Chapter 9
Hydrogeology

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9.1 Introduction

This chapter considers and assesses the likely significant effects with regard to Hydrogeology associated with both the construction and operational phases of the proposed River Suir Sustainable Transport Bridge in Waterford.

Measures to mitigate any likely significant adverse effects of the proposed River Suir Sustainable Transport Bridge are proposed and residual impacts are described. The chapter initially sets out the methodology used (Section 9.2), describes the existing hydrogeological environment (Section 9.3), examines the predicted impacts of the proposed development (Section 9.4), proposes mitigation measures (Section 9.5), and identifies residual impacts (Section 9.6).

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 Road 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;
- 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);
- Geological Survey of Ireland – Groundwater Body Characterisation Reports;
- Environmental Protection Agency – "Hydrotool" Map Viewer (www.epa.ie);
- Department of Environment, Community and Local Government on-line mapping viewer (www.myplan.ie);
- Protected areas, Biodiversity Ireland (maps.biodiversityireland.ie);
- Integrated Pollution Control (IPC) and Industrial Emissions (IE) Licences, EPA;
- Historic Maps from the Ordnance Survey of Ireland (www.osi.ie);

- Aerial Photography from the Ordnance Survey of Ireland (www.geohive.ie);
- Met Éireann historical weather data (www.met.ie).

9.2.2 Site Investigations

A walkover survey of the site and its environs was carried out by Roughan & O'Donovan in 2017. Following this initial site walkover, IGSL Ltd. were commissioned to carry out intrusive ground investigations for the North Quays and at the location of the proposed crossing. A Contamination Assessment of the site was also carried out by O'Callaghan Moran (OCM) as part of this site investigation. The intrusive ground investigations involved the drilling of exploratory boreholes with appropriate in-situ testing. In addition, a marine geophysical survey was carried out at the location of proposed bridge crossing by Apex Geo-services. This survey provided information regarding the nature of the soil and bedrock profile of the river bed at the location of the proposed bridge.

Further details of the findings of the geophysical surveys, ground investigations and the contamination assessment are presented in Chapter 8 Soils & Geology.

9.3 Description of the Receiving Environment

Soils & Subsoils

GSI Mapping

The Teagasc soil mapping identifies Made Ground for the area surrounding the proposed development. It is likely that the river is underlain by Alluvium and that the made ground on either quay is underlain/mixed with Alluvium material. Given the location of the site within Waterford City, it is likely that a variety of materials and soils are present beneath either quay. Refer to Figure 8.1 of Volume 3 of this EIAR for Teagasc soils mapping of the area.

Intrusive Site Investigations

Alluvium was encountered at a number of boreholes and in general increases in thickness from north to south. Site investigations encountered Glacial Till deposits beneath the Alluvial material and Sands and Gravels were also noted to be present at depth at a number of locations.

Bedrock Geology

GSI Mapping

The bedrock geology of the surrounding area is complex characterised by a faulted sequence of sediments and volcanics. The proposed crossing is underlain by the Ballylane Formation to the north of the river which is described as green & grey slate with thin siltstone. South of the river the site is underlain by the Ross Member Formation which is a dark grey slate with thin siltstone. A number of fault lines are recorded running both parallel and perpendicular to the River Suir. 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 8.2 of Volume 3 for GSI bedrock geology mapping of the area.

Intrusive Site Investigations

Site investigations identified siltstone, sandstone or interbedded mudstone rocks beneath the site. Depth to bedrock varies from 1.5m Below Ground Level (BGL) near the northern riverbank to more than 30m on the southern quayside.

Contaminated Land

Samples were taken from exploratory holes and were tested at the Chemtest Accredited Laboratory in the UK. All samples have been classified as falling within either the non-hazardous or inert limits. Some very low localised elevated levels of hydrocarbons (PAH) and heavy metals (Arsenic) were recorded, specifically in locations along the River Suir riverbed, however, levels were very low and only classify the material as very lightly contaminated.

Groundwater Resources

The River Suir forms a groundwater divide between rocks in terms of flow and productivity. The lands south of the River Suir are located within the Waterford Groundwater Body (IE_SE_G_149), which is predominantly characterised as comprising productive fissured bedrock. Given the fissured nature of the bedrock the aquifer is categorised as a Regionally Important Aquifer (Rf) - Fissured bedrock. North of the River Suir the site is within the Mullinavat Groundwater Body (IE_SE_G_155) whose flow regime is limited by predominantly poorly productive bedrock. Correspondingly, the bedrock underlying the site north of the River Suir is categorised as a Poor Aquifer (Pl) - bedrock which is generally unproductive except for local zones. Refer to Figure 9.1 of Volume 3 of this EIAR for GSI Aquifer and Groundwater Body (GWB) mapping of the area.

Groundwater Vulnerability

Groundwater vulnerability mapping for the site indicates that groundwater is moderately vulnerable to pollution at the ground surface. Having examined the site intrusive records for the area it is necessary to revise this rating taking into account local site conditions. North of the river subsoil cover forms a thin layer (generally <5m) of low to moderate permeability subsoil or made ground. Given that concrete and other impermeable materials may also be present, a vulnerability of extreme to high is appropriate. Subsoil thickness increases rapidly travelling across the River Suir towards the South Quay and given the presence of low permeability material groundwater vulnerability is likely moderate to low from approximately the centreline of the river at the proposed crossing location. Refer to Figure 9.2 of Volume 3 of this EIAR for GSI vulnerability mapping of the area.

Groundwater Recharge

Taking account of the low permeability and storativity of the Ballylane Formation, a recharge cap of 100mm has been assigned to these rocks indicating rejection of infiltration water annually. Recharge south of the river has been estimated at c.120mm per annum.

Site Hydrogeology

Given the proximity to the river and the topographical orientation towards the Suir valley, discharge from both Groundwater Bodies at the proposed crossing will be to the River Suir. Groundwater flow paths in the area north of the river will be very short due to the bedrock generally being poorly permeable with the exception of fracture zones. Flow paths to the south may be longer however, the proximity to the river is the dominant flow control.

Groundwater Abstractions

There are no recorded public groundwater supplies or group water schemes within the GSI database. There are a small number of recorded boreholes within 1.5km of the proposed crossing which are either for private domestic or light industrial use.

Groundwater Quality

Under the requirements of the Water Framework Directive (WFD), both the Waterford and Mullinavant groundwater bodies were classified as having an overall good status for water quality and quantity 2010-2015. An additional Groundwater Body – Waterford City (IE_SE_G_150) – is listed within the WFD mapping portal and is classified as having an overall poor status. Waterford and Mullinavant GWBs are classified as 'at risk' of not achieving at least good Ecological or good chemical status/potential by 2015. The objective for Waterford City GWB is 'restore'.

Site Conceptual Model

A Conceptual Site Model (CSM) was compiled showing the depth and extents of overburden, bedrock profile, location of surface water features and groundwater levels was compiled in conjunction with the Lands and Soils Assessment (refer to Plate 8.2 - Chapter 8). Groundwater flow is in a north-south direction towards the River Suir within the Mullinvant GWB. Groundwater flow is south-north towards the River Suir within the Waterford GWB. Groundwater levels are generally close to the ground surface (1-2m BGL) and are tidally influenced due to interaction with the river. The source-pathway model for risk identifies the necessity for a receptor when assessing the risk – in this case a likely significant impact. The site investigations included water quality analysis at some of the boreholes and Electrical Conductivity values observed at all sampled locations were in excess of 1500µscm^{-1} indicating brackish water as a result of the tidal influence. In this scenario, considering the aquifer immediately beneath the site as a resource (receptor) is considered to be a conservative approach as the salinity of the groundwater would limit its use as potable water supply. Given the likelihood for net discharge of freshwater to the river it is considered prudent to treat the aquifer as a receptor in the CSM.

Summary of Hydrogeological Features

The main features of importance identified at the site and in the study area are summarised in Table 9.1.

Table 9.1 Features of Importance

Feature	Importance	Criteria / Justification
Bedrock aquifer classified by the GSI as a Poorly Productive Aquifer which is productive only in local zones (Pl)	Low	A poorly productive aquifer is considered to be of low value on a local scale.
Bedrock aquifer classified by the GSI as a Regionally Important Aquifer comprising fissured bedrock (Rf)	High	A regionally important aquifer is considered to have a high quality or value on a regional scale
River Suir	Extremely High	* *See explanation below.*

* The River Suir is a hydrological feature of importance. The IGI guidance does not designate importance ranking to hydrological features, however the Transport Infrastructure Ireland (TII) guidance states that if groundwater supports a river or surface water body ecosystem protected by EU legislation (e.g. Lower River Suir Special Area of Conservation (SAC)) that it should be considered an attribute of extremely high importance.

9.4 Potential Impact Assessment

This section describes the impacts associated with the proposed development before mitigation measures are applied. Both direct and indirect impacts will be addressed for the construction and operation of the proposed development. The nature, extent and duration of the impacts will also be assessed.

The proposed development will involve the following activities during the construction phase which have the potential to impact the hydrogeological features of importance:

- Excavations during the construction stage which will be up to approximately 2.5 mBGL to construct the bridge abutments and foundations. The excavations may encounter material with very low levels of contamination.
- Construction of steel driven piles with rock sockets and the excavation and removal of in-situ material.
- Storage of stockpiles during the construction phase.
- Minor pumping may be required if groundwater is encountered during excavations, although this is expected to be very localised to the site. This groundwater may be contaminated.

During the operational phase, the area will be an urban environment covered in hard standing. There are therefore no perceived activities which pose a risk to the hydrogeological features of importance with the exception of the Lower River Suir SAC during the operational phase.

9.4.1 Construction Phase

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

- Excavation of made ground,
- Contamination of soils, and
- Contamination of groundwater.

Excavation of Made Ground

Excavation of made ground will take place during construction. 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. 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.

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 Imperceptible.

Contamination of Groundwater

There is a potential risk of localised contamination of the groundwater due to construction activities i.e. construction spillages, leaks from construction plant and material etc. resulting in a Permanent Negative impact on groundwater. The groundwater table is approximately 1 – 3.6m BGL in the vicinity of the River Suir. The bedrock has been proven at numerous locations ranging from 1.5m BGL to 30m BGL. Bedrock is generally overlain by either alluvium or alluvium overlying till. The presence of this low permeability alluvium (and tills) will limit the potential for contamination to infiltrate into the underlying aquifer.

However, the requirement to construct piles through the overlying soils, which have been shown to be slightly contaminated at discrete locations, could potentially create a preferential flowpath through the subsoils directly into the bedrock allowing some of these contaminates to mobilise. Expected construction practice will involve the piling to take place in the dry within temporary cofferdams. A base concrete slab will be constructed prior to pile installation to seal the potential pollution source. All foundation piles will be filled with concrete immediately after excavation preventing contamination of the bedrock aquifer. For these reasons, the impact is Negligible on the groundwater contained within the bedrock aquifer. The significance of this impact is Imperceptible.

9.4.2 Operational Phase

The operational phase of the proposed development is predicted to have an overall Neutral long-term impact on hydrogeology within the study area. During the operational phase runoff from the proposed development which may be polluted with either sediment or hydrocarbons/metals may enter the River Suir and degrade water quality. This potential impact and associated mitigation measures are fully considered in the surface hydrology impact assessment contained within Chapter 10 of this EIAR.

9.5 Proposed Mitigation Measures

9.5.1 Construction Phase

A project-specific Environmental Operating Plan (EOP) and Outline Construction Environmental Management Plan (OCEMP) have been prepared and appended to Chapter 4 of this EIAR (see Appendix 4.1 and 4.1 B respectively). They will be maintained by the Contractor for the duration of the construction phase. The EOP will cover all potentially polluting activities and include an emergency response procedure. All personnel working on the site will be trained in the implementation of the procedures. As a minimum, the EOP for the proposed development will be formulated in consideration of the standard best practice. The EOP 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.
- Temporary pumping of groundwater shall be treated by means of a temporary sedimentation pond (or similar) prior to discharge
- 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.
- Mitigation measures during the construction phase will include implementing best practice during excavation works to avoid sediment entering the River Suir (refer to Chapter 10 of this EIAR for details).

9.5.2 Operational Phase

No mitigation measures are required during the operational phase providing the requirements as set out in Chapter 10 of this EIAR relating to the protection of water quality within the Lower River Suir SAC are implemented in full.

9.6 Residual Impacts

The incorporation of the mitigation measures outlined in Section 9.5 results 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