BALLINA FLOOD RELIEF SCHEME

Environmental Impact Assessment Report
Chapter 11: Land, Soils, Geology & Hydrogeology

MGW0290-RPS-EI-XX-R-EN-1100
Ch 11 Land, Soil, Geology and Hydrogeology
S4. P04
April 2025

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
S4. P03	Final for Submission	ND	TK	JF	April 2025

Approval for issue

JF	4 April 2025

Prepared by:

RPS

Prepared for:

Mayo County Council

Dublin | Cork | Galway | Sligo | Kilkenny
rpsgroup.com

RPS Group Limited, registered in Ireland No. 91911
RPS Consulting Engineers Limited, registered in Ireland No. 161581
RPS Engineering Services Limited, registered in Ireland No. 99795
The Registered office of each of the above companies is West Pier Business Campus, Dun Laoghaire, Co. Dublin, A96 N6T7

Contents

Tables

Acronyms

Term	Meaning
BL	Ballina Limestone Formation (Lower)
BU	Ballina Limestone Formation (Upper)
CEMP	Construction Environmental Management Plan
CFRAM	Catchment Flood Risk Assessment and Management
CGS	County Geological Site
CIRIA	Construction Industry Research & Information Association
CSM	Conceptual Site Model
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EPA	Environmental Protection Agency
EU	European Union
FRS	Flood Relief Scheme
GHA	Geological Heritage Area
GI	Ground investigation
GPR	Ground Penetrating Radar
GSI	Geological Survey of Ireland
GWB	Groundwater Body
GWDTE	Groundwater Dependent Terrestrial Ecosystems
IED	Industrial Emissions Licence
IFI	Inland Fisheries Ireland
IGI	Institute of Geologists of Ireland
IGH	Irish Geological Heritage
IPC	Integrated Pollution Control
MCC	Mayo County Council
mOD	Metres Over Datum
Mbgl	Metres Below Ground Level
NRA	National Roads Authority
OPW	Office of Public Works
OSI	Ordnance Survey Ireland
SAC	Special Area of Conservation
SI	Site Investigation
TII	Transport Infrastructure Ireland
WAC	Waste Acceptance Criteria
WFD	Water Framework Directive

11 LAND, SOILS, GEOLOGY AND HYDROGEOLOGY

11.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) identifies, describes and presents the assessment of the likely significant effects of the Ballina Flood Relief Scheme (FRS) on land, soils, geology and hydrogeology of the study area. The assessment presented is based on the information provided in:

- **Chapter 5: Project Description.** The assessment presented is further informed by the following EIAR chapters:
- **Chapter 9: Aquatic Biodiversity:** Impact pathways for biodiversity.
- **Chapter 12: Water:** Direct or indirect effects on the groundwater environment depending on the degree of interaction between surface water and groundwater.
- **Chapter 16: Material Assets (Waste & Utilities):** Reuse of soils.
- **Chapter 17: Material Assets (Land and Properties):** Indirect impact on surrounding agriculture and land use.

The scope and objectives of this assessment are to:

- Review and characterise the baseline soils, geological and hydrogeological conditions of the existing environment within the study area.
- Evaluate the impact of the Proposed Scheme on these attributes and establish the activities associated with the construction and operation of the Proposed Scheme.
- Identify groundwater vulnerability to assess the impacts of the Proposed Scheme on the underlying aquifers and any potential impacts on public/private water abstractions/wells.
- Consider the likely hydraulic and hydrochemical impacts that are likely to arise from the construction and operation of the Proposed Scheme.
- Address interactions with other disciplines (hydrology, ecology, waste); whether there are likely to be any indirect impacts by changes in hydrology/hydrogeology on terrestrial and aquatic habitats including annexed species that are designated and thus protected under Irish and European law.
- Identify and assess any potential impacts on any geological heritage sites or sites of geological interest.
- Identify and incorporate appropriate mitigation measures, that would prevent, reduce or remediate the identified impact.
- Conclude any residual impacts that would remain or arise from the mitigation measures identified.

All drawings associated with this chapter can be found in **Appendix 11.1**.

11.2 Methodology

11.2.1 Guidance

The impact assessment has regard to the general guidance regarding the undertaking of an EIA as presented in **Section 1.5** of **Chapter 1: Introduction** and the following topic specific guidance in relation to land, soils, geology and hydrogeology:

- Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements, hereafter referred to as the 'Guidelines', IGI (2013).
- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes' (National Roads Authority), TII (2009).

11.2.2 Legislation

A summary of the EU policy provisions and Irish legislation relevant to land, soils, geology & hydrogeology are provided in **Table 11-1**.

Table 11-1: Summary of Legislation Relevant to Groundwater

Legislation	Relevance to Groundwater	How and where considered in the EIAR
EIA Directive 2014/52/EU	Planning policy, specifically in relation to soil, land and water is contained the EIA Directive 2014/52/EU amends the previous EIA Directive (2011/29/EU) and is designed to ensure that projects likely to have a significant effect on the environment are subject to a comprehensive assessment of environmental effects prior to development consent being given. The IGI interpret the requirement of the Directive to consider the environmental sensitivity of soil, land and water as an assessment of the soils, geological and hydrogeological environment.	The potential effects of the construction, operational and maintenance phases of the Proposed Scheme are assessed in **Section 11.4**. Factored-in measures are discussed in **Section 11.5**
EU Water Framework Directive (WFD)	Overlapping obligations stem from the EU Water Framework Directive (WFD) (2000/60/EC) which established a framework for the protection of both surface and groundwaters and replaced the previous Groundwater Directive (80/68/EEC). The WFD is implemented through River Basin Management Plans in three six-year cycles. The WFD aims to improve our water quality and outlines the measures required to achieve or maintain good chemical and quantitative status for groundwater	The potential effects of the construction, operational and maintenance phases of the Proposed Scheme are assessed in **Section 11.4**. Factored-in measures are discussed in **Section 11.5**.
EU 'Floods' Directive	The EU Directive on the Assessment and Management of Flood Risks (2007/60/EC) (the 'Floods' Directive) was transposed into Irish Law by the EU Regulations SI No,122 of 2010. The Directive requires Member States to assess if all watercourse and coastlines are at risk from flooding, to map the flood extent, assets and humans at risk in these areas and to take adequate and co-ordinated measures to reduce this flood risk. Identifying areas that may be susceptible to groundwater flooding through both hazard and risk maps is a requirement of the EU Floods Directive.	The potential effects of the construction, operational and maintenance phases of the Proposed Scheme are assessed in **Section 11.4**. Factored-in measures are discussed in **Section 11.5**.
Planning & Development Regulations S.I.No.600/2001	On a national level the EIA Directive has been transposed into Irish legislation by The planning and Development Regulations 2001 (S.I.No.600/2001) which outlines the types of project for which mandatory EIA is required. According to Schedule 6 of the Planning and Development Regulations a description of the aspects of the environment likely to be significantly affected by the Proposed Scheme is required on 'soil, water, air, climatic factors and the landscape'.	The potential effects of the construction, operational and maintenance phases of the Proposed Scheme are assessed in **Section 11.4**. Factored-in measures are discussed in **Section 11.5**.

11.2.3 Zone of Influence

To examine the potential impacts on adjacent soils and land, the study extends outside the footprint of the Proposed Scheme which includes a 1 km buffer zone from the works areas. In accordance with the Guidelines and to further examine the potential impacts on groundwater, a wider zone of influence for bedrock aquifers and groundwater bodies was also considered i.e. the environs within 2km of the Proposed Scheme adjacent to the River Moy within the extents of the area underlain by the Ballina Groundwater Body (GWB). The Ballina GWB underlies the proposed works therefore the baseline conditions on a regional scale are considered. The Land, Soils, Geology and Hydrogeology study area will be referred to as the 'Hydrogeological Study Area', see Drawing MGW0290-RPS-EI-XX-D-EN-1100.

11.2.4 Sources of Information to inform the Assessment

11.2.4.0 Desk Study

A desk-based search of available baseline information was undertaken to identify the key geological and hydrogeological characteristics and/or sensitivities. Verified online information, published and unpublished literature were utilised for the impact assessment and scientific literature was consulted where appropriate. The following publicly available sources were utilised:

- Geological Survey of Ireland (GSI) Spatial Viewer https://dcenr.maps.arcgis.com
- Groundwater Flooding Data Viewer https://dcenr.maps.arcgis.com
- EPA https://gis.epa.ie/EPAMaps/
- EPA Catchments https://www.catchments.ie/
- Ordnance Survey Ireland (OSi) Basemap and Historical Mapping - GeoHive https://www.geohive.ie/
- Mayo County Development Plan 2022-2028
- GSI (1992) The Geology of North Mayo, Sheet 6
- Catchment Flood Risk Assessment and Management Studies (CFRAM)
- National Parks & Wildlife Service maps, data, reports and research. Available at https://www.npws.ie/
- Office of Public Works (OPW) (2009) The Planning System and Flood Risk Management Guidelines for Planning Authorities
- Irish Water Ballina Town Mixed Supply Water Supply Zone - Drinking Water Quality Results 2016-2023 - https://www.water.ie/help/water-quality/results/

The following unpublished site-specific investigation reporting has informed conceptualisation and baseline characterisation for land and soils:

- IGSL (2022) Ballina Flood Relief Scheme - Ground Investigation (November 2022)
- RPS (2023) Ground Investigation Report (August 2023)

11.2.4.1 Scheme Walkover

Information from a site walkover completed in January 2023 was used in this assessment to inform, supplement and verify the desktop assessment.

11.2.5 Key Parameters for Assessment

A description of the works is provided in **Chapter 5: Project Description**. The key activities that have potential to result in likely significant effects on land, soils, geology and hydrogeology are outlined below:

- Loss of soil reserves through the construction of, hardstanding, flood walls, culverts and embankments. This includes erosion, compaction and sealing.
- Localised ground subsidence or settlement from embankment and culvert construction and excavations.
- Impacts to aquifer through removal of protective overburden material during construction works for foundations.
- Accidental emissions and release of potentially hazardous substances during construction that can affect the quality of soils, most notably associated with cement, concrete materials (high alkalinity run-off), temporary oils and fuel particularly where below ground excavations are required.
- Potential to encounter and/or disturb contaminated soils or materials during the construction works.
- Dewatering activities for instream works and foundation placement.

- Short-term effects upon groundwater quality through the infiltration of surface runoff within or adjacent to construction areas.
- Potential impacts to geological heritage areas.

11.2.6 Assessment Criteria and Significance

The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the predicted impacts.

The significance of an impact is defined by first considering the importance of the attribute impacted and secondly the magnitude of the impact. The importance of geological and hydrogeological attributes (rating criteria) is defined in accordance with Transport Infrastructure Ireland (TII) *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes* (2009). With the exception of the exclusion of the terms ‘not significant’ and ‘very significant’, this guidance uses the same significance terminology as the EPA (**Table 11-6**) and includes intermediate steps for rating site importance (**Table 11-2** & **Table 11-3**) and magnitude of impact (**Table 11-3** & **Table 11-4**), and then significance of impact (**Table 11-7**). For the purposes of this assessment, a rating of moderate and above is considered significant in EIA terms.

Table 11-2: Criteria for Geological Feature Importance Rating (TII, 2009)

Importance	Criteria
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and / or soft organic soil underlying road development is significant on a national or regional scale.
High	Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and / or soft organic soil underlying road development is significant on a local scale.
Medium	Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and / or soft organic soil underlying road development is moderate on a local scale.
Low	Attribute has a low quality, significance or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and / or soft organic soil underlying road development is small on a local scale*.

**Relative to the total volume of inert soil disposed of and/or recovered*

Table 11-3: Criteria for Hydrogeological Feature Importance Rating (TII, 2009)

Importance	Criteria
Extremely High	Attribute has a high quality, significance or value on an international scale.
Very High	Attribute has a high quality, significance or value on a regional or national scale
High	Attribute has a medium quality, significance or value on a local scale
Medium	Attribute has a medium quality or value on a local scale
Low	Attribute has a low quality or value on a local scale

Table 11-4: Estimation of Magnitude of Impact on Geological Attribute (TII, 2009)

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute	• Loss of high proportion of future quarry or pit reserves. • Irreversible loss of high proportion of local high fertility soils. • Removal of entirety of geological heritage feature.

Magnitude of Impact	Criteria	Typical Examples
		• Requirement to excavate / remediate entire waste site. • Requirement to excavate and replace high proportion of peat, organic soils and / or soft mineral soils beneath alignment.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Loss of moderate proportion of future quarry or pit reserves. • Removal of part of geological heritage feature. • Irreversible loss of moderate proportion of local high fertility soils. • Requirement to excavate / remediate significant proportion of waste site. • Requirement to excavate and replace moderate proportion of peat, organic soils and / or soft mineral soils beneath alignment.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Loss of small proportion of future quarry or pit reserves. • Removal of small part of geological heritage feature. • Irreversible loss of small proportion of local high fertility soils and / or high proportion of local low fertility soils. • Requirement to excavate / remediate small proportion of waste site. • Requirement to excavate and replace small proportion of peat, organic soils and/or soft mineral soils beneath alignment.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	• No measurable changes in attributes.
Minor Beneficial	Results in minor improvement of attribute quality	• Minor enhancement of geological heritage feature.
Moderate Beneficial	Results in moderate improvement of attribute quality	• Moderate enhancement of geological heritage feature.
Major Beneficial	Results in major improvement of attribute quality	• Major enhancement of geological heritage feature.

Table 11-5: Estimation of Magnitude of Impact on Hydrogeology Attribute (TII, 2009)

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute	• Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. • Potential high risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Removal of moderate proportion of aquifer. Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. • Potential medium risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems. • Potential low risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >0.5% annually.

Magnitude of Impact	Criteria	Typical Examples
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	• Calculated risk of serious pollution incident <0.5% annually.

Table 11-6: Definition of Terms Relating to the Significance of Impact Levels (EPA, 2022)

Term	Definition
Imperceptible	An effect capable of measurement but without significant consequences.
Not Significant	An effect which causes noticeable changes in the character of the environment but without significant consequences.
Slight Effects	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities.
Moderate Effects	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends.
Significant Effects	An effect which, by its character, magnitude, duration or intensity, alters a sensitive aspect of the environment.
Very Significant	An effect which, by its character, magnitude, duration or intensity, significantly alters most of a sensitive aspect of the environment.
Profound Effects	An effect which obliterates sensitive characteristics.

The significance of the impacts on soils/geology and hydrogeology attributes are determined by correlating the importance/ sensitivity of the receptor with the magnitude of the impact. The method employed for this assessment is presented in **Table 11-7**. For the purposes of this assessment, any impacts with a significance level of slight or less have been concluded to be not significant in EIA terms.

Table 11-7: Matrix used for the Rating of the Significance of Environmental Impact (TII, 2009)

Importance of Attribute	Magnitude of Impact			
	Negligible	**Small adverse**	**Moderate adverse**	**Large adverse**
Extremely high	Imperceptible	Significant	Profound	Profound
Very high	Imperceptible	Significant/Moderate	Profound/Significant	Profound
High	Imperceptible	Moderate/Slight	Significant/Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

11.2.7 Data Limitations

This chapter of the EIAR was prepared using the best available information and in accordance with current best practice and relevant guidelines.

There were no technical difficulties or otherwise encountered in the preparation of this chapter of the EIAR. Preliminary site-specific ground investigation and geotechnical reports were reviewed as part of this assessment and relevant details included as appropriate throughout. Further site investigation (SI) works will be required to inform the detailed design phase of the project prior to the commencement of the construction works and therefore do not form part of this assessment.

11.2.8 Consultation

A summary of the key issues raised during consultation activities undertaken to date specific to land, soils, geology and hydrogeology is presented in **Table 11-8** together with how these issues were considered in the production of this EIAR chapter. Further detail is presented within **Chapter 3: Consultation**.

Table 11-8: List of Consultations

Consultee and type of response	Comments and Issues raised	Response to issue raised and where considered in this chapter
Geological Survey of Ireland (GSI)-	There are no County Geological Sites (CGS), in the vicinity of the proposed scheme. Regionally important aquifer - karstified underlies area of scheme, groundwater vulnerability is variable. The GSI recommend the use of the groundwater viewer to identify areas of high to extreme vulnerability. Aggregate Potential can be seen via the Aggregate potential map viewer, use this to ensure that natural resources used in the scheme are from properly licensed facilities. GSI recommend that geohazards and flooding be taken into account when developing areas where these risks are prevalent. GSI requests that if the project goes ahead that a report with all SI works data be shared with them.	Refer to **Section 11.3.8** and **Section 11.4.2.7**

11.3 Existing Environment

This section describes the existing conditions and important features in terms of the land, soils, geology and hydrogeology within the study area of the Proposed Scheme. The existing land, soils, geology and hydrogeology have been interpreted from a review of the publicly available information, set out in **Section 11.2.4**, consultations, scheme walkover and from a description of site-specific ground conditions following a review of previous and the Proposed Scheme specific site investigation. Where applicable, the importance of a particular attribute in terms of the Proposed Scheme is addressed. A detailed description of the Proposed Scheme is provided in **Chapter 5: Project Description**.

11.3.1 Site Investigation

11.3.1.1 Previous Site Investigations

The details of previous site investigation reports located within the study area that were used in the assessment of the baseline ground conditions are presented in **Table 11-9**.

Table 11-9: Historic & Previous Site Investigations within the Study Area

Report Title	Year	Contractor	Location	Scope
Report on Site Investigation at Ridgepool, Ballina for the National Building Agency	1992	IGSL	Between Barret St and the River Moy	4 no. cable tool boreholes
Report on Site Investigation for a Development at Market Sq, Ballina for Primark Ltd (Penneys)	2005	IGSL	Market Square, Ballina	3 no. cable tool boreholes
Ballina Arts Centre	2008	Glover Site Investigation	Ballina Arts Centre	4 no. cable tool boreholes
Mary Robinson Centre	2016	Ground Investigations Ireland	Junction of Moy Lane & Emmet St Ballina	3 no. cable percussion boreholes, 3 no. rotary core boreholes

Report Title	Year	Contractor	Location	Scope
				Geophysical Survey
Rehins Fort, Ballina-Ground Investigation	2019	Causeway Geotech	Rehins Fort, Ballina	9 no. boreholes 7 no. dynamic probes 8 no. trial pits 1 no. infiltration test

11.3.1.2 Site Specific Site Investigation

11.3.1.2.1 Preliminary Site Investigation

A preliminary ground investigation (GI) was carried out by IGSL between May and November 2022. The purpose of the GI was to collect samples of the superficial soils for geotechnical testing and to locate services. This information was used to supplement the above information gleaned from the desktop study to further establish subsurface conditions within the study area and in particular along the proposed works areas. The ground investigation comprised:

- 26 No. cable percussion boreholes
- 8 No. machine dug trial pits
- 15 No. slit trenches
- 1 No. Ground Penetrating Radar (GPR) Survey

11.3.2 Topography & Regional Geomorphology

The topography within the study area is relatively flat (adjacent to the River Moy at Ballina Town) to gently undulating reflecting the underlying bedrock typical of a karst landscape. Within the study area elevations range from 0 m–40 m OD.

Regional topography slopes towards the River Moy which flows from the south to north through Ballina.

The geomorphology of the study area comprises drumlins and ribbed moraines trending north-south across the study area; a flat alluvial-lacustrine plain forms the ground along the River Moy. Other geomorphological features include esker ridges in the vicinity of Carrowcushlaun at the southeast of the study area. The site walkover noted drumlins orientated north-south at Quignasee/Ballyholan adjacent to the Bunree River and at Quignamanger adjacent to the Quignamanger Stream.

11.3.3 Land Use

The EPA's CORINE 2018 landcover map consists of an inventory of land cover under various classes. This dataset is replicated in "CORINE 2018 Land Cover" drawing (Drawing MGW0290-RPS-EI-XX-D-EN-1101). It shows that the landcover distribution is principally occupied by a dense clustering of Continuous and Discontinuous Urban Fabric within the centre of the study area consistent with the population centre of Ballina Town. Beyond this urban area the surrounding agricultural land is dominated by pastures with an area of mixed forest in the north-west at Belleek Woods. The land at Ballina Golf Club is classified as artificial surface for sport and leisure facilities.

11.3.4 Quaternary Geology

GSI mapping classify the superficial soil deposits within the study area as predominantly limestone till with alluvial deposits present in the river/floodplain areas.

Results of the preliminary SI carried out in the centre of Ballina Town along the quays flanking the River Moy between Lower Bridge and Bunree Bridge show that ground conditions are typical and are as expected for this part of the study area. The overburden deposits are found to consist of made ground overlying a minimum of approximately 3.5 m of glacial till derived from limestone with deposits of peat encountered in some boreholes between an upper cohesive till and deeper granular till.

11.3.4.1 Soils

Teagasc soils mapping characterises the majority of the soils in the study area as deep well drained basic tills (grey brown podzolics and brown earths) Teagasc Code: BminDW. In the southeast of the study area, poorly drained tills comprised of surface and groundwater gleys are dominant, BminPD. Poorly drained land was observed at Ballyholan adjacent to the Bunree. Alluvial deposits, Teagasc Code: A, are associated with the River Moy and the Brusna (Glenree) River. Shallow well drained Glaciofluvial sands and gravels derived from limestone sands and gravels are present at the east of the study area, BminSW. Pockets of cutover peat (Teagasc Code: Cut) and rock exposure (Teagasc Code: RcKa) are present and the artificial surfaces of the urban centre of Ballina Town comprises 'Made Ground'. The distribution of soil types across the study area is shown in "Teagasc Soils Drawing" (Drawing MGW0290-RPS-EI-XX-D-EN-1102).

The soil types present within the study area and their importance in terms of drainage properties and fertility is set out in **Table 11-10**.

Table 11-10: Teagasc Soil Classifications within the Study Area

Teagasc Soil Code	Attribute	Location	Importance
Made Ground- Made	Artificial cover in Urban centre	Ballina Town & Environs	Low
Peat- Cut	Organic soil with a high moisture content	Pockets within the study area	Low
Bedrock at Surface-RckCa	Rock exposure where subsoil cover is thin or absent	Pockets within the study area	Low
Alluvium-A	Associated with the floodplains of the River Moy and the Brusna (Glenree) River	Adjacent to the River Moy and the Brusna (Glenree) River	Medium
Tills-BminDW	Deep well drained Limestone Tills	Widespread	High
Tills-BminPD	Poorly drained Limestone Tills	Southeast of the study Area	Low
Glaciofluvial Sands & Gravels - BminSW	Shallow well drained Glaciofluvial sands and gravels	East of the study Area	High

11.3.4.2 Subsoils

The dominant subsoil type is Till derived from limestones (GSI code: TLs). Made ground (GSI code: Urban) dominates Ballina Town Centre and suburbs. Alluvial deposits are associated with the River Moy and the Brusna River (Glenree) (GSI code: A). Pockets of Bedrock outcrop or subcrop (GSI code: RCk) and Cutover peat (GSI code: Cut) are present across the study area. At the east of the study area in the vicinity of Ardnaree and Ballylohan Gravels derived from limestones (GSI code: GLs) are present. The quaternary geology underlying the study area is shown in "Quaternary Geology Drawing" (Drawing MGW0290-RPS-EI-XX-D-EN-1103).

The descriptions of the subsoils below are derived from the previous SI listed above in **Table 11-9** and from the site-specific SI carried out for the Proposed Scheme.

Made ground comprises the urban centre of Ballina Town. The most recent SI data encountered made ground at depths of between 0.1 m to 2.8 m (average thickness of 1.3 m) in a number of boreholes drilled adjacent to the River Moy. The material generally comprises hardcore stone roadfill with wood, glass with occasional brick and plastic fragments in a gravelly clay matrix.

At the Mary Robinson Centre made ground was encountered to a depth of 0.8-1.4 mbgl described as brown/grey sandy clayey gravel with cobbles or as black/brown slightly gravelly clay with occasional cobbles with inclusions of brick and waste. At the Ballina Arts Centre, also adjacent to the River Moy, made ground comprising grey sandy fine to coarse gravel with occasional cobbles and pieces if concrete was encountered at depths between 0.5-1.9 mbgl overlying a thin band of alluvium.

Further south, the made ground was typically described as reworked sandy gravelly fill at Rehins Fort present to a depth of 0.1-2.0 m.

Previous SI describe the Alluvial deposits at Rehins Fort as typically soft silty or loose to medium dense sands and gravels extending to a maximum depth of 5.0 mbgl, encountered below the made ground.

Deposits of alluvium were also encountered below the made ground at the Ballina Arts Centre between 0.5-2.6 mbgl.

The preliminary SI for the proposed scheme encountered peat in a number of boreholes along Batchelors Walk (BH1, BH15, BH17, BH18, BH20A and BH22) at depths between 1.0-4.0 mbgl, with an average thickness of 0.9 m. The material is generally described as soft dark brown peat or grey silty peat. The peat was encountered underlying the cohesive glacial till described above. Previous SI encountered Peat at the Mary Robinson Centre at depths of between 2.2-3.4 mbgl and was described as very soft black silty peat. Peat is also mapped as underlying the urban deposits along the Tullyegan Stream between Station Rd and the Railway line.

Cohesive Glacial Till and Granular Limestone Till are the dominant overburden materials and are found below the peat or alluvial deposits. The cohesive material comprises soft grey or brown silt/clay or sandy gravelly silty clay with occasional cobbles. The granular material underlies the cohesive material and comprises silty clayey gravel, angular sandy gravel with cobbles or silty sandy gravel with cobbles.

The subsoil types present within the study area is set out in **Table 11-11**. Their importance in terms of potential for presence of soft soils and potential for contamination is addressed in **Section 11.3.6** and **Section 11.3.9**.

Table 11-11: Subsoil Types within the Study Area

Soil Type	Attribute	Location
Made Ground (Urban)	Artificial cover in Urban centre	Ballina Town & Environs
Limestone Till (TLs)	Till derived from Limestone	Widespread
Alluvium (A)	Associated with the floodplains of the River Moy and the Brusna (Glenree) River.	Adjacent to the River Moy and the Brusna (Glenree) River.
Bedrock (Rck)	Limestone Bedrock outcrop or subcrop	Pockets within the Study Area
Peat	Organic soil with a high moisture content	Pockets within the Study Area
Gravels (GLs)	Gravels derived from Limestone	East of the Study Area

11.3.5 Bedrock Geology

The underlying bedrock comprises Carboniferous Limestone form the Dinantian series and the study area is underlain by dark grey calcareous limestones and shales of the Ballina Limestone Formation (BU). The Ballina Limestone Formation is divided into the Ballina Limestone Upper and Lower Formations with the study area principally underlain by the pure Ballina Limestone Formation (upper) (BU) and the northeastern portion of the study area underlain by the Impure Ballina Limestone Formation (Lower) (BL). Each of the areas of proposed works are underlain by Ballina Limestone Upper Formation (upper) (BU).

Bedrock outcrops are mapped at the east of the study area in the vicinity of Ballyholan, Shanaghy and Rathkip, Rehins Fort, Quignamanger and along the River Moy.

A review of previous SI carried out in the study area describes bedrock adjacent to the River Moy as strong dark to medium grey thinly laminated fossiliferous Limestone. The preliminary SI carried out specifically for the proposed scheme did not prove bedrock.

There is a north-south trending fault mapped along the River Moy with a number of northwest-southeast trending anticlinal axes mapped beyond the northeastern extents of the study area within the Ballina Limestone Formation (Lower) (BL).

In general, across the study area, depth to bedrock is likely to be between 5.0-10.0 m below the surface with depth to bedrock likely to be >10 m at the southeast of the study area. There are small areas where depth to bedrock is <1 m or 1-3 mbgl particularly along the River Moy and at the east of the study area in the vicinity of Ballyholan. Depth to bedrock is discussed in more detail in **Section 11.3.13**, below.

The importance of the Ballina Limestone Formation in terms of economic importance is considered further under **Section 11.3.7**.

The bedrock geology underlying the study area is shown in “Bedrock Geology Drawing” (Drawing MGW0290-RPS-EI-XX-D-EN-1104).

11.3.6 Soft and/or Unstable Ground

Soft and/or unstable deposits within the study area consist of cutover peat, alluvium, and soft cohesive materials. Soft deposits were identified within the study area from a from a desktop assessment of the Quaternary Geology and a review of the available ground investigation reports and logs from the area. As described in **Section 11.3.4.2,** Alluvial deposits are predominantly associated with the banks of the River Moy and the Brusna River (Glenree). Alluvial deposits at the River Moy are described as very soft grey/brown silt/clay with occasional gravel. Pockets of Cutover peat (GSI code: cut) are present across the study area (found underlying the Alluvial deposits) and is described as very soft to soft dark brown peat The volume of peat and / or soft organic soil underlying the proposed development is thought to be small on a local scale, therefore this attribute is of Low Importance.

Based on review of the GSI's Landslide Susceptibility mapping, the study area is rated as having 'Low' landslide susceptibility. There are no records of landslides held by the GSI within the study area. Landslide potential is therefore low to minimal.

The soft subsoil types present within the study area and their importance in terms of possible soft soils is set out in **Table 11-12**.

Table 11-12: Soft Soil Types within the Study Area

Soil Type	Attribute	Location	Importance
Alluvium (A)	Associated with the floodplains of the River Moy and the Brusna (Glenree) River.	Adjacent to the River Moy and the Brusna (Glenree) River.	Medium
Peat	Organic soil with a high moisture content	Pockets within the Study Area	Medium

11.3.7 Mineral/Aggregate Resources

Based on review of the GSI Spatial viewer, there are two non-metallic mineral locality within the study area and a number of historic pits and quarries, many of which are located within the western urban area of Ballina Town. There are no metallic mineral localities identified on the GSI Spatial viewer within the study area.

Table 11-13 presents a summary of the mineral localities and historic gravel pits and quarries relevant to the works areas:

Table 11-13: Mineral Localities & Historic Pits & Quarries

GSI Ref	Status	Location	Description
2444	Mineral locality	Ballina Town- close to the junction of Telling St and McDermott St.	Historic Clay Brickfield
1216	Mineral locality	Behybeg-150m south of the River Brusna	Sand & Gravel (Esker deposit)
-	Historic Pit	On the River Moy- between Moy Heights and The Glebe.	Large Mid-Late 19th Century gravel pit
-	Historic Pit	Behy Road-adjacent to the Bunree River	Gravel Pit
-	Historic Quarry	Behy Road-adjacent to the Bunree River	Quarry
-	Historic Quarry	Ballina-between Convent Hill Crescent and Kilala Road	A late 19th Century to Mid-20th Century mica brick field
-	Historic Quarry	Kilala Road adjacent to the present day Libadore housing estate	Limestone Quarry
-	Historic Pit	Shanaghy- adjacent to the Glenree (Brusna) River	Early to Mid-20th Century pit

Across the study area in general, Crushed rock aggregate potential mapping shows the crushed rock potential ranges from ‘moderate’ to predominantly ‘high’ to ‘very high’.

Crushed rock Aggregate potential is rated as ‘Very high’ at the following locations due to a combination of shallow depth to bedrock in places along the river and the quality of the material as is evident by historical quarrying that took place in these areas:

- In the vicinity of the River Moy due to a combination of the shallow depth to bedrock in places along the river and the quality of the material.
- Along the Bunree River in the vicinity of Ballyholan where there is outcropping rock or subcrops.
- Along the Quignamanger Stream where it joins the River Moy.
- Along the Glenree River in the vicinity of Rathkip/Shanaghy.
- Outside of these pockets of ‘very high’ aggregate potential the works area are located in areas rated as ‘high’ in terms of crushed rock aggregate potential.
- Granular aggregate potential, relevant only to the alluvial areas identified along the floodplains and where there are gravel deposits, is classified by the GSI as low along the alluvial plains of the River Moy and ‘high’ and ‘very high’ where there are fluvioglacial deposits present at the east of the study area at Ardnaree and Ballylohan.

Relevant to the areas of works, there is an area rated as ‘moderate’ along the Brusna River at Rathkip and Shanaghy.

The crushed rock aggregate potential and the locations of historic pits and quarries and mineral localities are included in the “Minerals/Aggregate Resources Drawing” (Drawing MGW0290-RPS-EI-XX-D-EN-1105).

The GSI Aggregate potential rating within the study area and its relative importance in terms of its economic importance is set out in **Table 11-14**.

Table 11-14: GSI Aggregate Potential along the Areas of Works

GSI Aggregate Potential	Potential	Location	Importance
Crush Rock Aggregate Potential	High-Very High	River Moy	High
	High-Very High	Bunree River	High
	High	Brusna (Glenree) River	Medium
	Very High	Quignamanger Stream	High
	High	Tullyegan Stream	Medium
Granular Aggregate Potential	Low	River Moy	Low
	Moderate	Brusna (Glenree) River	Moderate

11.3.8 Geological Heritage Areas

There is one geological heritage area (GHA) identified within the study area: The River Moy is a designated County Geological Site under the Irish Geological Heritage (IGH) Programme theme of IGH14 Fluvial and Lacustrine Geomorphology due to its significance as one of the best example of a U-shaped river channel meandering in the country (Mayo -County Geological Site Report, GSI, 2019- https://gsi.geodata.gov.ie/downloads/Geoheritage/Reports/MO089_River_Moy.pdf).

In accordance with TII Guidelines, Geological heritage areas are considered to be attributes of High importance.

The location of this Geological Heritage Area is included in the “Geological Heritage Drawing” (Drawing MGW0290-RPS-EI-XX-D-EN-1106).

11.3.9 Contaminated Land

Various sources of information including historic mapping, aerial photography, the scheme walkover, Teagasc soil mapping, CORINE landcover mapping, EPA datasets and the SI information specific to proposed scheme were reviewed to assess the potential for contaminated land within the study area.

OSi historic 25-inch mapping dating back to 1888-1913 indicates that an extension of the Ballina railway line extended through Ballina and branched north westwards towards Killala. However, more recent aerial photographs and mapping show that the old railway network has since been removed and replaced by residential developments and the R314 to Killala.

Historical industries present in the past along the River Moy included a gas works and sawmill at Barrett Street, a cornmill at Lower Bridge, Ridgepool and an Engine house and oil tanks at Station Road associated with the Railway line. The present-day graveyard at the rear of St. Michael's Church at Plunkett Road dates back to 1829-1841 as is evident from historic OSi 6 inch mapping.

The Ballina Flax Mill was present on historic 6 Inch (1829-1841) at Behy Rd adjacent to the Bunree River but was not present on the OSi historic 25-inch mapping dating between 1888-1913.

Similarly, the Bunree soap works and Flax Mill at Bunree south of the Brusna (Glenree) River are noted on the 6 Inch mapping but had ceased to exist by the time the 25-inch mapping was carried out (1888-1913).

Apart from the expansion of housing and commercial developments into the surrounding greenspace, no substantial industrial developments have taken place within the study area and there is no indication of the existence of historical or currently active landfill sites.

There are no licenced waste facilities within the study area. The closest licenced waste facility is Rathroeen Landfill located to the north of the study area. **Table 16-7** in **Chapter 16: Material Assets (Waste and Utilities)** details licenced waste facilities in County Mayo. There are no legacy landfills recorded within the study area. There are three EPA licenced facilities within the study area, Thomas Archer (Ballina) Limited located 500m to the east of the River Moy on Bunree Road, Henniges Elastomers Ireland GmbH located 1.5km to the west of the River Moy on Crossmolina Road and Hollister ULC located 250m to the west of the River Moy on the Foxford Road. All three facilities are Integrated Pollution Control Industry (IPC) licence facilities with Thomas Archer (Ballina) Limited and Henniges Elastomers Ireland GmbH also licenced as Industrial Emissions (IED) facilities. There is a waste metal scrap yard associated with Steeltech Sheds Mayo and Timber yard (Wests Timber) located at Behy Road adjacent to the Bunree. Shamrock Metal recycling is located at Creggs Road adjacent to the Quignamanger. There are no historic landfills registered with the EPA within the study area. From a review of previous SI, no evidence of contaminated land was noted.

Section 11.3.7 details a number of historical non-metallic mineral localities within the study area.

Apart from the presence of made ground which comprises hardcore stone roadfill and the potential to contain waste components, there is no evidence of contaminated land within the study area. The potential to encounter contaminated land is low to minimal and is limited to historical fuel spills associated with the land use as a railway and to the presence of made ground comprising the residential and commercially developed centre of Ballina Town and floodplain of the River Moy. The degree or extent of soil contamination is moderate on a local scale; therefore, this attribute is of medium importance.

The subsoil types present within the study area and their importance in terms of the degree or extent of potential soil and/or subsoil contamination is set out in **Table 11-11**.

Table 11-15: Contamination Potential within Subsoil Types in the Study Area

Soil Type	Attribute	Location	Importance
Made Ground (Urban)	Artificial cover in Urban centre	Ballina Town & Environs	High
Limestone Till (TLs)	Till derived from Limestone	Widespread	Low
Alluvium (A)	Developed area associated with the floodplains of the River Moy and the Brusna (Glenree) River.	Adjacent to the River Moy and the Brusna (Glenree) River.	Medium
Bedrock (Rck)	Limestone Bedrock outcrop or subcrop	Pockets within the Study Area	Low

Soil Type	Attribute	Location	Importance
Peat	Organic soil with a high moisture content	Pockets within the Study Area	Low
Gravels (GLs)	Gravels derived from Limestone	East of the Study Area	Low

A summary of potential sources of contamination adjacent to the proposed areas of works within the study area and the importance locally is presented in **Table 11-5**.

Table 11-16: Summary of Potential Sources of Contamination Adjacent to the Proposed Scheme

Feature	Source	Location	Importance
Ballina Rail line	Historic 6 Inch Mapping	Ballina Town	Medium
Sawmill	Historic 25 Inch Mapping	Barrett St	Medium
Gasworks	Historic 6 Inch Mapping	Barrett St	Medium
Cornmill	Historic 6 Inch Mapping	Lower Bridge, Ridgepool	Medium
Engine House	Historic 6 Inch Mapping	Station Road	Medium
Oil tanks	Historic 6 Inch Mapping	Station Road	Medium
Engine House Tank	Historic 25 Inch Mapping	Rehins Fort	Medium
Ballina Flax Mill	Historic 6 Inch Mapping	Behy Road	Medium
Soap Works	Historic 6 Inch Mapping	Bunree	Medium
Flax Mill	Historic 6 Inch Mapping	Bunree	Medium
Bunree Cornmill	Historic 25 Inch Mapping	Bunree	Medium
Smithy	Historic 6 Inch Mapping	Kilala Road	Medium
St. Michaels Graveyard	Historic 6 Inch Mapping	Plunkett Road	Medium
Leigue Cemetery	Historic 6 Inch Mapping	Kilala Road	Medium
Gravel Pits	Historic 6 Inch Mapping Historic 25 Inch Mapping Historic 25 Inch Mapping	River Moy Behy Road	Medium
Historic Quarry	Historic 25 Inch Mapping Historic 25 Inch Mapping Historic 6 Inch Mapping	Behy Road Convent Hill Crescent	Medium
Waste Metal yard	Noted during Site Walkover	Steeltech Sheds Mayo	Medium
Fuel Depot		Ridgepool	Medium
Service Station		Top Oil, Behy Road	Medium
Timber yard		West Timber Depot, Behy Road	Medium
Metal yard		Shamrock Metal recycling, Creggs Road	Medium
Service Station		Casey's Circle K, Circular Road	Medium

11.3.10 Regional Hydrogeology

The study area lies within the Moy and Killala Bay WFD Catchment and is principally underlain by the Ballina Groundwater Body (GWB). The Ballina GWB is a productive karstic GWB composed of the Dinantian Pure Bedded Limestones with karstified cavities at depth. At the northeast of the study area the less productive Impure Limestones form the Foxford GWB. The Ballina Gravel GWB overlies the contact between the Ballina Karstic GWB and the Foxford GWB.

Although groundwater flow through karst areas is complex and unpredictable, groundwater flow within the study area is expected to be reflective of topography and flow towards the River Moy.

The aquifers in the productive Ballina GWB supply number of high yielding wells such as Knocbaun, Cullens, Corry (Ballina GWB Description, GSI. 2004). Flow paths can be up to several kilometres in length with flow velocities rapid and variable and occurring within large conduit systems. Groundwater discharges locally to small springs, streams and rivers. However, owing to the poor productivity of these aquifers baseflow proportion of total streamflow is considered to be small. The poorly productive Foxford GWB is present at the northern boundary of the Ballina GWB. This aquifer provides little groundwater for water supply. Flow paths are likely to up to 150 m with shallow groundwater flow dominating.

11.3.11 Aquifer Classification

The vast majority of the bedrock geology in the study area is classified by the GSI as a Regionally Important Karstic Aquifer (Rk) represented by the Pure Bedded Limestone of the Upper Ballina Limestone Formation. This aquifer is dominated by both diffuse and conduit flow. The pure bedded limestones are highly transmissive and groundwater flow occurs through fissure, faults joints and bedding planes, many of which are enlarged by karstification. Regionally Important (R) aquifers should have (or be capable of having) a large number of 'excellent' yields: in excess of approximately 400 m^3/d. The aquifer is primarily composed of bedrock with transmissivity ranging from 1 m^2/d to 200 m^2/d. Yields in this aquifer are generally variable.

A small portion of the bedrock geology towards the northeast of the study area comprises the Impure Limestones of the Lower Ballina Limestone Formation which is classified as a Locally Important Aquifer (LI) - bedrock which is moderately productive only in local zones. Groundwater flow in these aquifers is typically concentrated in upper fractured and weathered zones and in the vicinity of fault zones (GSI, 2004). The aquifer is primarily composed of low transmissivity bedrock. Yields in this aquifer are generally low.

Overlying the limestone bedrock aquifers at the northeast of the study area there is a deposit of Gravels called the Ballina Gravels which is classified as Lg- Locally Important gravel aquifer. A Lg Aquifer is classed as a sand and gravel deposit with a continuous area of 1-10 km^2 with consistent permeability. Groundwater gradients are typically low with a strong interaction between surface water and groundwater. This aquifer is present in the vicinity of Quignalegan and extends in a north easterly direction as far as Carha, beyond the extents of the study area.

The aquifer types present within the study area are presented in Drawing MGW0290-RPS-EI-XX-D-EN-1107 and their importance in terms of a resource out is set in **Table 11-7**.

Table 11-17: Aquifer Types within the Study Area

Aquifer Type	Description	Location	Importance
Regionally Important Karstic Aquifer (Rk)	Bedrock aquifer capable of supplying important abstractions or 'excellent yields'	Majority of the study area	High
Locally Important Aquifer (LI)	Bedrock which is moderately productive only in local zones	Northeast of the study area	Medium
Locally Important Sand & Gravel Aquifer (Lg)	A sand and gravel deposit with a continuous area of 1-10km^2 with consistent permeability	Northeast of the study area	Medium

11.3.12 Karst

The Ballina GWB is described as karstified due to presence of cavities at depth. Karstification means that there is a high degree of interconnection between groundwater and surface water and the Ballina GWB Description (GSI, 2004) describes groundwater flux as '*likely to be in the upper part of the aquifer, although cavities are recorded at 64 m below ground and between 27-41 m below ground in two boreholes in the southwestern part of the GWB'*.

Despite the presence of cavities at depth there are no mapped karst features in the study area; no karst features were noted during the site walkover and the SI did not encounter any evidence of karstification.

Given that the volume of and depth of removal of bedrock will be minimal, the risk of encountering of karst is low to minimal.

11.3.13 Groundwater Vulnerability

The GSI have developed a system to classify aquifer vulnerability based on the thickness and permeability of the overburden. The greater the thickness and permeability, the greater the protection to the groundwater in the underlying aquifer. The study area is predominantly classified as having a predominantly High Groundwater Vulnerability rating indicating a depth to bedrock of 5-10 m underlying moderate permeability subsoil. Vulnerability is classified as Moderate in the southeast of the study area in the vicinity of the gravels at Ardnaree. Areas of Extreme Vulnerability (E) and Extreme Vulnerability (X) are present at Ridgepool and Emmet St along the River Moy. In addition, there are areas of Extreme Vulnerability (E) in close proximity to the proposed works at Behy Road along the Bunree River and the proposed works at Rathkip and Shanaghy along the Brusna (Glenree River) at the east of the study area.

Adjacent to the River Moy on the western bank, bedrock was encountered in various boreholes at depths between 1.1- 4.6 mbgl (at the Mary Robinson Centre, Ballina Arts Centre and Ridgepool) indicating an Extreme to High Vulnerability rating. Groundwater strikes were recorded at depths of 3.0 - 3.1 mbgl.

To the west of the River Moy in the vicinity of Pearse St bedrock was not encountered in boreholes drilled to depths between 2.6-3.7 mbgl indicating a depth to bedrock >3 m and at least a High Vulnerability rating moving away from the River Moy.

Further south, adjacent to the Tullyegan Stream at Rehins Fort possible bedrock was encountered at a depths of 1.5 m and 1.8 m in trial pits indicating a vulnerability rating of <3 m - Extreme Vulnerability. Groundwater was encountered in percussion boreholes at 2.6 - 4.0 m within the glacial till.

The aquifer vulnerability classification of the study area is presented in the “Aquifer Vulnerability Drawing” (Drawing MGW0290-RPS-EI-XX-D-EN-1108).

11.3.14 Groundwater Recharge

The GSI Groundwater recharge mapping across the study area indicates generally high recharge rates (~477 mm/year). The ability of the bedrock to accept recharge is based generally on the permeability of the overlying subsoil and the thickness of the fissured/fractured zone of bedrock likely extending 3.0–5.0 m below the bedrock surface. Recharge rates are highest (603 mm/year) where the bedrock is overlain by well-drained soil overlying the permeable fluvioglacial gravels at the east of the study area.

Recharge rates are lower (200 mm/year) for the Locally Important Aquifer at the northeast of the study area. The GSI recharge data indicates that the recharge is capped for these bedrock aquifers due to the fact they have low transmissivity and storage.

Recharge is restricted further where there are paved surfaces (made ground) in the urban area of Ballina Town Centre and environs and where there is low vulnerability peat, restricting diffuse rainfall from reaching the underlying aquifer.

11.3.15 Groundwater Quality and Levels

Based on previous ground investigation in the area, groundwater levels are generally within 3 m of the surface and are closer to the surface near the rivers and streams. The preliminary SI encountered groundwater at depths between 0.8-2.5 mbgl, adjacent to the River Moy.

There are no publicly available historical groundwater level or groundwater quality data to review from the study area. The closest active EPA Groundwater Level monitoring station is located outside of the study area and in a different GWB at Killala. The closest available groundwater chemistry data are from Kilaser, Co. Mayo, to the south of the study area within the Swinford GWB.

11.3.16 WFD Groundwater Quality Status

The Water Framework Directive (WFD) establishes a legal framework for the protection and management of water resources in the EU. It requires each member state to implement changes to the management of water bodies taking account of all aspects of the water cycle. Under the WFD, the Groundwater Bodies (GWBs) of the study area that need to be protected are:

- Ballina GWB
- Foxford GWB
- Ballina Gravels Group 1

The WFD Quality Status for each GWB is presented in Drawing MGW0290-RPS-EI-XX-D-EN-1109. The WFD Quality Status and Risk Status for each GWB are summarised in **Table 11-18**. The water quality status is Good for all GWBs.

Table 11-18: Groundwater Body Risk & Quality Status

GWB	Element	Rating for GWB (WFD Status 2013-2018)	Objectives	Measures to Achieve Objectives
Ballina	Water Quality Status	Good	• Restore_2021 • Prevent Deterioration • Restore Good Status • Reduce Chemical Pollution • Achieve Protected Areas Objectives	***Basic Measures*** • The Bathing Water Directive (2006/7/EC) • The Habitats Directive (92/43/EEC) • The Drinking Water Directive (98/83/EC) • The Major Accidents (Seveso) Directive (96/82/EC) • The Environmental Impact Assessment Directive (85/337/EEC) • The Sewage Sludge Directive (86/278/EEC) • The Urban Waste Water Treatment Directive (91/271/EEC) The Plant Protection Products Directive (91/414/EEC) • The Nitrates Directive (91/676/EEC) • The Integrated Pollution Prevention Control Directive (96/61/EEC) ***Specific Measures*** • Cost recovery for water use • Promotion of efficient and sustainable water use • Protection of drinking water sources • Control of abstraction and impoundments • Control of point source discharges • Control of diffuse source discharges • Authorisation of discharges to groundwater • Controls on other activities impacting on water status • Prevention or reduction of the impact of accidental pollution incidents
	Risk Category	Not at Risk		
Foxford	Water Quality Status	Good		
	Risk Category	Not at risk		
Ballina Gravels Group 1	Water Quality Status	Good		
	Risk Category	Not at Risk		

11.3.17 Groundwater Flooding

According to the GSI's Groundwater Flooding Viewer there are no mapped flood extents of groundwater flooding within the study area. There are however areas of historic groundwater flooding noted at the west of the Study Area in the vicinity of Coolcran and Farrandeelion, outside the footprint of the Proposed Scheme.

11.3.18 Groundwater Abstractions

11.3.18.1 Public Supply Wells

Within the study area no public water supply schemes have been identified that rely on groundwater. The study area is supplied by Ballina Regional Water Supply Scheme (RWSS) which abstracts water from Lough Conn from an intake at Wherrew. There are no source protection areas associated with groundwater abstraction schemes.

11.3.18.2 Domestic Wells

Low yielding wells for domestic and farm water supply are relatively common in rural Ireland. Data on wells in the study area was collected from the GSI Groundwater Data Viewer.

The location of these wells are illustrated on the “Groundwater Wells and Springs Drawing” (Drawing MGW0290-RPS-EI-XX-D-EN-1110). These wells are not located within the near vicinity of the proposed work areas; therefore, no impact is envisaged as a result of the proposed works. It is possible that there are unmapped private wells associated with farms or private properties within the study area. Domestic Wells are considered to be attributes of low hydrogeological importance on a local scale.

The recorded GSI wells in the study area are shown in **Table 11-19**.

Table 11-19: GSI Groundwater Well Data

No.	GSI Name	Well Type	Depth (m)	Townland	Source Use	Yield Class	Yield (m3/day)
1	1131SWW004	Borehole	37.2	Ballina	Industrial	Excellent	1308
2	1131NWW020[1]	Borehole	35.1	Ardoughan	-	Poor	33
3	2039SWW003[1]	Borehole	14	Farrannoo	Agri & domestic use	Good	109

[1]Exact location unknown mapped with a locational accuracy of 1km

11.3.19 Groundwater Dependant Ecosystems (GWDTE)

Designated sites identified for the land, soils, geology and hydrogeology chapter are described in **Table 11-20**. Note that this table only includes the strictly water groundwater dependent habitats relevant to land, soils, geology and hydrogeology chapter. Water dependent habitats and species that are relevant to Qualifying Interests of European sites and fishes of salmonid waters are covered in **Chapter 9: Aquatic Biodiversity**. Mammals (otter, harbour seal) and terrestrial or riparian based habitats (e.g. alluvial vegetation habitats) are covered in **Chapter 10: Terrestrial Ecology**.

Table 11-20: Designated Sites and Relevant Qualifying Interests for the Land, Soils, Geology and Hydrogeology Chapter

Designated Site	Closest Distance to Works Area (km)	Relevant Qualifying Interest
Killala Bay/Moy SAC	0	• Humid dune slacks [2190] Sea Lamprey *Petromyzon marinus*
River Moy SAC	0	• Alkaline fens [7230] • Alluvial forests [91E0] • Active raised bogs [7110]

The Killala Bay/Moy Estuary SAC lies within the study area. This SAC supports humid dune slacks [2190] which are an EU Annex I Groundwater Dependent Terrestrial Ecosystem (GWDTE) under the WFD [7140]. GWDTE are habitats/species that are dependent on groundwater to maintain the environmental supporting conditions required to sustain that habitat or species.

The River Moy SAC lies within the study area. This SAC supports alkaline fens [7230] and alluvial forests [91E0] which are EU Annex I Groundwater Dependent Terrestrial Ecosystems (GWDTE) under the WFD [7140].

GWDTE were assessed by the EPA under the Framework for the Assessment of Groundwater-Dependent Terrestrial Ecosystems under the WFD (EPA, 2008). GWDTE were classified based on water supply mechanisms and geo-hydrogeological setting.

Humid dune slacks are typically direct discharges associated with sandy soils underlain by a low permeability layer (Strive Report, 2011). They represent zones where there is diffuse seepage within a fluctuating basin. Their water supply mechanism as characterised by the EPA under the above-mentioned Framework displays a dynamic variability in groundwater level requiring a high groundwater contribution.

Alkaline fens are dominated by rushes at diffuse seepages. Alkaline fens were characterised as having a constant-moderate variability in groundwater level requiring a high groundwater contribution.

Alluvial forests are dominant at seepages typically associated with poorly drained silty alluvial deposits associated with rivers and lakes (Strive Report, 2011). Their water supply mechanism is characterised as having a dynamic variability in groundwater level requiring a low-moderate groundwater contribution.

Active raised bogs comprise of peat in varying stages of decomposition and compaction, they are mainly fed by recharge with a minor shallow and deep groundwater contribution. Groundwater hydrostatic pressures can be essential for maintaining the topography and high-water table in the high bog of Irish raised bogs (Strive Report, 2011).

Annex I ecosystems have a High importance rating. Although the Proposed Scheme and the SACs are both located within the Ballina GWB, a review of GeoHive Environmental Sensitivity Mapping identified no Annex I GWDTE i.e. dune slacks, alkaline fens, alluvial forests or active raised bogs associated with the Killala Bay/Moy SAC or River Moy SAC in the vicinity of the proposed works.

As part of the ecological survey carried out, tufa formations were identified in the open reach of the Quignamanger Stream at the junction of Quay Road and Creggs Road. Tufa are the deposits that form where calcareous water deposit tufa (a porous rock of calcium carbonate). Tufa cascades are commensurate with the priority Annex I habitat *Petrifying Springs* [7220]. Petrifying springs represent groundwater discharge zones and the Tufa cascades at Quay Road are spring fed. Their water supply mechanism is characterised as having a constant-moderate variability in groundwater level requiring a high groundwater contribution. **Section 9.4.4.2** of **Chapter 9: Aquatic Biodiversity** characterises the deposition of the tufa cascades as constant and seasonal.

Water sampling, as set out in **Section 9.2.3.1.2** of **Chapter 9: Aquatic Biodiversity**, was carried upstream and downstream of the tufa habitat in the open section near the Quay Road displayed no notable difference between upstream and downstream quality physio-chemical parameters, indicating that the tufa formation is likely fed from a spring source further upstream in the catchment (most likely from those that form the source of the stream in the townland of Quignashee). This is supported by the expected direction of groundwater flow from the southeast to the northwest towards the River Moy. The Ballina GWB is unconfined with a high level of interaction between the groundwater and the water in the stream which would support tufa formation from a calcareous aquifer, especially at the area of interest where groundwater is likely to be close to the surface at the approach to the River Moy.

11.3.20 Conceptual Site Model (CSM)

11.3.20.1 Source Characterisation

The principal sources of potential groundwater risk/impact within the study area are both diffuse and point sources:

- Diffuse sources will come from direct rainfall recharge percolating through the more permeable subsoil (granular till, described in **Section 11.3.4**) and rock at or close to surface along Behy Road and at Rathkip. The aquifer recharge rate within the made ground is restricted to 20% of the effective rainfall (710 mm/yr) i.e. 142 mm/yr. The recharge rate increases to 60% within the well-drained tills i.e. 425 mm/year and to 85% within the high permeability granular till where it is overlain by well-drained soil i.e. 60 mm/yr.

Although there are no mapped karst features it is thought that point recharge will occur through many small sinks that are present in the low permeability till areas, where the subsoil is breached or through unmapped karst features (GSI, 2004).

11.3.20.2 Pathway Analysis

- Lateral groundwater flow:
  - The karstic aquifer of the Ballina GWB allows for rapid transport of contaminants between surface and groundwater in the many fissure, faults and bedding planes enlarged by karstification in the upper part of the aquifer.
- Vertical groundwater flow:
  - Bedrock outcrops or subcrops within the limestones, will allow for diffuse recharge and runoff containing potential contaminants to percolate downwards to the aquifer.
  - The drumlin ridges comprise glacial sand and gravel deposits and will provide a permeable pathway for recharge.
- Surface water pathways:
  - Ingress and flow along surface water channels – there is a high degree of groundwater-surface water interaction.

11.3.20.3 Receptors

The main environmental receptors are summarised in **Table 11-21**.

Table 11-21: Environmental Receptors

Receptor	Key Receptor Attributes	Distance from the Proposed Scheme	Receptor Importance
River Moy CGS	Geological feature of high value on a local scale (County Geological Site). The attribute has a high quality, significance or value on a local scale.	Within the Proposed Scheme.	High
Soil	Predominantly deep well drained Limestone Tills. The attribute has a high quality, significance or value on a local scale.	Underlying the Proposed Scheme	High
Killala Bay/Moy Estuary SAC and River Moy SAC	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation. The attribute has a high quality or value on an international scale.	Within the Proposed Scheme	Extremely High *(see note)*
GWDTE	Tufa formation commensurate with Annex I Petrifying Springs. The attribute has a high quality or value on a national scale.	Within the Proposed Scheme	Very High
Bedrock Aquifers	Predominantly Regionally Important Karstic Aquifer (Rk). The attribute has a high quality or value on a local scale.	Underlying the Proposed Scheme	High
Surface Water Bodies	Groundwater will discharge to the numerous springs and as baseflow to the Rivers Glenree, Bunree, Quignamanger and Tullyegan and streams crossing the study area.	Within the Proposed Scheme	High
Industrial & Private Well users	Wells drilled for domestic, agricultural or Industrial purposes. This attribute has a low quality or value on a local scale.	Within the study area	Low

Note: *The potential impacts to the Killala Bay/Moy Estuary SAC and River Moy SAC during the construction and operational phases have been considered in **Chapter 9: Aquatic Biodiversity** and **Chapter 10: Terrestrial Biodiversity***

11.3.21 Evolution of the Environment in the Absence of the Proposed Scheme

In the event that the Proposed Scheme is not constructed, there would be no resulting impacts on the land, soils, geology, or hydrogeology along the Proposed Scheme. However, in the absence of the Proposed Scheme flooding will continue to increase and possibly worsen over time resulting in localised and small scale cumulative negative impacts on the land, soils and groundwater environment within the study area. This increased flooding can result in increased soil erosion and loss of land for development.

11.4 Description of Likely Significant Effects

11.4.1 Characteristics of the Proposed Scheme Likely to Result in Significant Effects on the Geological and Hydrogeological Environment

The project description including the details of the activities required to construct the Proposed Scheme are provide in **Chapter 5: Project Description**. The key civil engineering works for the Proposed Scheme which will have potential for impact on the land, soils, geology and hydrogeology receiving environment during construction are summarised below:

- The undertaking of earthworks for embankments, culvert and foundation construction including the stockpiling of material and further processing and haulage
- The use of concrete, fuel, oils or chemicals
- Undertaking dewatering activities for instream works

The Proposed Development has the potential to impact on the geological and hydrogeological environments through these operational stage activities:

- Maintenance activities - (accidental spillages and leaks)
- Embankment monitoring
- Culvert inspections

The potential impacts on the geological and hydrogeological environment, as they relate to the above proposed activities, are outlined in the subsequent sub-sections - **Section 11.4.2** and **Section 11.4.3.**

11.4.2 Construction Phase

11.4.2.1 Importation of Construction Materials

It is expected that more than 23,830 m^3 of soil and stone material will arise as a result of the Proposed Scheme and while there will be some opportunities for reuse on site as, for example as trench backfill and reuse off site (subject to testing), it is anticipated that the Proposed Scheme will require the importation of 1,205 m^3 of clay fill, and 1,500 m^2 of geotextile mat. It is anticipated that topsoil will be stored for reuse with minimal quantities imported. The importation of material or by-products will be undertaken meaning the excavation of soil reserves from other construction sites and/or quarries.

This activity has an indirect, temporary negligible effect of **imperceptible significance** on the geological environment during the construction phase (TII, 2009).

11.4.2.2 Embankment Settlement

The proposed works include the construction of new embankments with an average height of 1.1m (max. height 1.8 m) as flood defences along the River Brusna at Rathkip and Shanaghy. In addition, an embankment will be installed along the Tullyegan Stream to tie in with the Iarnród Éireann/Irish Rail embankment.

Potential impacts with regard to embankment settlement includes settlement of the altered ground profile and slope instability during excavation and construction of the earth embankments. These elements have been considered in the geotechnical design of the Proposed Scheme; therefore, It is expected that settlement will be minor and complete within the construction period.

Embankment settlement is considered to be a direct, temporary small adverse effect of **moderate/slight significance** (TII, 2009).

11.4.2.3 Infiltration of Surface Runoff

Silt-laden water can arise from exposed ground and soil stockpiles during construction. Surface water runoff containing large amounts of silt could migrate into the groundwater which can cause significant pollution of water through the generation of suspended solids.

Where topsoil and other soils are to be stored on site, stockpiles with significant side slopes can create a source of sediment laden runoff. Once the slopes are built up, rainfall landing on the slope and runoff from the top of the stockpile travel uncontrolled down the slope – potentially at high velocities – causing suspension of soil particles from the surface of the slope. Another source of runoff can arise from exposed earthwork surfaces during the excavation of overburden for foundation construction. Over compaction of soil and subsoil due to vehicles and plant tracking over areas of topsoil and subsoil to access the works causing strain to the existing subsoil structure, leading to a reduction in soil integrity and less resilience to erosion.

Short-term effects on groundwater quality can occur through the infiltration of surface runoff within or adjacent to construction areas. The impact is predicted to be localised to the footprint of the Proposed Scheme and construction compounds. Where subsoil is present at a sufficient depth, the natural subsoil will provide adequate attenuation and filtration. The infiltration of surface water runoff is considered to be an indirect, small adverse effect of **moderate/slight significance** on the groundwater environment (TII, 2009).

Impacts of the proposed works on surface water quality are assessed in **Chapter 12: Water**.

11.4.2.4 Overburden Excavation (Loss of Soil Reserve)

Topsoil, subsoil removal and possibility bedrock where it is close to the surface is an unavoidable consequence of the construction works. The removal of topsoil and subsoils during excavation works is a direct and permanent impact.

The flood wall construction will include excavation of cut off trench and foundation to a depth of 2mbgl. The embankment construction work will include topsoil stripping and excavation for the clay core to a suitable stratum depth, typically 3 mbgl. The construction of replacement culverts, pumps stations and associated pipework will be required to be excavated to invert level and backfilled accordingly. Excavation requirements for the implementation of the Proposed Scheme are summarised in **Table 16-11** of **Chapter 16: Material Assets: Waste and Utilities**

The removal of soil will result in the irreversible loss of a minor proportion of local high fertility soils (Limestone Till) along the Bunree/Behy Stream and River Brusna and/or a minor proportion of local low fertility soils (made ground) along the River Moy. The construction of proposed embankments, flood walls, pump stations and associated surface drainage and replacement of culverts will generate approximately 23, 830m³ of subsoil (soil and stone material). It is estimated that 3,000 m³ of material will be reused on site for primarily pipe trench backfill material therefore a total of 20,830m³ of excavation waste is proposed to be disposed.

The attributed importance of soils within the made ground is low and high within the Limestone Tills as they are, in general, classified as deep well drained soils. Loss of soil reserves is considered to be a small adverse permanent impact of **moderate/slight significance** (TII, 2009) on the soils of the area.

11.4.2.5 Rock Excavation (Loss of Bedrock)

It is anticipated that bedrock will require removal (360m³) where outcrops are mapped and/or where bedrock has been identified as close to the surface i.e. at areas identified as Extreme in terms of groundwater vulnerability. Excavation works are required at the following locations where bedrock is at or close to the surface (<3 mbgl):

- River Moy: In the areas of the proposed works for flood wall construction where bedrock outcrops are mapped at Barret St and at the junction of Emmet Street and Lower Bridge and where areas of Extreme Vulnerability (E) and Extreme Vulnerability (X) are present at Ridgepool and Emmet St along the River Moy.
- Quignamanger: At the junction of Quay Road and Creggs Road for flood wall construction (outcropping bedrock).
- Tullyegan Stream: At Rehins Fort possible bedrock was encountered at a depths of 1.5 m and 1.8 m in trial pits indicating a vulnerability rating of <3 m - Extreme Vulnerability.

Based on the length of flood walls and associated foundation areas required for their construction, the volume of bedrock removal will be minimal (anticipated to be 360m³). The bedrock encountered will be ripped or broken using an excavator. The receptor is of High importance as it includes bedrock that is predominantly classified as very High – High in terms of aggregate potential which has a high quality, significance or value on a local scale. Due to the localised nature and minimal depth of the excavation required this impact is considered, without mitigation, to be a permanent Small Adverse impact of slight/moderate significance (TII, 2009) on the geological environment during the construction phase.

The excavation or rock can also diminish future quarry reserves and pit reserves which have been shown to be utilised in the past such as the historic pits and quarries in the west of Ballina Town and gravel pits associated with the River Moy, however the magnitude of this effect on a local scale is negligible and therefore of imperceptible significance as it is insufficient to affect the potential of the land and soils as a potential future quarry or pit reserve.

11.4.2.6 Impact to Aquifers (Loss of Aquifer and/or Increase of Aquifer Vulnerability)

The removal of soil can have an impact on aquifer vulnerability where protective overburden is removed during excavation works for foundations and trenches through increasing the aquifer's vulnerability to contamination. In addition, the backfilling of material in trenches for the construction of flood defences has the potential to impact on the groundwater table. Where groundwater is encountered during intrusive works, flow paths or the groundwater table can be altered reducing an aquifer's ability to provide baseflow to watercourses or water supplies.

The underlying limestone bedrock is classified as a Regionally Important Aquifer, however there is anticipated to be minimal excavation into the limestone rock (excavation depths will be no more than 3 mbgl) and there are no groundwater wells in the vicinity of the proposed works. Considering the areal extent of the aquifer the magnitude of this effect is negligible and of **imperceptible significance** on the underlying aquifer.

11.4.2.7 Use of Concrete, Fuel, Oils or Chemicals (Accidental Spillage)

During the construction phase, the import and pouring of concrete material for foundations can result in accidental spillage and contamination of adjacent watercourses and soils. Intrusive works during construction can potentially create pathways to impact subsoils and groundwater. Localised accidental spillages of fuel, oils or chemicals on the site have the potential to contaminate the underlying soils and groundwater by exposure, dewatering, or construction related spillages resulting in a short-term, small adverse effect of **moderate/slight significance** on soils and groundwater (TII, 2009).

Impacts of the use of cement and hydrocarbons on surface water quality during the construction phase are assessed in **Chapter 12: Water**.

11.4.2.8 Encountering Contamination

The study area is located in an area of historical and current industrial activity (refer to **Section 11.3.9** which identifies potential sources of historical contaminants relevant to Proposed Scheme) therefore, site clearance and excavation works within Made Ground have the potential to encounter contaminated material from former industrial activities (see **Table 11-6**).

Potential for encountering historical contamination within Made Ground and shallow subsoil is present at:

- Rehins Fort - site of former Engine House tank identified in close proximity to the proposed flood wall and embankments at along the Tullyegan Stream.
- Barrett St - site of former sawmill and gasworks a identified in close proximity to the proposed flood wall construction and along the River Moy.
- Ridgepool - site of a former cornmill identified in close proximity to the proposed flood wall construction along the River Moy
- Behy Road - site of a former flaxmill identified in close proximity to the proposed culvert upgrades along the Behy Road Stream

Made ground encountered during the SI typically comprises hardcore stone roadfill with wood, glass, brick and plastic fragments. The excavation of made ground results in the production of excess material that requires placement elsewhere.

If not handled correctly, the excavation and handling of potentially contaminated made ground or contaminated soil can result in the mobilisation of contaminants which increases the potential impacts on the quality of soil and groundwater. Dependant on the contaminant of concern; these impacts can include leachate of contaminants to clean soils and groundwater, surface water runoff from exposed contaminated made ground as well as a risk to human health due to direct contact and from volatile or semi-volatile vapours.

If encountered, the excavation of potentially contaminated made ground would have a temporary negative effect on the soils, geology and hydrogeology of the study area. These may be slight to significantly negative impacts depending on the nature of the contamination and the sensitivity of the receiving environment. Given that limited extent and depths of excavation required the potential for encountering contaminated ground is low and the resulting impact would be considered to be a short-term, small adverse effect of **moderate/slight significance** on soils (TII, 2009).

Conversely, should any waste material be encountered during construction, it will be removed to a suitably licensed facility. Assuming proper handling, this would be considered to be a direct, permanent, minor beneficial effect on soils by removing a potential source of contamination.

Waste Generation and excavation of waste as a result of the construction of the Proposed Scheme is addressed in **Chapter 16: Material Assets (Wastes & Utilities).**

11.4.2.9 Loss or Damage to Geological Heritage Area

Loss or soils, bedrock or change to the characteristics of the bedrock or groundwater environment has the potential to diminish the value of a GHA which can result in a permanent loss of the in-situ characteristics of the GHA in question.

The proposed works on the River Moy include flood walls along the left and right bank of the river which will require the use of temporary cofferdams created using sandbags. The reshaping of the groyne near Ballina Art Centre and the installation of the ramp at Ridgepool does not involve the extraction of thick alluvial deposits along the floodplain and there is no channel dredging proposed which would have the potential to impact on the geological and geomorphological importance of the river's U-Shaped channel. Therefore, there is **no potential impact** to the GHA envisaged as part of the proposed works.

11.4.2.10 Loss or Damage to GWDTE

Where dewatering is required to facilitate the culvert upgrade on the Quignamanger and where excavations are required in the shallow subsurface for flood wall construction, there is the potential for a hydrogeological impact in terms of alteration to groundwater level, flow direction and/or quantity of groundwater baseflow feeding the Tufa formation. However, considering that the source of the groundwater feeding the tufa formation is most likely further upstream (as outlined in **Section 11.3.19**) the effect on the groundwater flow feeding the tufa formation as a result of dewatering or excavation works will be temporary and minor. Furthermore, as outlined in **Section 9.4.5.2** of **Chapter 9: Aquatic Biodiversity** it is considered that the tufa deposits will reform in the operational phase following construction phase disturbance and may even be improved in the long term because of slightly higher water velocities during elevated flows as a result of channel improvement works.

The receptor is of Very High importance as the attribute has a high quality, significance or value on a regional or national scale, it is therefore considered that, without mitigation, this effect would be considered to be a short-term, small adverse with a significance rating of **significant/moderate** on groundwater (TII, 2009) but could be positive long term.

11.4.2.11 In-Channel Works and Dewatering

Instream works will be required to facilitate construction activities along some sections of the Rivers Moy, (Ridgepool and Lower bridge to Rope Walk Lane), Quignamanger, Bunree/Behy Road Stream, Brusna and along the Tullyegan Stream. **Section 5.7.9**. of **Chapter 5: Project Description Table 9-14** of **Chapter 9: Aquatic Biodiversity** outlines the in-stream works required to facilitate construction activities.

Where dewatering is required to facilitate flood wall construction, culvert upgrades and placement of submersible surface water pump stations, there is the potential for a hydrogeological impact on local water features such as groundwater wells, groundwater level and flow direction and alteration to groundwater baseflow feeding watercourses or GWDTE's. Dewatering also has the potential to create subsurface changes to soils and sediments that include movement and settlement of surrounding ground. In stream works have the potential to alter stream bed geomorphology as a result of changes to flow velocities and hydraulics impacting on the natural erosional or depositional regime. Without mitigation, the construction or alteration of culverts has the potential to cause channel bed degradation, lateral erosion of banks and deposition of eroded sediments. The receptors' importance from a hydrological perspective ranges from Very High (River Moy & Brusna) to High (Tullyegan Stream) to Medium (Quignamanger & Bunree/Behy Streams).

Without mitigation, this effect is a temporary, small adverse with a significance rating of **slight** (Quignamanger & Bunree/Behy Streams) to **moderate/slight** (Tullyegan Stream) to **significant/moderate** (River Moy & Brusna) (TII, 2009).

11.4.3 Operational Stage Impacts

11.4.3.1 Maintenance and Inspection Activities

Maintenance activities during the operational stage will involve periodic inspection of flood walls, pumping stations, monitoring of the newly constructed embankments to check for signs of instability or soil slippage and inspection of culverts. This work is expected to be carried out as a visual walkover, inspections and general landscaping activities. There is no expected negative effect on land, soils, geology and hydrogeology as a result of such activities.

11.4.3.2 Surface water Pumping Stations

Surface water pumping stations will be installed at a number of locations as set out in **Section 5.5.4** of **Chapter 5: Project Description.** The pumping stations will manage excess flood water only and will not impact on the groundwater regime. Excess surface flows will be pumped directly from the pumping station to the river.

11.5 Mitigation Measures

11.5.1 Construction Phase

11.5.1.1 Importation of construction materials

The importation of surplus clean and inert excavated material from quarries or as a by-product from other sites will be undertaken. By-product will be subject to an Article 27 notification to the EPA in accordance with relevant waste legislation and taking account of the findings of the current EPA public consultation document '*Regulatory position on soil & stone by-products*' published in October 2018.

11.5.1.2 Embankment Settlement

Soft soils will be removed during the construction of the foundation to create a stable base and a geotextile membrane placed over the formation to strengthen the foundation. If a high-water table is encountered during excavation an appropriate backfill such a Class 6A material will be incorporated. Embankments will be constructed of suitable compacted materials, tamped down and reseeded immediately to ensure stability and to minimise the potential for erosion of sediments into the adjacent Brusna River and Tullyegan Stream. To prevent suspended sediment runoff a barrier method such as a sediment barrier or silt fence will be placed on the river side of the embankment. Permanent cut-off ditches on the land side of the embankment will be used to prevent over land flow. Ensuring that a Construction Environmental Management Plan (CEMP) is in place will mitigate any risks associated with embankment construction activities, thus reducing these impacts to an Imperceptible level.

11.5.1.3 Infiltration of Surface Runoff

Where stockpiling of topsoil is required, stockpiles shall be limited to heights not exceeding two metres, shall be battered back to a stable slope, and shall not be unnecessarily trafficked (TII, 2011). There will be no stockpiles within the SAC and or within 20 m of the main channel of the River Moy or any drains that connect to the river. Care will be taken in reworking this material to minimise the effects of weathering, dust generation, groundwater infiltration and generation of runoff. Construction compounds have been selected at the Old Ballina Diaries site, Mayo County Council (MCC) lands on Barrett Street and sites located on private lands at Ridgepool Road, Behy Road and Bonniconlon Road where there will be designated stockpiling areas. These locations will allow material to be delivered to central locations and is not bound by the works programmes at each embankment/flood wall works area.

Where compaction occurs due to vehicle and truck movements remediation works will be undertaken to reinstate the ground to a condition to at least equal to that of the original surface. Vehicles will minimise tracking over natural or unfinished surfaces and will not track over reinstated soils.

Ensuring that a CEMP is in place will mitigate any risks associated with the removal of superficial deposits and/or bedrock, thus reducing these impacts to an imperceptible level.

Section 9.5.1 of **Chapter 9: Aquatic Biodiversity** sets out mitigation measures for sediment loss controls. The measures set out in **Section 12.5.1** of **Chapter 12 Water** for limiting suspended solids from entering water will also protect groundwater.

11.5.1.4 Loss of Soil and Bedrock Reserves

Where possible the removal of topsoil will be avoided (except where topsoil will need to be removed for the placement of fill under embankments, temporary access roads and stockpiles in which case the topsoil will be stripped and assessed for reuse within the Proposed Scheme ensuring appropriate handling, processing and segregation of material. The excavated material will be reused for side-slope protection of the new embankments at Rathkip and Shanaghy and Tullyegan Stream and regrading adjacent to the new flood walls. Excavations will be kept to a minimum using shoring or trench boxes.

A Soil Management Plan will be developed by the contractor as part of the CEMP. This plan will identify actions on site to minimise the loss of topsoils and soils and its potential for erosion such as stabilising side surfaces to prevent erosion through appropriate slope angles. The CEMP will provide appropriate measures for mitigating against ingress of groundwater and management of the groundwater table during excavation works for foundations, trenches and placement of submersible surface water pumps such as pumping out groundwater and/or rainfall with a sump pump.

Dewatering will be carried out where required prior to backfilling to avoid impacts to the water table and backfill material will be of appropriate composition to achieve compaction to avoid seepage of groundwater. The extent of dewatering required will be small and local in nature over a short timeframe and is therefore not expected to result in any significant impact on the hydrogeological regime and no groundwater wells were identified in proximity to the area of proposed works. Soils removed during excavations will be reinstated as soon as possible and suitable inert material will be used as infill to protect the quality of the surrounding subsoil.

Where surplus soil cannot be reused it will be removed off site for treatment, recycling or disposal at an authorised waste management facility off site. **Table 16-7** in **Chapter 16: Material Assets (Waste and Utilities)** details licenced waste facilities in County Mayo that may be considered for the disposal of material and waste streams generated by the Proposed Scheme. The Waste Management Plan will address the analysis of waste arisings, methods proposed for the prevention, reuse and recycling of wastes and material handling procedures.

In areas of soft soils and peat, excavate and replace options are proposed in order to achieve acceptable settlement limits.

11.5.1.5 Impact to Aquifers (Loss of Aquifer and/or Increase of Aquifer Vulnerability)

The mitigation measures set out above under **Section 11.5.1.5** will mitigate against loss of aquifer and/or an increase in groundwater vulnerability.

11.5.1.6 Use of Concrete, Fuel, Oils or Chemicals (Accidental Spillage)

Construction activities will be undertaken in strict compliance with measures set out in CIRIA's *Control of water pollution from construction sites*. *Guidance for consultants and contractors* (2001) to minimise the risk of transmission of hazardous substances to adjacent soils, groundwater and watercourses.

These measures will ensure soil and groundwater and adjacent watercourses remain free from pollution:

- Ensuring that all areas where liquids (including fuel) are stored, or cleaning is carried out, are in designated impermeable areas that are isolated from the surrounding area and within a secondary containment system, e.g., by a roll-over bund, raised kerb, ramps or stepped access.
- The location of any fuel storage facilities shall be considered in the design of the construction compounds. These are to be designed in accordance with relevant guidelines and codes of best practice and will be fully bunded.
- Good housekeeping at the site (daily site clean-ups, use of disposal bins, etc.) during the entire construction phase.
- Spill kit to be provided and to be kept close to the storage area. Staff to be trained on how to use spill kits correctly.

The CEMP will include an emergency plan to deal with accidental spillages. **Section 9.5.1** of **Chapter 9: Aquatic Biodiversity** and **Section 12.5.1** of **Chapter 12 Water** set out mitigation measures for concrete loss and general hydrocarbon loss controls.

11.5.1.7 Encountering Contamination

The appointed contractor will be responsible for regular testing of excavated soils to monitor the suitability of the soil for reuse. If contamination is encountered suitable measures will be put in place to avoid mobilising the contamination based on best practice for contaminated land management. Samples of ground suspected of contamination will be tested for contamination by the appointed contractor during the ground investigation. Five compounds are to be developed in the locations shown in **Figure 5-2** of **Chapter 5: Project Description**. The management of surplus excavated material or temporarily stored material at the site compounds will be determined by the classification of the material and will be stored in such a manner as to prevent disturbance of any existing contamination that may be present in the material itself or at the site compound.

After temporary storage contaminated material will be disposed of to a suitably licensed or permitted sites in accordance with the current Irish waste management legislation. **Section 16.3.2** of **Chapter 16: Material Assets (Wastes & Utilities)** details licenced waste facilities in County Mayo. Any dewatering required in areas of contaminated ground shall be designed by the appointed contractor to minimise the mobilisation of contaminants into the surrounding environment. Mitigation measures for waste in terms of waste segregation auditing, storage and removal are discussed further in **Chapter 16: Material Assets (Wastes & Utilities), Section 16.5.1.2.**

11.5.1.8 Loss or Damage to GWDTE

The majority of works on the Quignamanger consist of the replacement of the existing diversion culvert and instream works are limited to the open section before the water flows under Quay Road. Any instream works will be undertaken during low flow conditions and water will either be diverted or over pumped. The lower section of the Quignamanger Stream before the bridge has been designed with an open channel and allowed to flood to support and even improve existing growth of Tufa cascade.

Section 9.5.1.5 of **Chapter 9: Aquatic Biodiversity** sets out the measures required for the protection of the Tufa deposit.

11.5.1.9 In-Channel Works and Dewatering

As set out in **Section 11.4.2.11** above, in channel works and the placement of submersible pumps will be undertaken during low level conditions and within the seasonal restrictions placed on the programme using an appropriate method of water management, e.g., dam and pump-over, temporary piping. To avoid the use of sheet piles, cofferdams for dewatering will be constructed using geotextile sandbags and silt netting to prevent the influx of water into the workings and also to prevent sediment from entering the river.

The extent of dewatering required will be small and local in nature over a short timeframe and is therefore not expected to result in any significant impact on groundwater levels as the works will be temporary and localised to a small footprint. In order to mimic the naturally occurring substrates, river margin reinstatement measures prior to cofferdam removal are set out in **Chapter 9: Aquatic Biodiversity**.

There will be no direct discharge of surface water from any element of the works without suitable attenuation and treatment of sediments. New culverts and culvert upgrades are required to be constructed in accordance with the requirements of the OPW and IFI.

11.5.2 Operational Phase

Mitigation measures, proposed for the construction phase will be implemented for maintenance operations, where relevant. OPW Guidance will be adhered to for periodic maintenance and/or repair of flood defences.

11.6 Residual Effects

The significance of all impacts identified in **Section 11.4** will be reduced to **Imperceptible** with the implementation of the mitigation measures outlined in **Section 11.5**.

11.7 Monitoring

11.7.1 Construction Phase

11.7.1.1 Sediment Runoff

Refer to **Chapter 12: Water** for the measures proposed for the monitoring of sediment runoff during the construction phase.

11.7.1.2 Embankment Monitoring

The appointed contractor shall monitor settlement every two to three days using settlement plates during and after embankment construction at Rathkip and Shanaghy and along the Tullyegan Stream.

11.7.1.3 Waste Monitoring

Chapter 16: Material Assets (Waste and Utilities) sets out monitoring controls for waste material.

11.7.1.4 Excavations Monitoring

Records shall be kept of all truck movements relating to the removal of site clearance vegetation, topsoil and construction soil. The records shall include quantity, nature/ type and quality of the material, and the excavation and disposal locations. Excavations shall be monitored during earthworks to ensure the stability of side slope and that excavated soils meet the Waste Acceptance Criteria (WAC) testing classifications and descriptions.

11.7.2 Operational Phase

OPW Guidance will be adhered to for ongoing inspection and monitoring of flood defences and culverts.

11.8 Interactions and Cumulative Effects

Inter-relationships are the impacts and associated effects of different aspects of the Proposed Scheme on the same receptor. The potential for cumulative effects has been considered for the construction and operation of the Proposed Scheme cumulatively with other projects. Please see **Chapter 20 Interactions and Cumulative Effects** for further details on the potential interactions and cumulative effects for Land, Soil, Geology and Hydrogeology.

11.9 Schedule of Environmental Commitments

Please see **Chapter 22 Schedule of Environmental Commitments** which sets out all the mitigation and monitoring commitments to minimise the potential impacts for Land, Soil, Geology and Hydrogeology during the construction and operational phase of the Proposed Scheme.

11.10 Chapter References

CIRIA, 2001. *Control of Water Pollution from Construction Sites. Guidance for Consultants and Contractors C532,* s.l.: CIRIA.

Drilling, I., 2009. *Athenry Relief Road- Site Invetigation,* s.l.: s.n.

EC, 2006. *Thematic Strategy for Soil Protection [SEC(2006)620] [SEC(2006)1165] COM/2006/0231 final,* s.l.: s.n.

Environment Agency UK, 2004. *The Model Procedures for the Management of Land Contamination CLR 11,* s.l.: s.n.

Environment Agency UK, 2020. *Guidance on Land Contamintation Risk Management (LCRM),* s.l.: s.n.

EPA, 2011. *Guidance on the Authorisation of Discharges to Groundwater,* s.l.: s.n.

EPA, 2013. *Guidance on the Management of Contaminated Land and Groundwater at EPA Licensed Sites,* s.l.: s.n.

European Commission, 2017c. *Environmental Impact Assessment of Projects - Guidance on the Preparation of the Enviromental Impact Assessment Report,* s.l.: s.n.

GSI, 2004. *1st Draft Clarinbridge GWB Description,* s.l.: s.n.

GSI, 2004. *Geology of Galway Bay,* s.l.: s.n.

GSI, E., 2015. *Irish Aquifer Properties - A reference manual and guide,* s.l.: s.n.

GSI, M. e. a., 2019. *Galway- County Geological Site Report,* s.l.: s.n.

IGI, 2013. *Geology in Environmental Impact Statements - A Guide,* s.l.: Institute of Geologists of Ireland.

IGI, 2013. *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements,* s.l.: Institute of Geologists of Ireland .

IGSL, 2022. *Ballina Flood Relief Scheme - Ground Investigation,* s.l.: s.n.

MCC, 2022. *Mayo County Development Plan 2022-2028,* s.l.: Mayo County Council.

NPWS, 2023. *Guidelines for the Assessement of Annex I Priority Petrifying Springs in Ireland - Irish Wildlife Manuals 142,* s.l.: s.n.

RPS, 2023. *Ground Investigation Report ,* s.l.: s.n.

TII, 2008. *Guidelines for the Crossing of Watercourses During the Construction of National Road Schemes,* s.l.: Transport Infrastructure Ireland .

TII, 2009. *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes,* s.l.: Transport Infrastructure Ireland .

TII, 2013. *Specification for Road Works Series 600 - Earthworks ,* s.l.: Transport Infrastructure Ireland.