

## 5.4 SOILS, GEOLOGY AND HYDROGEOLOGY

### 5.4.1 CONTEXT

O'Connor Sutton Cronin (OCSC) Consulting Engineers have undertaken an assessment of the potential and likely environmental impacts on Soils, Geology and Hydrogeology regarding the proposed flood defence scheme for the River Dargle, Bray, Co Wicklow. This assessment was prepared in accordance with the following:

- European Communities (Environmental Impact Assessment) Regulations, 1989 (as amended);
- The Planning and Development Regulations, 2001 (as amended);
- Guidelines on Information to be contained in Environmental Impact Statements (Environmental Protection Agency (EPA), 2002);
- Advice Notes on Current Practice in the preparation of Environmental Impact Statements (Environmental Protection Agency (EPA), 2002), and
- Geology in Environmental Impact Statements, a Guide (Institute of Geologists of Ireland, 2002).

### 5.4.2 METHODOLOGY

An assessment of the Soils (including Subsoils/Quaternary Geology), Bedrock Geology, and Hydrogeology underlying the study area was undertaken in consultation with, inter alia, the following:

- The Geological Survey of Ireland;
- Geology of Kildare - Wicklow, 1:100,000 Bedrock Geology Map (Geological Survey of Ireland Publications, 1994);
- Ordnance Survey Sheet 56 (Discovery Series, Second Edition);
- Review of historical OS maps;
- Wicklow County Council Groundwater Protection Scheme as produced by the Geological Survey of Ireland, March 2003;
- EU Council Decision of 19th December 2002 “establishing criteria and procedures for the acceptance of waste material at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC”;
- CIRIA Document 532 “Control of Water Pollution from Construction Sites” dated 2001, and

- Drawings and sections of the proposed development as compiled by O' Connor Sutton Cronin & Associates.

Specific geological and hydrogeological information was obtained from the following site investigations undertaken at and in the vicinity of the study area:

- Site Walkover undertaken by OCSC staff;
- *Geotechnical Report for Site Investigation at Bray Golf Course and Industrial Yarns, Bray, Co. Wicklow* dated June 2004, undertaken by Byrne Looby Partners (See Appendix E1 showing geological logs and locations of boreholes and trial pits);
- *Site Investigation at Dargle Road, Bray* dated February 1997 undertaken by Irish Geotechnical Services Ltd. (IGSL) (See Appendix E2 showing geological logs and locations of boreholes), and
- Site Investigation undertaken by Marine Geotechnical Ireland in June 2005 in respect of *Shanganagh / Bray Main Drainage Scheme – Contract No. 2 – Transfer Pipeline and Water Storage Tank Foreshore Application*. (See Appendix E3 showing geological logs and locations of boreholes).

### 5.4.3 RECEIVING ENVIRONMENT

#### 5.4.3.1 Existing Land Use

The proposed development site comprises the river bed and banks of the River Dargle from the Harbour Bridge to the N11 Bridge. The study area has been divided into the following five areas:

##### **Area 1 – Bray Harbour Bridge to Bray Bridge**

Area 1 comprises the section of the River Dargle between the Bray Harbour Bridge and Bray Bridge. This stretch of the River is bounded by Ravenswell Road to the north, which provides access to the Bray Golf Club Lands and the residential properties of No's 1 to 4 Ravenswell Road. The residential areas of Seapoint Court, Milton Terrace and Shankill View are located to the south.

##### **Area 2 – Bray Bridge**

Area 2 relates to the riverbed of the River Dargle at Bray Bridge.

##### **Area 3 – People's Park and the Maltings**

Area 3 comprises the section of the River Dargle between Bray Bridge and the western end of People's Park. Along this section the areas to the north include Lower Dargle Road and People's Park. The residential area of the Maltings is located to the south of the River Dargle.

**Area 4 – People’s Park to the Slang/Rehills Land**

Area 4 comprises the section of the River between the western end of People’s Park and the Slang/Rehills Land. The residential areas of Glenburgh Terrace, Coburg, the River Vale Apartments and the Diamond Valley Apartments are located to the north of the River. The Country Brook stream flows into the River Dargle along this section of the River, at the western end of Coburg.

**Area 5 – La Vallee to the NII Bridge**

This area comprises the section of the River Dargle from La Vallee Apartments to the NII. La Vallee Apartments are located on the northern bank of the River Dargle.

**5.4.3.2 Site History**

A review of the site history/former land-uses at the study area was undertaken by referencing Historical Ordnance Survey (OS) Maps, the survey dates of which range from 1833 to 1909.

A summary of the findings of the review of the historical OS Maps is presented in Table 5.4.1 below. The Historical OS Maps are presented in Appendix E4.

**Table 5.4.1**  
**Review of Historical Ordnance Survey (OS) Maps**

Year	Sheet No.	Summary
1833	4	This sheet illustrates the portion of the study area south of the River Dargle. A brewery, corn mill and a number of churches were located adjacent to the southern banks of the River Dargle. A "Fairy Hill" was also shown to be present in the vicinity of the river.
1837-1843	26	This sheet illustrates the portion of the study area north of the River Dargle from Bray Harbour to Bray Bridge. The study area is shown to be located in a relatively rural area with some development along Castle Street.
1871	26	This sheet illustrates the portion of the study area north of the River Dargle from Bray Harbour to Bray Bridge. The study area is still quite rural; however, some additional development has been undertaken when compared to the 1837-1843 OS map.
1874	28	This sheet illustrates the portion of the study area to the north of the River Dargle. Further development south of Bray Commons is illustrated, when compared to earlier OS maps.
1885	4	This sheet illustrates the portion of the study area south of the River Dargle. The brewery, corn mill and churches are still present, however the "Fairy Hill" appears to be redeveloped as a green area/pitch and a gas works site was developed on reclaimed ground close to the mouth of the River Dargle.
1909	4	This sheet illustrates the portion of the study area south of the River Dargle. The brewery and corn mill lands appear to have been redeveloped. The gas works remain and a site described as "electricity works" has been developed. Bray Harbour with a lighthouse has been developed at the mouth of the River Dargle.

#### 5.4.3.3 Soils

Information obtained from site investigations undertaken in the vicinity of the River Dargle between 1997 and 2005 indicates that, where it was encountered, up to 0.9 m of topsoil was present. Made Ground was also encountered in the vicinity of the river to a depth of 2.9 m below ground level (BGL).

These investigations also revealed that the river bed is predominantly composed of mixed gravels, sands and silts.

#### 5.4.3.4 Subsoils (Quaternary Geology)

Information obtained from the Geological Survey of Ireland indicates that the subsoil underlying the River Dargle is composed of alluvium, which has been deposited by the river itself. Glacifluvial sands and gravels, which were formed by outwash from retreating glaciers, are located in the vicinity of the study area. Localised areas of "Irish

Sea Till” are located south of the River Dargle. As with many developed areas there is a large area surrounding the River Dargle underlain by Made Ground.

Three subsoil samples were obtained from the study area in June 2006 and forwarded to an independent UKAS accredited laboratory where they were analysed for the parameters listed in EU Council Decision of 19<sup>th</sup> December 2002, “establishing criteria and procedures for the acceptance of waste material at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC”, to determine if the material is inert. The samples were taken from Bray Bridge, People’s Park and the Slang and the associated analytical results are presented below in Table 5.4.2. Any concentration in excess of the limit value is underlined.

**Table 5.4.2**  
**Analytical Results**

Parameter	Bray Bridge	Peoples Park	Slang	Inert Limits (mg/kg)
<i>Leachate Analysis</i>				
Arsenic (As)	0.06	0.03	0.05	0.5
Barium (Ba)	1.61	1.61	1.39	20
Cadmium (Cd)	<0.01	<0.01	<0.01	0.04
Total Chromium (Cr)	0.02	0.04	<0.01	0.5
Copper (Cu)	0.04	0.04	0.03	2
Mercury (Hg)	<0.0005	<0.0005	<0.0005	0.01
Molybdenum (Mo)	<0.01	<0.01	<0.01	0.5
Nickel (Ni)	0.04	0.13	0.02	0.4
Lead (Pb)	<0.01	<0.01	<0.01	0.5
Antimony (Sd)	<u>0.08</u>	<0.01	<0.01	0.06
Selenium (Se)	0.01	<0.01	<0.01	0.1
Zinc (Zn)	0.43	0.29	0.30	4
Chloride	45	41	50	800
Fluoride	4	3	3	10
Sulphate	42	39	0.20	1,000
Phenol Index	<0.1	<0.01	<0.01	1
Dissolved Organic Carbon	<20	39	35	500
Total Dissolved Solids	1,081	939	909	4,000
<i>Soil Analysis</i>				
Total Organic Carbon	0.26	0.20	0.13	3%
BTEX	<0.01	<0.01	<0.01	6
PCB (7 Congeners)	<0.001	<0.001	<0.001	1
Mineral Oil (C10-C40)	<1	<1	<1	500
PAH	<0.001	<0.001	<0.001	Individual Member states to set limit values

Each parameter for each soil sample analysed was below its respective inert limit value, with the exception of Antimony in the Bray Bridge sample, which had a concentration of 0.08 mg/kg. This concentration was slightly in excess of its limit value of 0.06 mg/kg.

These analytical results indicate that the soil samples, which were analysed, may generally be described as inert.

#### 5.4.3.5 Bedrock Geology

Information obtained from the Geological Survey of Ireland (GSI) publication *Geology of Kildare - Wicklow*, 1:100,000 Bedrock Geology Map, 1994 indicates that the study area is underlain by two types of bedrock, the local boundary of which is roughly marked by the River Dargle. The two types of bedrock are as follows:

- *Maulin Formation* – This Formation, which is located to the north of the River Dargle and is part of the Bray Group, is described as comprising dark blue-grey slates, commonly laminated with pale siltstones, which have been metamorphosed to phyllites and schists. The GSI have classified this Formation as being Cambrian in age, and
- *Bray Head Formation* – This Formation, which is located to the south of the River Dargle and is part of the Ribband Group, is in faulted contact with the older rocks of the Bray Group. This Formation comprises greywacke sandstones and siltstones interbedded with green, purple, red and grey slates and massive quartzites. The GSI have classified this formation as being lower to mid Cambrian in age.

According to a well search carried out by the GSI of the known wells within a 3 km radius of the study area, the depth to bedrock ranges from 0.2 m at Bray Head, Co. Wicklow to 27.4 m in the Townland of Killarney, Co. Wicklow.

Site specific information indicates that bedrock was encountered at approximately 18 m BGL in the downstream section of the River. Bedrock is also seen to crop out at the base of the river bed in the vicinity of La Vallee.

According to information received from the Heritage Section of the Geological Survey of Ireland there are no areas of interest with regard to geological heritage within the study area.

#### 5.4.3.6 Hydrogeology

According to *The National Draft Bedrock Aquifer Map* (Geological Survey of Ireland, 2007) there are two bedrock aquifer systems underlying the study area. The two systems, which are roughly separated by the River Dargle, are as follows:

- *Locally Important Aquifer* – The area to the north of the River Dargle is classified as being a locally important bedrock aquifer, which is moderately productive only in local zones (LI), and
- *Poor Aquifer* – The area to the south of the River Dargle is classified as being a poor bedrock aquifer, which is generally unproductive except for local zones (PI).

The Geological Survey of Ireland carried out a well search of the known wells within a 3 km radius of the study area. This search revealed the presence of 34 wells, 21 of which were bored wells, 11 of which were dug wells and two of which were springs. Twelve of these wells are reported to be used for domestic purposes and two are used for agricultural purposes. The usage of the remaining wells is unknown. The reported yields range from 1 m<sup>3</sup>/day to 300 m<sup>3</sup>/day. The full details of the well search are presented in Appendix E5.

#### **5.4.4 Potential Impacts of the Proposal**

##### **5.4.4.1 Construction Phase**

The following outlines the proposed works to be undertaken at each of the five areas:

###### **Area 1 – Bray Harbour Bridge to Bray Bridge**

The river in this stretch will be deepened and widened, where possible, with defences being constructed along each side of the river.

###### **Area 2 – Bray Bridge**

The riverbed at Bray Bridge will be lowered to increase its cross sectional area. A new culvert will be constructed under Castle Street on the northern side of the river to provide greater flow capacity at the bridge.

###### **Area 3 – People’s Park and the Maltings**

The river channel in this section will be widened and deepened, where possible, to increase the flow capacity. The existing river walls will be replaced with new defences to the required flood defence level.

###### **Area 4 – People’s Park to the Slang/Rehills Land**

An extensive amount of river regarding and excavation will be undertaken in this area. The existing defences will be enhanced and additional defences will be provided where necessary. A debris trap will be located in this river reach to prevent trees and other large objects from travelling down the river.

###### **Area 5 – La Vallee to the NII Bridge**

The river channel will be deepened and widened, where possible, along this reach to increase the flow capacity.

The following outlines the significant potential impacts pertaining to the proposed development at Construction Phase with respect to Soils, Geology and Hydrogeology.

*1. Soil/Subsoil/Riverbed Sediment*

It is anticipated that the construction phase of the proposed development will necessitate the permanent relocation of approximately 99,000 m<sup>3</sup> of soil/subsoils from the banks of the River Dargle during the following proposed engineering measures:

- c. 3,000 m<sup>3</sup> at the Golf Club Lands Protected (Engineering measure A4);
- c. 17,000 m<sup>3</sup> at the New Culvert, Bray Bridge (Engineering measure B3);
- c. 9,000 m<sup>3</sup> at Glenwood (Engineering measure C7), and
- c. 70,000 m<sup>3</sup> at Rehills Land (Engineering measure D8).

Detailed descriptions of each of the proposed engineering measures are presented in Section 3.4.2.

It is anticipated that approximately 51,000 m<sup>3</sup> of riverbed sediment will be removed during the proposed regrading works on the bed of the River Dargle to facilitate the following engineering measures:

- c. 16,000 m<sup>3</sup> at the Golf Club Lands and Seapoint Court Defences (Engineering measures A4 and A5);
- c. 4,000 m<sup>3</sup> at Bray Bridge (Engineering measure B2);
- c. 9,000 m<sup>3</sup> at the Maltings (Engineering measure C4);
- c. 3,000 m<sup>3</sup> at the Walk along the River (Engineering measure C1);
- c. 13,000 m<sup>3</sup> at Coburg (Engineering measure D1); and
- c. 6,000 m<sup>3</sup> at Killarney Glen (Engineering measure R3).

As part of the Engineering Measure R1, which is described in Section 2.4.2 and involves the excavation of bedrock within the river channel, it is also likely that a volume of riverbed sediment will be excavated at this time.

It is currently proposed to place approximately 50% of the excavated soil/subsoil/riverbed sediment at the Slang, which is currently zoned for development. This will result in the level of the Slang being raised by approximately 1m to 1.25m. The Slang will then be landscaped and the remaining 50% transported off-site for authorised disposal. Even though this potential impact is likely to be long term, it is likely to have minimal impact on local receptors. As such it may be deemed to be of slight significance. Suitable environmental testing of the excavated material will be undertaken prior to its placement on the Slang to confirm that it is suitable for its proposed use.

The removal of soils and subsoil may increase the vulnerability of the underlying aquifer in the immediate vicinity of the River Dargle, however bedrock already outcrops in the vicinity of La Vallee. This indicates that, even though this will be a permanent impact, it

is unlikely that it will have a significant consequence on the underlying aquifer. As such it may be deemed slightly significant.

Potential contaminants such as fuel and lubricants, which will be used in connection with the on-site machinery, have the potential to spill, which would result in the contamination of the local soil. Any such spill would also have the potential to contaminate the River Dargle. Sediment may also run-off from the construction areas into the River Dargle. This negative impact would be reversible, however, a number of receptors would be impacted upon as a consequence. As such this potential impact may be deemed moderately to highly significant. However, with the application of the relevant mitigation measure associated, as described in Section 5.4.5.1, its probability of occurring is low.

## 2. *Bedrock Geology*

The proposed engineering measure R1, which is described in Section 3.4.2, may require the excavation of bedrock within the river channel. It is anticipated that a volume of bedrock may be excavated, the volume of which will be accurately calculated at the detail design stage.

As with the removal of soil and subsoils, the removal of bedrock to a maximum depth of 1m may increase the potential for contamination to migrate into the underlying bedrock aquifer. However, it is not deemed that the removal of bedrock in this area will have a significant impact as bedrock in this area will have a significant impact as bedrock already outcrops in the area. As such the probability of the possible removal of bedrock of having negative impact is low. In addition to this, there are no reported areas of geological heritage in the study area.

## 3. *Hydrogeology*

The installation of sheetpile walls along approximately 35% of the river banks in the study area to a maximum approximate depth of 4 m BGL adjacent to the River Dargle may adversely affect the local groundwater flow by acting like an underground dam with a resultant increase of groundwater levels hydraulically upgrading of the sheetpile walls. The water levels detected during the site investigations indicate that groundwater was encountered at approximately 3.5 m BGL, with further water strikes at deeper horizons. There is an exception where groundwater was encountered 0.8 m BGL, with a further water strike at 8.3 m BGL. This groundwater information, together with the fact that only approximately 35% of the riverbanks will be installed with sheetpile walls, indicates that the probability of the proposed sheetpile walls significantly affecting the local groundwater flow is low. As such this potential impact may be deemed moderately significant. Notwithstanding this the groundwater levels, in the area where the sheetpile walls are to be installed will be monitored, as described in Section 5.4.1.1.

Potential contaminants such as fuel and lubricants, which will be used in connection with the on-site machinery, have the potential to spill, which would result in the contamination of the local hydrogeology. As such this potential impact may be described as moderately to highly significant. However, this potential impact is reversible and if the appropriate mitigation measures, as described in Section 5.4.5.1 is implemented, the probability of the impact occurring is low.

#### 5.4.4.2 Operational Phase

##### 1. *Soil and Geology*

No potential impacts to the Soil and Geology Environments are foreseen during the Operational Phase of the proposed development.

##### 2. *Hydrogeology*

The vulnerability of the underlying aquifer to contamination may permanently increase due to the removal of soils/subsoils and bedrock. However, as discussed in the previous Section, this is not considered to be a significant impact.

As in the construction phase, the installation of sheetpile walls along stretches of the riverbank may impede local groundwater flow during the operational phase of the proposed works. However, as previously discussed it is unlikely that this impact will be significant.

#### 5.4.5 Mitigation Measures

Mitigation Measures with respect to impacts on the Soil, Geology and Hydrogeology Environments during the Construction and Operational Phases are set down below.

##### 5.4.5.1 Construction Phase

A construction management plan will be established prior to commencement on site. In particular, a fuel/chemicals handling and storage management plan will be implemented at the outset of the construction phase and rigidly adhered to throughout, in order to minimise the risk of adversely impacting the soils, geology and hydrogeology of the proposed development. This management plan shall incorporate the practices outlined in the CIRIA document “Control of Water Pollution from Construction Sites”, a number of which are outlined below:

- The fuel/oil transfer area should be located on an impermeable pavement with a bunding facility capable of handling a major spill during delivery;
- All tanks on-site should be clearly marked and should only be used for the storage of the substance for which the tank was supplied;
- Tanks should be placed on secure foundations and should be properly bonded, and
- Absorbent pads and booms should be used in the event of a spillage.

Mitigation measures specific to each of the Soil, Geology and Hydrogeology Environments are outlined below:

1. *Soil/Subsoil*

Any soil that is to be excavated and disposed of shall be sampled, analysed and classified to determine the most suitable disposal outlet.

Any soil that is to be reused on-site shall be sampled and analysed to confirm its suitability.

2. *Bedrock Geology*

The impact on the local geology will be minimal and as such no mitigation measure is required.

3. *Hydrogeology*

As previously discussed, the hydrogeological impact is deemed not to be significant and as such additional measures over and above the implementation of a fuel/chemical handling and storage management plan are not likely to be required.

#### **5.4.5.2 Operational Phase**

It is foreseen that no mitigation measures will be required during the Operational Phase of the proposed development with regard to the Soil, Geology and Hydrogeology Environments.

#### **5.4.6 Residual Impacts of the Proposal**

The following section outlines the likely significant predicted residual impacts of the proposed development pertaining to the Soils, Geology and Hydrogeology Environments during the construction phase and the operational phase of the proposed development.

##### **5.4.6.1 Construction Phase**

The following sets down the significant predicted residual impacts pertaining to the proposed development at Construction Phase with respect to Soil, Geology and Hydrogeology.

1. *Soil/Subsoil*

The proposed works will entail the excavation of approximately 99,000 m<sup>3</sup> of soil/subsoil from the riverbanks and approximately 51,000 m<sup>3</sup> of sediment from the riverbed. Approximately 50% of this material will be placed at the Slang and then landscaped with the remainder transported off-site for authorised disposal. The placement of this material at the Slang will result in its increased level by approximately 1m to 1.25 m. As previously discussed in Section 5.4.4.1, the significance of this impact is slight.

## 2. *Bedrock Geology*

As part of the Engineering Measure R1, an area of bedrock, the exact volume of which will be calculated at a detailed design stage, may be excavated and removed from the base of the riverbed in the vicinity of La Vallee. As discussed in Section 5.4.4.1 the potential removal of bedrock in this area will not have a significant impact.

## 3. *Hydrogeology*

The vulnerability of the underlying aquifer may increase due to the removal of soils/subsoils and bedrock, however, as previously discussed, this is not considered to be a significant impact.

The local groundwater flow may be affected due to the installation of sheetpile walls. However, as previously discussed, this is not considered to be a significant impact. Notwithstanding this the groundwater levels in the areas of potential impact will be monitored, as described in section 5.4.11.

### 5.4.6.2 **Operational Phase**

No residual impacts to the Soil and Geology Environments are foreseen during the Operational Phase of the proposed development.

Regarding the Hydrogeological Environment the vulnerability of the underlying aquifer may increase due to the removal of soil/subsoil and possibly bedrock. However, this is not deemed to be a significant impact.

### 5.4.7 **The ‘Do Nothing’ Scenario**

The “Do Nothing Scenario” assesses the environmental impact of not developing the proposed development site in respect of the existing impacts to Soils, Geology and Hydrogeology at the proposed development site.

Under the “Do Nothing Scenario” there would be no change in the current land use of the site. The Soil, Geology and Hydrogeology Environments would remain in their current state.

### 5.4.8 **The Worst Case Scenario**

With regards to the Soil/Subsoil Environment the “Worst Case” scenario in respect of the proposed development and its impacts pertains to the permanent relocation of soil and subsoil. Notwithstanding this, it should be noted that approximately 50% of the material will be re-used on-site, with the remaining material disposed of off-site in a proper and authorised manner.

The River Dargle itself could potentially become contaminated due to the accidental spillages of contaminants and sediment run-off, however a construction management plan will be initiated and adhered to at all times to ensure that this risk is minimal and, if

required, oil absorbent booms etc., which will be stored on-site, may be used immediately in the event of an accidental spill.

With regard to the Hydrogeology Environment, the “worst case” scenario in respect of the proposed development and its impacts pertains to the possible contamination of the underlying aquifer and the possible adverse impact to the local groundwater flow. A construction management plan will be implemented during the construction phase to mitigate the possibility of accidental on-site spillages of contaminants. The local groundwater levels will be monitored to confirm that the installation of the sheetpile walls do not have an adverse impact on the local groundwater flow.

#### **5.4.9 Positive Impacts**

The proposed works will have the effect of containing the River Dargle and thus mitigating the possibility of future flooding events.

#### **5.4.10 Reinstatement**

The development will be landscaped where possible to ensure the preservation of soils/subsoil removed during the construction phase of the proposed development.

#### **5.4.11 Monitoring**

Suitable sampling and chemical analysis of the soil/subsoil will be undertaken prior to its excavation to ensure that the soil/subsoil is suitable for re-use on-site and/or to determine the most suitable off-site disposal route (where required).

The local groundwater levels will be monitored pre and post construction phase to determine if the installation of the sheetpile walls have any adverse impact to local groundwater flow. A suitable monitoring programme will be compiled prior to the start of the proposed works.

It is proposed to implement a groundwater level monitoring programme at and in the vicinity of the sheet pile walls/other structures (as required) in order to assess the local fluctuations in groundwater level before, during and after the implementation of the proposed flood alleviation measures.

A Dust Management Plan will be implemented during the construction stage of the proposed development. (See Section 5.6.1).