromorphology

Potential Permanent Slight Negative Impact

The gravel bars and shoals developing through the town are generally evolving over periods of years, however, this is dependent on flood magnitude and frequency and periodic rapid change may occur between periods of relative inactivity. As such the hydromorphic state of the reach will be slowly evolving leading to bar development, channel narrowing and relative stability. Bar features of the order of 1 – 1.5m high can be expected to extend several metres into the channel on the northern bank and on the southern bank further downstream.

Repeat dredging of developing gravel features, such as might occur during the operation of the proposed scheme, will not allow equilibrium to develop affecting the local temporal hydromorphic balance. This, however, would only be for a short reach through the town and many other equivalent hydromorphic reaches exist elsewhere. Dredging will periodically disrupt channel morphology and hydraulic habitats but these would redevelop. The major impact would be to sediment movement downstream, with gravel units becoming starved of sediment following repeat removal at Bandon.

Overall, the hydromorphic impact of local dredging through the town will be minimal and short term when viewed against the state of the wider river provided sediment transport continuity is maintained. Upstream changes will be prevented by the bedrock rapid in the vicinity of the weir. The hydromorphic units that develop under an infrequent dredging regime are comparable to those created by dynamic processes along natural reaches with bar disruption, gravel transfer and sediment redeposition occurring in response to floods. However, the full development of vegetated gravel bed features may compromise flood relief.

Mitigation Measures

The hydraulic modeling carried out in relation to the design of the flood relief scheme has shown that the impact of the gravels on flood levels is apparent but low in comparison with bridge and weir effects. As such frequent removal is unnecessary, however, the full development of vegetated gravel bed features will compromise flood relief. Vegetation control and occasional gravel removal and reintroduction downstream is likely to be required. This should be triggered by a threshold to be defined at detailed design stage. It is important for the maintenance of channel dynamics downstream that gravel movement is not disrupted; Reintroduction of the dredged gravels across several riffle and rapid sites downstream, where possible, will ensure that the sediment dynamics downstream are unaffected and channel stability is maintained. The hydromorphic units that develop under an infrequent dredging regime are comparable to those created by dynamic processes along natural reaches with bar disruption, gravel transfer and sediment re-deposition occurring in response to floods.

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 Bandon River. The abovementioned mitigation measures will be put in place in order to minimise these impacts without compromising the intended operation of the scheme itself.