Chapter 9:
Hydrogeology

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Chapter 9 Hydrogeology

9.1 Introduction

The proposed development for the Trinity Wharf site will facilitate a mix of office, leisure and residential development, with a primary objective of increased sustainable employment. It will also include the development of high-quality public realm spaces within the development and pedestrian friendly links along the waterfront linking to Crescent Quay and to Wexford town centre.

9.2 Methodology

This chapter has been prepared in accordance with the following guidelines:

- Institute of Geologists of Ireland (IGI) (2013) Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements;
- National Roads Authority (NRA 2008) Environmental Impact Assessment of National Roads Schemes – A Practical Guide;
- National Roads Authority (NRA 2008) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Transport Infrastructure Ireland (TII 2015) Road Drainage and the Water Environment (DN-DNG-03065)
- Environmental Protection Agency (EPA 2015) Draft Advice Notes for Preparing Environmental Impact Statements; and
- Environmental Protection Agency (EPA 2017) Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports.

9.2.1 Desk Study

A desk study of the study area of the Proposed Development was carried out in order to establish baseline conditions. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation with the following:

- Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie);
- Groundwater quality status maps (watermaps.wfdireland.ie);
- Teagasc Subsoils map (gis.epa.ie/Envision);
- Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision);
- National Parks and Wildlife Services Map Viewer (webgis.npws.ie/npwsviewer/);
- Historic Maps from the Ordnance Survey of Ireland (www.geohive.ie); and
- Aerial Photography from the Ordnance Survey of Ireland (www.geohive.ie).

9.2.2 Site Investigations

A walkover survey of the site was undertaken by Roughan & O'Donovan in 2018. In 2007, IGSL were commissioned by Kavanagh Mansfield and Partners Consulting Engineers to carry out intrusive ground investigations at the development site. A total of 22 boreholes were investigated, with 7 samples sent to Al Control Geochem for environmental texting under the Murphy Suite requirements. The results of these surveys are detailed in Chapter 8 and in section 9.3.10 below. While adequate

information was available from these previous investigations, additional and more detailed ground investigations have been commissioned to be undertaken at the development site prior to detailed design stage in order to further classify ground conditions for design and also to quantify the disposal options for excavated material which may be contaminated.

9.3 Description of Receiving Environment

9.3.1 Soils & Subsoils

GSI Mapping

The Teagasc soil mapping identifies both Made Ground and Marine Sands and Gravel at the proposed development site. Boreholes undertaken in 2007 by IGSL on the site indicate made ground underlain by sands, silt and gravels. Refer to Figure 9.1 of Volume 3 for Teagasc soils mapping of the area.

Intrusive Site Investigations

Site Investigations (2007) identified made ground, sand, clay, silts, gravels and boulders on the site at depths varying from 0m to 9.5m Below Ground Level (BGL) across the site.

9.3.2 Bedrock Geology

GSI Mapping

The proposed development site is underlain by the Shelmaliere Formation which is described as white, purple quartzites with slates. A number of fault lines are recorded running parallel and perpendicular to the development site. It is likely that the historic faulting in the vicinity of the site has either extended existing fracturing and/or has created additional fractures in the rock. Refer to Figure 9.2 of Volume 3 for GSI bedrock geology mapping of the area.

Intrusive Site Investigations

Limestone and Sandstone/Siltstone bedrock was encountered at depths varying from 5m to 15.4m Below Ground Level (BGL) across the site. A highly weathered zone of up to 5m thickness was generally encountered during the intrusive investigations.

9.3.3 Groundwater Bodies & Bedrock Aquifers

The site is located with the Castlebridge North Groundwater Body (IE_SE_G_031). The bedrock aquifer underlying the site is classified as a Poor Aquifer (Pl) – Bedrock which is generally unproductive except for local zones. Refer to Figure 9.3 of Volume 3 for GSI Aquifer and Groundwater Body (GWB) mapping of the area.

9.3.4 Groundwater Vulnerabilities

Groundwater vulnerability mapping for the site indicates that groundwater is at low vulnerability to pollution at the ground surface as a result of human activities. Refer to Figure 9.4 of Volume 3 for GSI vulnerability mapping of the area. The intrusive site investigations generally encountered made ground overlying alluvium and sandy clays or gravels – refer to Section 8.4 for details. The actual groundwater vulnerability across the site therefore ranges between moderate and high depending on the exact thickness of silt/clay deposits present.

9.3.5 Groundwater Recharge

Taking account of the low permeability and storativity of the Shelmaliere Formation, a recharge cap of 100mm has been assigned to these rocks indicating rejection of infiltration water annually.

9.3.6 Groundwater Abstractions

There are no recorded public groundwater supplies or group water schemes on the GSI database within the study area. There are a small number of recorded boreholes within 1km of the development site which are for industrial use.

9.3.7 Groundwater Quality

Under the requirements of the Water Framework Directive (WFD), the Castlebridge North groundwater body is classified as having an overall good status for water quality and quantity 2010-2015.

9.3.8 Site Hydrology

The development site is bounded to the north, south and east by the Lower Slaney Estuary. Under the most recent Water Framework Directive monitoring period (2010 – 2015), the status of this water body is classified as being "poor".

9.3.9 Groundwater Dependant Terrestrial Ecosystems (GWDTE) /Special Areas of Conservation (SAC)

Sites designated under the Natura 2000 and within 2km are listed in Table 9.1 below:

Table 9.1 Designated Sites

Natura 2000 Sites	**Distance from Site**
Slaney River Valley SAC (000781)	Within Project Area
Wexford Harbour and Slobs SPA (004076)	Within Project Area
Nationally Designated Sites	**Distance from Site**
Wexford Slobs and Harbour Proposed NHA (000712)	Within Project Area

There are no GWDTE present within the site.

9.3.10 Ground Contamination

As part of the intrusive ground investigations undertaken previously at the site, samples of the made ground (sample depths between 0.5 – 2.5m below ground level) were taken from a number of exploratory boreholes as part of the investigations by IGSL and were tested at the ALcontrol Ltd. accredited Laboratory facility. Details of these ground investigations can be seen in Chapter 08.

The main findings from the soil analysis were as follows:

- The pH of the soil samples ranged between 7.0 – 8.9;
- Elevated levels of Sulphate were noted in nearly all of the soil samples;
- The presence of hydrocarbons was noted in 2 of the 7 samples, however concentrations were low when compared to the relevant LQM/CIEH Suitable 4 Use Levels (S4UL) threshold values. BTEX substances were not detected in any of the samples;

- Elevated levels of Polycyclic Aromatic Hydrocarbons (PAHs) were identified in all soil samples.

The results of the leachate analysis showed that the majority of the dissolved metals and other inorganics were below the level of detection or below the guideline values for the parameter. Sulphate concentrations within the leachate analysis were above the threshold for classification of a waste as inert but did not exceed the threshold for consideration as stable non-reactive hazardous waste and non-hazardous waste (WAC guidelines).

Non-intrusive investigations carried out to date of the site have found fragments of asbestos across the surface of the site, however the extent of which is still to be quantified. Prior to the start of any construction works, a site specific intrusive asbestos survey will be undertaken by a suitably qualified, licenced and experienced contractor to work with asbestos. The asbestos surveys will include intrusive asbestos surveys and site investigations. This will be implemented prior to site clearance works and the subsequent construction of the site. Measures for dealing with Asbestos are outlined in Chapters 4 and 8 of this EIAR).

The additional ground investigations will be undertaken to inform the development of a Remediation Strategy and to inform the detailed design stage however sufficient information is available at this stage for EIAR purposes.

9.4 Description of Potential Impacts

9.4.1 Construction Phase

During the construction phase the following activities may pose a potential impact:

- Excavation of made ground;
- Contamination of soils;
- Aquifer Contamination and;
- Piling and rock armour revetment installation.

9.4.1.1 Excavation of Made Ground

Limited excavation of made ground will take place during construction, particularly during the installation of the foul pumping station and any deep service trenches. The excavation of any localised areas of ground contamination will be a Permanent Positive impact on the soils environment due to the requirement to remove the material off-site and dispose or treat it in accordance with relevant legislation. During the construction phase, any excavated contaminated material which is stored on-site awaiting removal for disposal will present a risk due to contaminated surface runoff. This would represent a moderate to significant impact due to the downstream receptor being a European Site. Any improvement to the quality of soils will have a corresponding benefit to the underlying groundwater resources due to the removal of a potential source of contamination for percolating water. Therefore, the magnitude of this impact is Minor Beneficial due to a minor improvement to the attributes quality.

9.4.1.2 Contamination of Soils

There is a potential risk of localised contamination from construction materials leeching into the underlying soils by exposure, dewatering or construction related spillages resulting in a Permanent Negative impact on the soils. In the case of soils, the magnitude of this impact is Small Adverse as the requirement of good construction practices will necessitate the immediate excavation/remediation of any such spillage

resulting in a very low risk of pollution to the soils and consequently the underlying aquifers. The significance of this impact is slight.

9.4.1.3 Aquifer Contamination

There is a potential risk of localised contamination of the surface water and groundwater bodies due to construction activities i.e. construction spillages, leaks from construction plant and material etc. resulting in a Permanent Negative impact on these water bodies. The main surface water body that would be affected is the Lower Slaney Estuary which is immediately adjacent to the development site.

The excavation of material at the site will have the effect of locally increasing the vulnerability rating of the underlying aquifer; however, the majority of the areas where the material will be excavated will be covered in hardstanding, which will mitigate the potential for contaminants to enter the underlying aquifer from the surface. As such the potential impact may be deemed slight.

9.4.1.4 Piling and Rock Armour Revetment Installation

There is a potential risk of localised contamination during the installation of the proposed sheet pile wall surrounding the development and the pile foundations for the boardwalk, and/or proposed buildings and the chosen restraint option for the marina. The ground investigations undertaken in 2007 indicate that the site is moderately contaminated, while the presence of asbestos has also been discovered on the site. It is proposed that pile foundations be utilised and that these be driven into the existing ground. Along the northwest and south east edges of the site, a combined sheet pile wall and rock armour revetment will be constructed. There is a risk that the contaminants present in the made ground across the site may be brought to the surface during excavation works or driven down into underlying aquifer. The impact associated with driven piles is slight, as contaminated material will be dragged down into the underlying soil layers by shaft friction, however the displacement of these contaminants is likely to be insignificant. Any locally excavated material arising from these operations is assumed to be contaminated and will be removed off site and disposed of at an approved and licenced facility.

9.4.2 Operational Phase

9.4.2.1 Road Runoff – Groundwater Risk Assessment

A groundwater risk assessment has been carried out in line with the NRA (TII) Document DN-DNG-03065 in relation to potential impacts on groundwater from the proposed road drainage system and specifically in relation to the use of permeable drainage systems. DN-DNG-03065 outlines the required methodology for carrying out such an assessment and the specific criteria involved.

Table 9.2 Groundwater Protection Response Matrix for the use of permeable drains in road schemes (NRA (TII) DN-DNG-03065, 2015)

Vulnerability rating	Source protection area	Resource protection area (aquifer category)							
		Regionally Important Aquifer			Locally Important Aquifer			Poor aquifer	
		Rk*	Rf	Rg	Lg	Lm	Ll	Pl	Pu
Extreme: Rock near Surface or karst (X)	R4	R4	R4	R3(2)	R3(2)	R3(1)	R3(1)	R3(1)	R3(1)
Extreme (E)	R4	R2 (3)	R2 (2)	R3(2)	R3(2)	R2 (2)	R2 (2)	R2 (1)	R2 (1)
High (H)	R3(2)	R2 (2)	R2 (2)	R2(2)	R2(2)	R2 (2)	R2 (2)	R2 (1)	R2 (1)
Moderate (M)	R3(1)	R2 (1)	R2 (1)			R2 (1)	R2 (1)	R1	R1
Low (L)	R3(1)	R1	R1			R1	R1	R1	R1

As per Table 9.2 above *(Table A.4 of DN-DNG-03065 – Groundwater Protection Response Matrix for the use of permeable drains in road schemes),* the proposed development has a response of R1 indicating that the use of permeable road drainage systems is Acceptable subject to a number of criteria being met. The response R2(2) states that the use of permeable drainage systems is:

- Acceptable subject to minimum design standards in the NRA DMRB and Notes 1 and 2.

Water Strike readings ranged from 1.7m to 2.8m BGL on the development site. No karst features have been identified on the site.

9.4.2.2 Drainage and Foul Sewers

A new foul and surface water drainage system will be provided as part of the proposed development. Foul discharge will ultimately discharge to the existing combined network on Trinity Street and will not impact the existing groundwater body.

The surface water drainage system will comprise of sustainable urban drainage systems (SuDS). The proposed drainage system will comprise of SuDS components that will provide treatment to runoff and allow for limited infiltration to groundwater (see Section 9.4.2.3 below and Chapter 4), as deemed acceptable by the groundwater risk assessment undertaken.

9.4.2.3 Contaminated Land

Preliminary Intrusive Ground Investigations undertaken at the site have identified elevated levels of contaminants in the made ground (fill Material) principally PAH's and Sulphates. This material likely extends across the entire site within the made ground due to the historic uses of the site and the resulting disposal of contaminated materials.

For the purposes of this assessment, results have been benchmarked to both the LQM/CIEH Suitable 4 Use Levels (S4UL) and/or the Criteria for granular waste acceptable at landfills (Transposed from Council Decision annex 2003/33/EC). Soil leachate was assessed by comparing analytical results to the European Communities Environmental Objectives (Groundwater) Regulations, 2010 (Statutory Instrument No. 9 of 2010), or 2016 (Statutory Instrument No. 366 of 2016) where added or replaced, and the Environmental Protection Agency's Draft Interim Guidelines Values (IGVs) for the Protection of Groundwater, 2003.

The means for assessing the significance of soil contamination in this assessment was the use of a Conceptual Site Model and consideration of the pollutant linkages using the Source-Pathway-Receptor Model.

Source – Pathway – Receptor

<u>Source</u>

Made ground across the site has been shown to have elevated levels of PAH's and Sulphates during preliminary Site Investigations. A total of 22 boreholes were drilled across the site and the made ground material (which is where the contaminated material is expected to be present) was generally between 0 – 2.5m below ground level however the made ground extended to 4.1m below ground level (at BH06, see Plate 8.1 in Chapter 8 Soils & Geology) towards the north-western end of the site. It must be noted that it is likely that a small portion of the contaminated material present at the site will be excavated and removed off-site for disposal to allow for the construction of elements of the development including the foul pumping station and any deep service trenches required.

Pathway

The contamination is already in place within the made ground and has been in place for an extended period. The main pathway therefore for the contamination to reach a receptor is mobilisation through infiltrating surface water with subsequent migration either downwards through the subsoil or migrating north-east towards the estuary.

Receptor

There are two possible receptors for mobilised contamination within infiltrating water:

- The River Slaney estuary (Slaney Slaney River Valley SAC) located along the east, south-east and north-western site boundaries. This is a European Site, which is of Extremely High Attribute Importance.
- The bedrock aquifer beneath the site (Mudstone/Limestone bedrock overlain by a highly weathered zone). This is a poorly productive aquifer which is of Low Attribute Importance.

Groundwater supplies in the vicinity of the site are not considered as potential receptors. This is due to the site being located immediately adjacent to the River Slaney and therefore down gradient of any potential groundwater abstraction sites. In addition, any groundwater abstractions which do occur within 1km of the site are not recorded as being utilised as potable water supplies.

Conceptual Site Model (CSM)

The contaminated material is contained within made ground (infill) deposits extending across the site which are generally between 0 – 2.5m in thickness but which were found to extend to a depth of up to 4.1m in isolated locations. The made ground deposits are underlain by silt/clays which overlie gravels/sandy clays beneath which the weathered bedrock is present. The bedrock aquifer is poorly productive and consists of limestone and mudstone. GSI mapping for the area also indicates the presence of quartzite and slate – neither of which were encountered during intrusive coring. A recharge cap of 100mm per annum has been assigned to the bedrock aquifer by the GSI at this location due to its poor primary (and secondary) porosity and subsequent limited ability to accept and store groundwater.

In addition, a significant portion of the site is overlain by subsoil of which the clay or silt fraction is high indicating low or moderate permeability. The presence of this silt (or alluvium with or without clay horizons) material will impede the infiltration of recharge water. The majority of rainwater falling across the site therefore runs off to the River Slaney Estuary and does not infiltrate through the subsoil. The groundwater table is relatively high due to the proximity to the estuary and is within 2 – 3m below ground level. The bedrock is overlain by a highly weathered zone of broken rock which was encountered across the entire site. The majority of groundwater flow beneath the site occurs within this weathered zone and within the gravel deposits, which overlie this zone. Groundwater flow is generally from west to east towards the estuary, which is likely a discharge zone – albeit discharge volumes will be low due to the nature of the aquifer. This Conceptual Site Model has been illustrated in a cross-section through the site given in Plate 9.1 below.

Potential Impact Assessment

The main pathway which exists to allow contaminants enter either the bedrock aquifer or the River Slaney Estuary is the infiltration of water through the made ground and underlying subsoil to groundwater. The proposed development will result in a significant proportion of the site being covered in hard-standing. This will limit the potential for infiltration of water through the contaminated material and subsequent

mobilisation of contaminants to groundwater. However, runoff from a significant portion of these hardstanding areas (buildings/roads/parking areas etc.) is being routed to permeable paving and/or vegetated swales where attenuation will take place. These features will allow some portion of this water to infiltrate while it is stored with the remainder discharging to one of multiple outfalls to the estuary.

Whilst this does pose a potential risk to the two identified receptors, the risk is low due to the low permeability subsoils which underlie the fill material and the results of the soil leachate tests which were generally below threshold values. The entire site will require the importation of fill material in order to raise the level of the site to the required finished floor and road elevations. Generally, the extent of this fill will be 1m or greater in thickness with the uppermost 250mm of this fill material comprising of compacted clay with a permeability of 1×10^{-7} ms^{-1} or less. This clay layer will be located beneath all permeable paving, swales, and the growing media required for landscaped areas. This low permeability compacted clay will effectively prevent infiltration of rainwater to the underlying subsoil and therefore prevent mobilisation of contaminants into the underlying gravels and weathered bedrock. Some limited infiltration will ultimately still occur, but this will represent a small fraction of total effective annual rainfall. In addition, the proposed sheet-piled wall at the site perimeter will also provide a barrier to contain contaminated material within the site thus representing an additional level of protection.

Given that the bedrock aquifer is of low importance the associated risk arising from the proposed development in combination with the contaminated material is extremely low and the impact rating is therefore Imperceptible. The incorporation of the low permeability fill material (and additionally the sheet-piled wall) will in fact reduce the existing risk arising from the site in its current state. The risk to the River Slaney Estuary SAC is also low and the potential impact assessment is deemed to be Imperceptible.

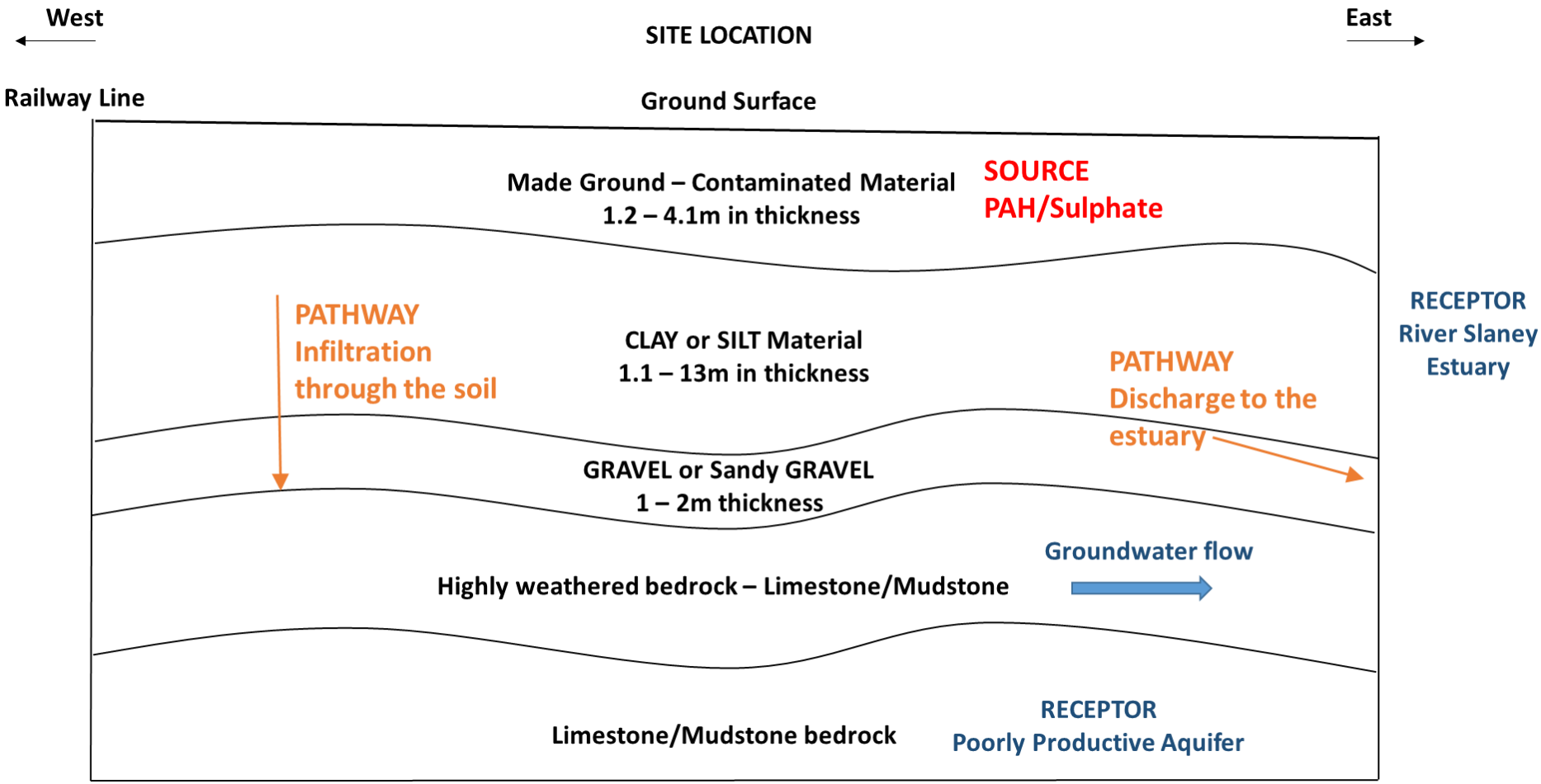

Plate 9.1 **Conceptual Site Model (CSM)**

9.4.2.4 Groundwater Supplies

The proposed development will not impact existing groundwater supplies and therefore there will be an imperceptible impact. It is proposed that the development be served from the existing water infrastructure in Wexford town.

9.4.2.5 Aquifer Recharge

As a result of the proposed development, there will be an increase in the total impermeable area of the site and correspondingly a potential reduction in aquifer recharge. Permeable paving in lightly trafficked areas such as cul-de-sacs and parking areas will be provided along with SuDS components such as swales which will be underlain by the low permeability clay material. This will allow for some surface water to infiltrate to ground however this will be limited. It is noted however that the low storage available within the underlying poorly productive bedrock aquifer already results in annual rejection of recharge with a recharge cap applied. Therefore, the potential impact to aquifer recharge is seen as imperceptible.

9.5 Mitigation & Monitoring Measures

9.5.1 Construction Phase

A project-specific Construction Environmental Management Plan (CEMP) and Environmental Operating Plan (EOP) will be prepared by the contractors for the development in line with the Outline CEMP and EOP appended to this EIAR (see Appendices 4.1 and 4.2). For the phased elements, it will be maintained by the separate contractors for the duration of the construction phase. The CEMP will cover all potentially polluting activities and include an Incident Response Plan. All personnel working on the site will be trained in the implementation of the procedures. As a minimum, the CEMP and EOP for the proposed development will be formulated in consideration of the standard best practice. The CEMP will include a range of site-specific measures which include:

- Earthworks shall be carried out such that surfaces promote runoff and prevent ponding and flooding;
- Runoff will be controlled and treated to minimise impacts to surface and groundwater;
- Prior to any works taking place on-site, a comprehensive and detailed ground investigation programme shall be undertaken to fully quantify the nature and extent of contaminated material present at the site;
- All material excavated at the site shall be assumed to be contaminated. Appropriate testing of this material by a suitably qualified and licenced waste contractor shall take place for all aspects of ground contamination and the material shall be disposed of off-site to a suitably licenced waste facility. Temporary storage of any contaminated material on-site shall be carefully managed so as to limit any risk of contaminated surface water runoff to the River Slaney Estuary. The material shall be stored at least 25m away from the high-water mark in the estuary. Runoff from the material shall be directed to lined pond or temporary sewer/tank and the water shall be disposed of off-site for treatment at an appropriate licenced facility. Alternatively, the material shall be covered while stored to remove the risk of surface water contamination;
- Excavations into the existing ground for the installation of the foul pumping station, deep service trenches and surface water drainage network serving the proposed access road off Trinity Street. The material removed will be assumed to be contaminated and will be appropriately disposed of (as outlined in the point above). Suitable backfill material to the pipes will be imported to site. A 250mm

layer of imported clay will be placed beneath the swale to prevent the infiltration of rainwater to the underlying subsoil and therefore prevent mobilisation of contaminants into the underlying gravels and weathered bedrock;

- Where temporary pumping of water is to be carried out, filters will be used at intake points and discharge will be through a sediment trap;
- All hazardous materials will be stored within secondary containment designed to retain at least 110% of the storage contents. Temporary bunds for oil/diesel storage tanks will be used on the site during the construction phase;
- Safe materials handling of all potentially hazardous materials will be emphasised to all construction personnel employed during construction; and
- Mitigation measures during the construction phase will include implementing best practice during excavation works to avoid sediment entering Wexford Harbour.

9.5.2 Operational Phase

All potential impacts have been identified as slight in the operational phase and as such no long-term mitigation measures are proposed.

9.6 Residual Impacts

The incorporation of the mitigation measures outlined in Section 9.5 will result in the magnitude of any impacts either during construction or operation to be considered as Negligible. As a result, the significance of all residual impacts is Imperceptible.

9.7 Difficulties Encountered

No difficulties were encountered in undertaking this hydrogeological assessment.

9.8 References

Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie);

Groundwater quality status maps (watermaps.wfdireland.ie);

Teagasc Subsoils map (gis.epa.ie/Envision);

Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision);

National Parks and Wildlife Services Map Viewer (webgis.npws.ie/npwsviewer/);

Historic Maps from the Ordnance Survey of Ireland (www.geohive.ie);

Aerial Photography from the Ordnance Survey of Ireland (www.geohive.ie);

Kavanagh Mansfield and Partners (2008): Report on a site investigation for a development at Trinity Wharf Wexford