Chapter 9
Land and Soils

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9. LAND AND SOILS

9.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) presents the land and soils assessment of the proposed construction and operational phases of the DART+ West project. 'Land' in the context of this chapter refers to the existing soil and geological characteristics of the receiving environment. Land use changes are addressed in the Chapter 7 Population, property impacts are dealt with in Chapter 16 Material Assets: Agricultural Properties and Chapter 17 Material Assets: Non- Agricultural Properties. This chapter sets out the methodology used to undertake the assessment (Section 9.3), describes the existing environment (Section 9.4), examines the predicted impacts of the proposed development (Section 9.5), proposes mitigation and monitoring measures (Section 9.6 and Section 9.7 respectively), and identifies residual and cumulative impacts (Sections 9.8 and Section 9.9 respectively). This chapter should be read in conjunction with the following Chapters, and their appendices, which present related impacts arising from the proposed development and proposed mitigation measures to ameliorate the predicted impacts:

- Chapter 4 Description of the Proposed Development.
- Chapter 5 Construction Strategy.
- Chapter 11 Hydrogeology.
- Chapter 19 Material Assets: Resource and Waste Management.
- Chapter 20 Archaeology and Cultural Heritage.
- Chapter 21 Architectural Heritage.

9.2 Legislation, policy and guidance

9.2.1 Legislation

Córas Iompair Éireann is applying to An Bord Pleanála for a Railway Order for the DART+ West project under the Transport (Railway Infrastructure) Act 2001 (as amended and substituted) ("the 2001 Act") and as recently further amended by the European Union (Railway Orders) (Environmental Impact Assessment) (Amendment) Regulations 2021 in Statutory Instrument No. 743/2021 ("the 2021 Regulations"). The purpose of the 2021 Regulations was to give further effect to the transposition of the EIA Directive (EU Directive 2011/92/EU as amended by Directive 2014/52/EU) on the assessment of the effects of certain public private projects on the environment by amending the 2001 Act. This land and soils impact assessment has been undertaken in accordance with these requirements and in relation to conditions relevant to soils and geology.

9.2.2 Policy

Relevant policy documents that have informed this chapter include:

- Dublin City Development Plan 2016-2022.
- Draft Dublin City Development Plan 2022-2028.
- Fingal Development Plan 2017-2023.
- Draft Fingal Development Plan 2023-2029.
- Kildare County Development Plan 2017-2023.
- Draft Kildare County Development Plan 2023-2029.
- Meath County Development Plan 2021-2027.
- Dunboyne, Clonee & Pace Local Area Plan 2009-2015
- North Lotts and Grand Canal Dock Strategic Development Zone Planning Scheme 2014.
- Ashtown – Pelletstown Local Area Plan 2014.
- Pelletstown Local Area Plan 2014.
- Hansfield Strategic Development Zone Planning Scheme 2006.

- Kellystown Local Area Plan, January 2021.
- Barnhill Local Area Plan 2019.
- Leixlip Local Area Plan 2020-2023.
- Maynooth Local Area Plan 2013-2019.
- Kilcock Local Area Plan 2015-2021.

9.2.3 Guidance

This chapter has been prepared following the guidance documents below:

- Environmental Protection Agency (EPA) (2022), *Guidelines on the Information to be contained in Environmental Impact Assessment Reports*.
- Environmental Protection Agency (EPA) (2015), *Advice Notes for Preparing Environmental Impact Statements.*
- Institute of Geologists of Ireland (IGI) (2013), *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*.
- Transport Infrastructure Ireland (TII) (2008), *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*.
- Environmental Protection Agency (EPA) (2003), *Advice notes on Current Practice in the Preparation of Environmental Impact Statements.*
- Environmental Protection Agency (EPA) (2002), *Guidelines on the information to be contained in environmental impact statements.*

9.3 Methodology

9.3.1 Study area

The proposed development extends for over 40 km along the existing railway line which runs through county Dublin (Dublin City and Fingal) into counties Meath and Kildare, which are mostly urban and suburban areas.

The east part is in a more densely populated, commercial, and urbanised area, starting from the Docklands in Dublin City Centre. Farther out along the route, land-use transitions more frequently to agriculture with farmland pastures either side of the existing transport corridor defined by the canal, railway line and other local or regional roads where present. Both ends of the development westwards in Kildare and northwards in Dunboyne are mainly small towns and undeveloped rural lands.

The study area is also affected by the historic developments of the original railway line and the adjacent canal, both of which mask the original context of the natural ground conditions. As a result of the existing railway corridor and tight constraints on these lines, the study area is taken as no more than a 100 m corridor along most of the existing railway lands, with local widening of areas at the proposed new works locations, including the new Spencer Dock Station, the new depot and the level crossing replacements where the area extends to the relevant tie-in points.

As outlined in Chapter 4 Description of the Proposed Development in Volume 2 of this EIAR, the proposed development has been divided into six zones (Zones A to F).

9.3.2 Survey methodology

9.3.2.1 Site walkover

Extensive site inspections were carried out during the period between June 2020 and May 2022 along the proposed development in both trackside and off-track locations by IDOM's senior engineers, accompanied by the Ground Investigation Contractor (GII) and Iarnród Éireann staff where appropriate. IDOM engineers supervised the investigation throughout the scheme gaining knowledge of the site soil and geology characteristics.

9.3.2.2 Desktop study

The desk study involved collecting all relevant geological data for the study area, particularly nearest to the railway and the vicinity of proposed level crossing closures where feasible design options were required.

Existing information such as mapping and aerial photographs were used during initial desktop studies to plan the ground investigations. Sources of historical information, geological maps and/or features had been established during the geotechnical desktop study of the area including a review of information from various previous projects and site developments. The sources of information review include:

- Geological mapping from the Geological Survey of Ireland (GSI), including GeoIndex, Historic Borehole Logs, Geotechnical, GeoUrban, Aquifer Viewers and GOLDMINE digital report depository (www.gsi.ie/mapping).
- Minerex geophysical surveys, Iarnród Éireann, Reilly's Ratoath Road, 2D Resistivity Survey, July 2010: Additional information on the potential for karstification in the Calp Limestone is reviewed locally at Reilly's Bridge Ratoath Road where XG002 Level Crossing Replacement investigated the conditions in the limestone rock (2010). This comprises a geophysical survey comprising electrical resistivity and intrusive cable percussion and rotary core boreholes into the rock which identified local weathering.
- Historical ordnance survey mapping information from OSI website, including historical maps available, OSI Historic 6" black & white and colour, OSI 6" Cassini and OSI Historic 25". (map.geohive.ie).
- Information on the hydrology and hydrogeology has been obtained from the interactive maps on the GSI website.
- Environmental Protection Agency (EPA).
- Topographical information from Ordnance Survey mapping published on the GSI website.
- Dublin SURGE project data and reporting as published on the GSI website.
- Opensource technologies such as Google Earth and Bing Maps.

9.3.2.3 Ground investigations

The ground investigations were undertaken in different phases with the precise purpose of designing and assessing the proposed development. Initially the first phase utilised geophysical surveying as a non-intrusive campaign during Autumn 2020, predominantly aimed at the various proposed route options at the level crossing, the proposed depot and in the docklands area.

The intrusive surveys were then focused on trackside investigations to begin with subsequent remaining investigation in roads, lands, and private properties along the proposed route, as required. This intrusive investigation started in December 2020 and is anticipated to be completed in May/June 2022, commissioned by IDOM and carried out by GII to determine the soil, bedrock, ground water conditions and to establish the environmental condition of the soil.

The surveys were detailed for key sections to obtain a better understanding of the soil condition, such as boreholes at and around structures (e.g., level crossings, depot area, docklands area), slit trenches were used to confirm and intercept existing utilities, and standpipes to monitor the water table.

Shallower investigations were specified by using vacuum excavation along the main alignment, such as window samplings and dynamic probing's with a typical depth of around 5m BGL (Below Ground Level).

The GI campaign includes:

- 33 no. geophysical surveys.
- 77 no. cable percussion boreholes.

- 77 no. rotary core boreholes.
- 193 no. dynamic probes and window samplings.
- 443 no. trial pits, observation pits and slit trenches.
- 48 no. groundwater standpipes.
- 18 no. structural coring.
- 235 no. suites of laboratory testing, including environmental and contamination tests.

Where suitable samples were obtained, laboratory and environmental testing were scheduled to identify parameters, to classify and characterise the materials present for assessment purposes, to inform design decisions, and inform this environmental impact assessment.

The ground investigation for the proposed development was undertaken with an appropriate number of locations to provide sufficient data to classify and characterise the site conditions for the proposed design elements and to inform on geotechnical risks. The investigation locations are shown in Drawings MAY-MDC-GEO-ROUT_DR-C-96001-D to 96024-D in Volume 3A of this EIAR.

9.3.3 Assessment methodology

The potential impact of the proposed development on the soils and geology environment has been assessed by classifying the importance of the relevant attributes and quantifying the likely magnitude of impact on these attributes. The rating criteria for assessing the importance of geological features within the study area are detailed in Table 9-1 whilst the rating criteria for quantifying the magnitude of impacts are detailed in Table 9-2.

The rating of potential environmental effects on the soils and geology environment are based on the assessment criteria presented in Table 9-3 which take account of both the importance of an attribute and magnitude of the potential environmental impacts of the proposed development on it. This assessment methodology is consistent with impact assessment criteria outlined in the EPA, Guidelines on the Information to be contained in Environmental Impact Assessment Reports (May 2022).

The impact assessment methodology is in accordance with the guidance outlined in Section 5.4 of the TII's Guidelines on Procedures for Assessment & Treatment of Geology, Hydrology & Hydrogeology for National Roads (TII, 2008). Impact categories, duration and the type/nature of impacts have been taken into account in this assessment in accordance with those guidelines.

Table 9-1 Criteria for rating importance

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance or value on a national or regional scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and/or soft organic soil underlying route is significant on a national or regional scale*	Geological feature rare on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource.
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 route is significant on a local scale*	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes. Geological feature of high value on a local scale (County Geological Site). Well drained and/or high fertility soils. Moderately sized existing quarry or pit. Marginally economic extractable mineral resource.

Importance	Criteria	Typical Example
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 route is moderate on a local scale*	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit. Sub-economic extractable mineral resource.
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 route is small on a local scale*	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomically extractable mineral resource.
** relative to the total volume of inert soil disposed of and/or recovered*		

Table 9-2 Criteria for rating the impact magnitude at EIAR Stage – Estimation of magnitude of impact on soil/geology attribute

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. 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 9-3 Significance of Effects

Significance	Description
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 or emerging baseline trends
Significant	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 Effect	An effect which obliterates sensitive characteristics

9.3.4 Consultation

Chapter 3 Alternatives of this EIAR details the alternatives considered and the consultation undertaken throughout the project. The key consultation phases and the feedback received that has informed this chapter include:

- Non-statutory EIA Scoping Report.
- Options Selection process.
  - Non-statutory public consultation no.1 emerging preferred option (Autumn 2020).
  - Non-statutory public consultation no.2 preferred option (Summer 2021) & Local Ashtown public consultation on the revised preferred option (Spring, 2022).

Consultation with the design team throughout the process has been a key factor that has informed this assessment. In addition to the datasets listed above in desktop study, the information sources that have been consulted in the assessment of the geological conditions, include:

- Geological Survey of Ireland (GSI).
- Environmental Protection Agency (EPA).

9.3.5 Difficulties encountered/limitations

Access to investigate some locations was not allowed, predominantly for intrusive investigations, however, a non-intrusive geophysical investigation has been conducted for comparison in most cases, sufficient to provide some information on the typical ground characteristics present.

9.4 Receiving Environment

9.4.1 General Description

9.4.1.1 Docklands

The proposed development begins in the Docklands area, which is historically an industrial area with port related activities located adjacent to the River Liffey. While port related activities are still present, the area has been subject to extensive mixed use urban regeneration developments in recent years, which is still ongoing in the area.

The site at Spencer Dock has been temporarily taken over to support adjacent construction site works plus acts as a local access into the Docklands transport link hub via the arches underneath Sherriff Street.

The majority of the soils reflect the urban setting, with 'made ground', that is associated with the construction of the port and canal at the end of the 19th Century. Some of these deposits have been contaminated from historic uses. Beneath this lie granular deposits of sands and gravels and Dublin Port Clay deposits. Rock is present and has been proven. The soils in this area are considered to be of high importance at shallow depths due to the significant degree of contamination on a local scale within the soils to be excavated.

9.4.1.2 Existing railway route and canal embankments

The Royal Canal was constructed in the 18th century with later addition of the contiguous railway early in the 19th century. The development involves works to 40 km of railway line that include parts of the Great Southern and Western Railway (GSWR) and the Midland Great Western Railway (MGWR). The MGWR runs adjacent to the Royal Canal for much of its length. The route travels through Dublin's northern inner city extending westwards towards Meath and Kildare.

For most of its length, the railway runs beside the Royal Canal, where it is often at similar levels. Near the proposed Spencer Dock Station, the difference in levels between the canal and the railway line is approximately 2 m.

Further along the route, the railway crosses the canal between Glasnevin and Broombridge and continues westward through suburban areas, passing several stations and crossing the M50 motorway. Further westwards, the railway passes through additional conurbations at Castleknock and Coolmine, gradually moving into less developed areas such as Clonsilla and Porterstown. In these areas, the upper surface comprises less made ground with Dublin Boulder Clay being encountered at shallower depths.

In the area between Drumcondra Road and Glasnevin Junction the railway is in a deep cut constrained by retaining walls and below the level of the canal. At Castleknock Station the railway line drops back down to a similar level as at Clonsilla. The canal is in a deep cutting of about 4 m maximum depth between Coolmine and Castleknock. The largest embankments are near Barberstown at approximately 7 m in height. The ground conditions in these areas are of medium to high importance due to the role of the soils and fill materials inherent in the stability and foundations of the embankments and retaining structures comprising the canal and railway. Refer also to Chapter 21 Architectural Heritage in Volume 2 of this EIAR regarding these structures.

Figue 9-1 Cuttings between OBD225 (Ballybough Road) and OBD223 (Drumcondra Road)

Other significant man-made features into the natural soil profile include at Leixlip and on crossing the M50, which is in a deep cutting and has both over- and under-bridges criss-crossing each other.

The study area overlies various deposits, primarily of glacial origin such as the Dublin Boulder Clay sequence. This glacial till is generally of medium to high importance to the route due to its tendency to provide suitable foundations, its suitability for excavation and reuse, and generally moderate volumes of soft soils present on a local scale. Other characteristic glacial features are recorded at the Phoenix Park however this is outside the study area. Soft soils and shallow bedrock are however present in many areas.

The land and soils of the area is mainly quite a uniform soil profile with progressive changes in soil and rock conditions notable along its length, the main exceptions being present in between Leixlip and Maynooth, and nearer to the Docklands where the effects of the Dublin Estuary can be seen.

9.4.2 Topography

The area rises from initial ground levels of +1 mOD (metres above Ordnance Datum) in the vicinity of the Docklands Station to +45 mOD at Ashtown and +60 mOD westwards near Leixlip, after which the terrain is generally flat-lying westwards to Maynooth. The highest ground level encountered is on the Dunboyne branch of the line which runs north from approximately +60 mOD at Clonsilla up to almost +70 mOD.

Along Zone A the railway starts at a level of +8.0 mOD at Connolly Station and gradually dips to approximately +2.1 mOD in the area of Newcomen bridge, where it merges to Zone B and continues running parallel to the canal. Following slightly to the north along Zone A, the levels of the railway rise to +8.6 mOD in Ballybough over the surrounding lands at levels of +2.6 mOD, and then consistently rise up to +18.7 mOD further west near Phibsborough. The railway runs in a cut and is bordered by retaining walls on either side, with the adjacent canal levels at +21.5 mOD.

Along Zone B, the railway starts at Spencer Dock from initial levels of +1 mOD with surrounding lands at similar levels. Travelling north west, the railway levels rise to approximately +2 mOD where Zone B merges with Zone A. The railway line in that area travels in a deep cut and is bordered from the canal by retaining walls. The canal embankment is at +4.5 mOD at the top of the retaining walls and runs predominantly at consistent levels until Croke Park.

In the Croke Park area, the alignment of the canal is at +4.5 to +6.0 mOD and for the majority part the rail track runs at levels 1-3m lower, at +2.8 to +3.5 mOD. In the area of Drumcondra the levels of the canal are at +10.8 mOD, which is higher than the rail track levels at +7.8 mOD.

The levels of the rail track and the canal are relatively equal further west until Zone C around Glasnevin, where the railway is similarly bordered by retaining walls along the canal. At Glasnevin, the railway runs at +22 mOD, approximately 6 m lower than the canal, at +28 mOD. The levels continuously rise to +36 mOD near Broombridge, where there has been flooding before. Continuing west, the difference in the levels between the railway and the surrounding lands, including the canal embankments, stays predominantly consistent at 1-3 m. Further west along Zone C, the railway levels are similar to the levels of the canal at +40.5 mOD at Ashtown and rise to +44 mOD around Martin Savage Park, while the canal remains close to +40.5 mOD.

In the vicinity of the M50, the railway rises to the level of +52.6 mOD and travels parallel to the canal, which is adjacent at a level of +51.0 mOD. Continuing further west, the railway and canal levels both rise to +56 mOD around Castleknock. The railway gradually rises to +60 mOD at Clonsilla, where the canal is 3 m lower at the level of +57 mOD with local parts of the Deep Sinking being deeper again where the canal is cut through the limestone bedrock, as explained in Chapter 20 Archaeology and Cultural Heritage in Volume 2 of this EIAR. The rock in this area is locally of high importance due to the inherent rock stability of the construction.

As the route forks northwards from Clonsilla Junction along Zone D, the levels of the railway along the embankment gradually rise to +72.8 mOD at M3 Parkway, with the levels of the surrounding lands predominantly at 0.5-2.0 m below the railway along the route.

Travelling west from Clonsilla along Zone E, the railway continues adjacent to the canal along an embankment. At Barberstown level crossing the levels of the railway are approximately 3 m higher than the canal levels, +59.5 mOD and +56.5 mOD respectively.

Further west the railway and canal levels gradually even out to +56.8 mOD in the area of Leixlip Confey, then rise to +57.5 mOD around the intersection with the Rye River tributary, where the railway is level to the canal but approximately 10m higher than the surrounding lands to the east. The railway line then continues west along a raised embankment parallel to the canal across generally flat lying land close to +58 mOD at Maynooth. The canal and surrounding lands in Maynooth area are similarly at the levels of +58 to +59 mOD.

9.4.3 Bedrock geology

Bedrock geology is informed by the GSI bedrock mapping which identifies that the proposed off-line twin track railway's extension and the proposed depot are underlain by the Calp Limestone, of Lower Carboniferous (Dinantian) age (drawing MAY-MDC-GEO-ROUT-DR-G-93000-D, in Volume 3A of this EIAR). The formation is part of the Dublin Basin Structure, which is a composite basin of combined sedimentary and structural origin. The Calp Limestone is also known as the Lucan Formation, as its characteristics are best observed in quarries at Lucan, Co. Dublin.

The Lucan Formation comprises dark-grey to black, fine-grained, occasionally cherty, micritic limestones that usually weather to pale grey. There are rare dark coarser-grained calcarenite limestones, sometimes graded, and interbedded dark-grey calcarenites. The formation ranges from 300m to 800m in thickness.

Faulting of bedrock is typically due to historic tectonic or earthquake events disrupting the deposits. This causes massive changes in the faulted rock structures and displaces some of the material significant distances either laterally and/or vertically. This tends to result in weaker zones that are then exploited by atmospheric weathering and lead to the formation of river channels for example.

Faulting of the bedrock formations is evident in many areas, particularly close to the M50 between Ashtown and Clonsilla where deposits of the Tober Colleen Formation are present and again east of Maynooth where the Tober Colleen Formation and Waulsortian Formation are present. These are described as dark-grey, calcareous, commonly bioturbated mudstones and subordinate thin micritic limestones (Tober Colleen) and as massive, unbedded lime-mudstone (Waulsortian). The thickness of these Tober Colleen and Waulsortian Formations are typically 50m to 250m and 300m to 500m thick respectively.

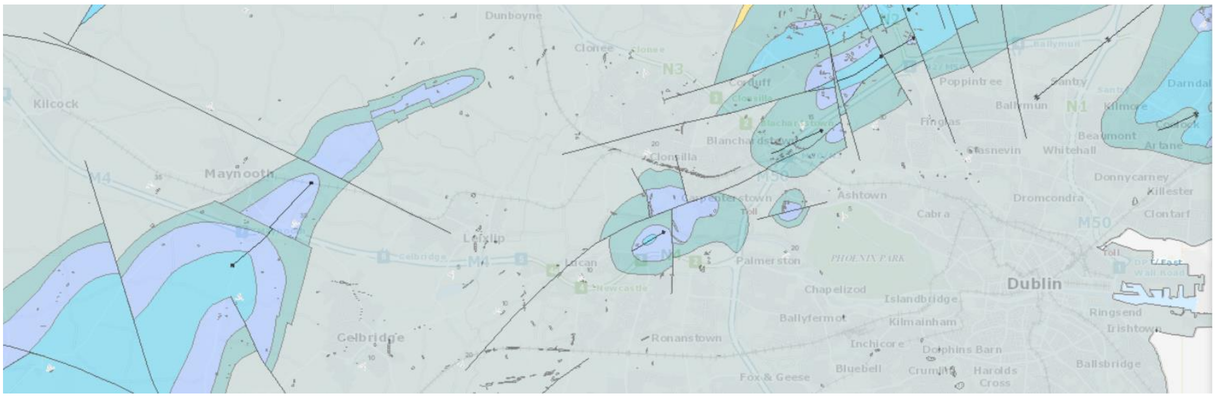

Figure 9-2 Bedrock Mapping showing geological units with associated faulting and discontinuities

The structure of these deposits is that the Lucan Formation is most prevalent across the region, with faulting and anticlinal axes typically trending in a north-easterly to south-westerly direction with some intersecting faults running in a north-north-westerly to south-south-easterly direction. The anticline present near Maynooth means the structure of the deposits has inherent weakness and is prone to karstification where weathering of the rock materials is enhanced due to material properties combined with the bedding and orientation.

Table 9-4 Bedrock units

Bedrock Units	
Zone* (* as per Table 4.1 of this EIAR)	**Type of Formation**
Zone A	Lucan Formation

Bedrock Units	
Zone* ***(* as per Table 4.1 of this EIAR)***	**Type of Formation**
Zone B	Lucan Formation
Zone C	Lucan and Tober Colleen Formations
Zone D	Lucan Formation
Zone E	Lucan, Tober Colleen and Waulsortian Formations
Zone F	Lucan and Tober Colleen Formations

One of the objectives of the GI was to confirm the bedrock level in relevant places along the proposed development, primarily where structures are proposed and rock is suspected to be shallow. Particular geological interest is also relevant where karst features are potentially present. These were characterised via geophysics and rotary coring, inspected and logged by geologists with engineering parameters established following specific laboratory testing:

- Docklands / Spencer Dock Station (Zone B).
- Level crossings and footbridges (Zone C).
- Sub-stations (Zones C to F).
- Karstified bedrock (locally in Zones E and F, refer to section 9.4.7).
- Depot (Zone F).

At the proposed Spencer Dock Station the area is underlain by laminated grey limestone with localised pockets of laminated brown mudstone. As this location is in the main basin of the River Liffey, the deepest bedrock encountered in the alignment was observed at approximately 27 m BGL (metres Below Ground Level), however, it rises to much shallower levels over the majority of the route. For the majority of the route the GSI depth of the bedrock tends to be much shallower, with rockhead level between 2 and 5 m BGL, however, there are localised depressions near the proposed depot and Ashtown Station, between 8 and 10m BGL. Coring undertaken during the investigations was predominantly into the Lucan Formation, described as weak or medium strong to strong thinly laminated grey to dark grey argillaceous or fossiliferous limestone with occasional calcite veins.

It was noted that coring in the Tober Colleen Formation revealed the presence of significant weathering in the proposed depot area. Borehole log BH02-OBG24 located to the east of the proposed depot reported a weak thinly laminated black fine-grained mudstone distinctively weathered to destructured at a depth of 9.8m BGL. Given that the rocks comprise argillaceous limestone and mudstone, there is low expectation of any karstification.

In addition to this GI, rather detailed records of previous site investigations at Leixlip were obtained from GSI mapping and used to inform the bedrock geology description in Zone E.

In many areas, there are rock exposures also mapped by the GSI where rock is present at ground surface. This is most notable between Castleknock and Clonsilla Junction associated with the Deep Sinking of the Royal Canal. The rock in this area is locally of high importance due to the inherent rock stability of the construction. The trend of these exposures also continues to the east along the Tolka River.

Table 9-5 Bedrock geology descriptions

Bedrock Summary			
Zone	**Area**	**Depth to rock**	**Description / Comments**
Zone A	Connolly / GSWR	N/A	N/A – coring into rock was not completed in this zone.
Zone B	Docklands / MGWR to Glasnevin Junction	22.1 - 25.2 m BGL	Weak to medium strong thinly laminated black fine grained calcareous mudstone with occasional calcite veins and clay bands

Bedrock Summary			
Zone	**Area**	**Depth to rock**	**Description / Comments**
		20.7 - 27.1 m BGL	Medium strong to strong thinly laminated grey fine grained argillaceous limestone
Zone C	Glasnevin Junction to Clonsilla Junction		
	Ashtown (Level Crossing)	8.0 - 8.7 m BGL	Medium strong to strong thinly laminated dark grey fine grained argillaceous limestone
	Coolmine (Level Crossing)	3.4 - 4.8 m BGL	Medium strong to strong thinly laminated grey fine grained fossiliferous limestone with occasional calcite veins and partial weathering
	Porterstown (Level Crossing)	2.8 - 4.7 m BGL	Medium strong to strong thinly laminated dark grey fine grained argillaceous limestone with occasional minor calcite veins
Zone D	Clonsilla Station / Junction to M3 Parkway Station	2.0 - 4.2 m BGL	Thinly laminated to very thinly bedded dark grey to black fine to medium grained limestone with calcite veins, clay smearing, partial weathering, and some pyrite specks
Zone E	Clonsilla Station / Junction to Maynooth Station	1.5 - 5.5 m BGL	Thinly bedded grey limestone with shaley partings and occasional interbedded laminated grey mudstones with a highly weathered upper horizon becoming less weathered and more thickly bedded with depth
	Barberstown (Level Crossing)	8.4 - 9.2 m BGL	Very strong thinly to thickly laminated black fine-grained argillaceous limestone with some clay smearing and banding. Unweathered to partially weathered
Zone F	Maynooth Station to Depot	3.8 - 9.8 m BGL	Medium strong to strong thinly to thickly laminated dark grey fine grained interbedded argillaceous limestone/mudstone

9.4.4 Quaternary sediments

The quaternary sediments of Dublin as observed in both historic mapping and investigation records and as confirmed in recent factual investigation information indicates primarily made ground and glacial soils are present, as seen in drawings included in Volume 3A (MAY-MDC-GEO-ROUT-DR-G-91000-D to 91011-D). This sequence is generally consistent across the scheme whether inside or outside of the railway line.

The first stratum encountered is ballast (trackside), which is typically described as grey coarse crushed rockfill. The ballast is considered to be of medium importance due to its role in the functioning of the existing railway. It is frequently excavated and replaced as part of ongoing maintenance. It is likely that much of the existing ballast may contain traces of diesel hydrocarbons which is consistent with the medium rating.

The second layer encountered is urban made ground, which is the predominant stratum nearest the surface outside of the tracks, varying in age and nature depending on types of historic and more recent developments and is known to often include plastic, brick, glass, ceramics, construction rubble and historical industrial wastes such as ash, clinker or metals (Glennon et al., 2012 – as discussed in Section 9.4.5). There is very little natural topsoil present as a result with organic contents suitable for supporting natural growth within the city.

The made ground typically consists of sandy gravelly clay with variable material additions in it, such as red brick and mortar. The thickness of the made ground varies along the alignment. It is generally more consistent and thicker in the more urbanised areas such as Dublin City centre, Maynooth, and Leixlip. There is less made ground in the less developed parts of the site where agricultural lands are still pervasive. In these areas, there is more topsoil present at the surface with organic contents suited to growth of grasses and other plants/crops which are considered to be medium to high importance.

Younger alluvium deposits are present occasionally around the western parts of the proposed development such as in the vicinity of Barberstown (Zone E). They are typically high plasticity silts and clays and may have modest organic content and shallow groundwater. This is of low importance due to the small volume of soft organic soil underlying the route on a local scale. Such deposits are often wetter and can support a variety of habitats at the surface which would be reflected in Chapter 8 Biodiversity and Chapter 11 Hydrogeology. Refer to Chapter 8 Biodiversity and Chapter 11 Hydrogeology in Volume 2 of this EIAR for more details.

At the eastern end of the proposed development, near the Docklands, the quaternary sediments typically consist of medium dense to dense fine to coarse gravel. However, significant deposits of estuarian soils known as Dublin Port Clay, not encountered during the ground investigation, exist within this area of the city. Although typically stiff and over consolidated due to the pressures under ice sheets prevalent during glaciation, these are often disturbed and soften during boring or piling depending on the techniques used.

The predominant stratum is Glacial Till, generally referred to as Dublin Boulder Clay (DBC) in the area of Dublin. Its behaviour has been studied thoroughly during the past decades. It is usually described as soft to stiff slightly gravelly clay with occasional cobbles and boulders and its strength usually increases with depth. Deposits of granular glacial soils are occasionally reported below and sometimes interbedded with the cohesive deposits. Groundwater may be perched in the upper layers and can soften the soils present.

9.4.4.1 Zones A and B

The table below refers to the typical ground profile and type of soils encountered in Zones A and B.

Table 9-6 Quaternary sediments in Zones A and B

Soil Layer	Thickness	Description
Ballast	0.1 - 0.3 m	Grey angular to subangular coarse crushed rock fill (Ballast)
Made Ground	1.2 - 6.0 m	Brown sandy slightly gravelly clay
		With occasional fragments of red brick, tile, mortar, concrete, and charcoal. (Soft to Firm)
Fine-grained Glacial Till	1.2 - 24.0 m	Cohesive deposits are often described as soft or firm brown slightly sandy gravelly clay
		The secondary gravel and sand constituents varied across the site and depth with granular lenses occasionally present in the glacial till matrix, the soil strength increased with depth.
Coarse-grained Glacial Till	0.0 - 2.0 m	Medium dense to dense grey/brown clayey gravelly fine to coarse sand/gravel
		With occasional subangular cobbles

9.4.4.2 Zone C

The table below refers to the typical ground profile and type of soils encountered in Zone C.

Table 9-7 Quaternary sediments in Zone C

Soil Layer	Thickness	Description
Ballast	0.1 - 0.8 m	Grey angular to subangular coarse crushed rock fill (Ballast)
		Occasional geotextile at base
Made Ground	0.3 - 3.6 m	Greyish to Brown sandy slightly gravelly clay, occasionally with fragments of red brick, tile, mortar, concrete, and charcoal.
		Stiff to firm, occasionally mottled brown.
Fine-grained Glacial Till	1.0 - 4.0 m	Often described as very soft/soft to stiff brown to grey slightly sandy gravelly clay
		The secondary constituent gravel is subangular to subrounded fine to coarse

9.4.4.3 Zone D

Typical order and type of soils encountered in Zone D shown in the table below.

Table 9-8 Quaternary sediments in Zone D

Soil Layer	Thickness	Description
Ballast	0.6 - 0.7 m	Grey angular to subangular coarse crushed rock fill (Ballast)
		Occasional Geotextile at the base of Ballast
Made Ground	0.4 - 1.4 m	Brown/Grey slightly sandy gravelly clay with occasional angular cobbles and boulders.
		Brown clayey Cobbles and Boulders
		Dark grey slightly clayey sandy fine to coarse angular to subangular gravel with occasional angular cobbles (dense)
Fine-grained Glacial Till	0.1 - 1.8 m	Cohesive deposits are located beneath the Made ground layer, often described as stiff to firm brown to grey slightly sandy gravelly clay.
		Often encountered obstruction due to large cobble or boulder
Coarse-grained Glacial Till	0.0 - 0.5 m	Seldom lenses of medium to very dense brown slightly clayey sandy fine to coarse angular to subrounded gravel with some cobbles

9.4.4.4 Zone E

The table below refers to the typical ground profile and type of soils encountered in Zone E.

Table 9-9 Quaternary sediments in Zone E

Soil Layer	Thickness	Description
Ballast	0.2 - 0.8 m	Grey angular to subangular coarse crushed rock fill (Ballast)
		Occasional geotextile at base
Made Ground	0.2 - 3.7 m	Greyish to Brown sandy slightly gravelly clay, occasionally with fragments of red brick, tile, mortar, concrete, and charcoal.
		Soft to stiff, occasionally mottled brown.
Fine-grained Glacial Till	0.5 - 2.4 m	Cohesive deposits are often described as very soft/soft to stiff brown to grey slightly sandy gravelly clay
		The secondary constituent gravel is subangular to subrounded fine to coarse
Coarse-grained Glacial Till	0.0 - 1.6 m	Granular deposits described as dense brown/grey slightly sandy clayey fine to coarse angular to subangular gravel, with occasional subangular cobbles

9.4.4.5 Zone F

The table below refers to the typical ground profile and type of soils encountered in Zone F.

Table 9-10 Quaternary sediments in Zone F

Soil Layer	Thickness	Description
Ballast	0.1 - 0.5 m	Grey angular to subangular coarse crushed rock fill (Ballast)
Made Ground	0.3 - 2.3 m	Greyish brown to brown sandy slightly gravelly clay, with occasional cobbles and boulders
		Dark grey clayey gravelly sand
		Sandy gravelly Clay or silty slightly sandy gravelly clay or slightly sandy gravelly clayey silt
Fine-grained Glacial Till	0.2 - >1.5 m	Firm to stiff / very stiff, occasionally mottled brown to grey slightly sandy gravelly clay
Coarse-grained Glacial Till	0.5 - 1.5 m	Medium dense to dense brown or grey clayey to very clayey, sandy subrounded to angular Gravel or brown gravelly fine to coarse sand

9.4.5 Existing geological heritage

There is one geological heritage audited site inside the study area at Leixlip, where Louisa Bridge cold spring is derived from shallow bedrock or quaternary deposits and surfaces immediately west of Louisa Station (MAY-MDC-GEO-ROUT-DR-G-90000-D to 90011-D, Volume 3A of this EIAR). This is a cold spring with a County Geology Site status and is therefore of high importance. Where encountered, excavations into the limestone and associated mudstone horizons can also include significant sulphate or pyrite deposits.

Two other County Geological Sites are close to the study area but are not affected, directly or indirectly. These include the variety of rocks evident as headstones in Glasnevin Cemetery and the presence of natural landscape comprising glacial features in the Phoenix Park. The Glasnevin Cemetery is a large public cemetery, first used in 1832. This site has been designated a County Geological Site status and given an IGH (15) theme of Economic Geology, as it provides an unparalleled range of worked rock types accessible to view (GSI, 2014).

Phoenix Park forms a 707 hectare (Ha.) natural landscape within the City of Dublin and is situated on Lower Carboniferous limestone bedrock. The site is of high importance as it has been assigned a County Geological Site status and is recommended for a Geological NHA status, due to the complexity of the site in terms of its glacial form as well as the historical manipulation of the deglacial landscape in the damming of the meltwater channels, and the fine terraces at the southern end (GSI, 2014).

Although not designated as a Geological Heritage Feature, the Deep Sinking at Clonsilla is constructed through limestone rock and comprises a key part of the Royal Canal. This is assigned a High to Very High importance locally.

9.4.6 Mineral observations

Mineral observations reported in GSI mapping relate to local observations of metallic or non-metallic constituents indicating materials of potential suitability or desirable characteristics in the soils or rocks. While not a confirmation that the material or site is now suited to economic exploitation, this is generally an historic record of traces or sites used for e.g. local supply of brick or lime minerals (non-metallic) or traces of elements like galena, zinc or lead (metallic) that are present locally in veins through the rock exposures. The majority of these observations date from Kinahan (1889).

Four records are present along the route (drawing MAY-MDC-GEO-ROUT-DR-G-90000-D to 90011-D in Volume A3), including brick clay at Clonsilla and nearby at Pelletstown, plus traces of galena and copper exposed in rock at Porterstown. An unsorted mix of sands and gravels is also noted at Bracetown on the far side of the M3 near M3 Parkway Station.

Another location further away from the route is noted at Laraghcon, where iron and an iron works were noted in the historical OS mapping, associated with the adjacent faulting, which has potential similarities to other faulting radiating around Porterstown to Clonsilla where the other metallic minerals listed above were noted.

Inclusions of pyrite may also be anticipated within Carbonaceous bedrock deposits. These may have high importance in the potential for chemical interactions and can lead to swelling should specific conditions arise.

9.4.7 Karstification and weathering of bedrock

No karst features are directly present along the route, however some potential features are noted in the surrounding areas between Louisa Springs and Carton Demesne, east of Maynooth where karstified bedrock units are present and weakness in the bedrock structure is concentrated due to faulting and discontinuities. There are two instances of caves mapped at Carton House from GSI Groundwater/Karst mapping. Weathered rock and karst conditions had previously been proven by coring for the adjacent Maynooth Eastern Ring Road project immediately south of the junction of regional roads R157 and R148. These findings informed the geophysical surveys and ground investigations conducted for the DART+ West project in these areas local to the changes in bedrock units and in particular near the anticline near OBG18 Pike Bridge as shown in Figure 9-3.

Anomalies were interpreted in the project geophysical surveys undertaken in the adjacent fields indicating possible karst voids which were thereafter also proven in limited direct intrusive investigations proving weathered profiles including cavities filled with clay and sand in the bedrock locally at BH20210, which was located closer to structure OBG18. The borehole log reported very strong, massive, brownish-grey, fine-grained limestone with many vugs as well as a cavity and fracture sets between 8.50m and 12.25 m BGL. The geophysical analysis suggests the local karstification is likely to between 3m and 5m over the majority but is likely to extend towards 20m to 25m depth BGL in the 3 zones identified.

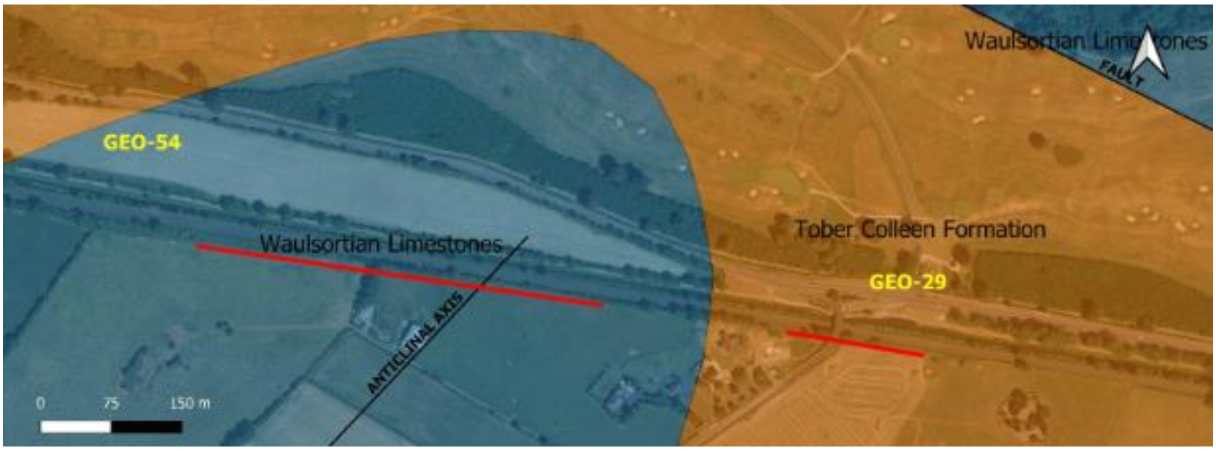

Figure 9-3 Bedrock units near OBG18 Pike Bridge (Apex Geophysics, 2020)

Refer to Chapter 11 Hydrogeology in Volume 2 of this EIAR for more details.

9.4.8 Contaminated soils

9.4.8.1 Site history

The Dublin SURGE (Soil Urban Geochemistry) Project (Glennon et al., 2012) provides widespread data on the constituents present in the topsoils around the city, investigated against historical industrial locations and analysed for contamination, particularly heavy metals, inorganic elements and to a lesser extent, organic pollutants such as Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs).

Heavy metals including lead, copper, zinc and mercury are especially elevated in the dockland, inner city and heavy industry areas, as well as originating from other human activities. Several of the investigated locations are within the assessed study area and provide useful references as to the potential for contamination in made ground.

Given the likelihood for encountering considerable volumes of made ground during construction, an investigation was scoped to identify the conditions present. Samples were selected from the exploratory boreholes for a range of environmental testing to assist the classification of soils and to provide information for the proposed design and impact assessment.

9.4.8.2 Scheduled environmental sampling and analyses

Environmental and chemical testing as required by the specification, including the Engineers Ireland Suite E, H, I, Organic Matter Content, Loss on Ignition, Acid Soluble Sulphate, Total Sulphate, Resistivity, Redox Potential and pH and sulphate testing was carried out by Element Materials Technology Laboratory in the UK.

Environmental tests were undertaken on relevant samples for several different purposes, to include:

- To investigate for potential contaminations of concern, associated with historical and industrial uses of the railway and adjacent lands and to classify the site in general.
- Potential presence of asbestos in railway building and in brakes system.
- Potential presence of fuels and other material, locomotive, carriage/bulk container/liquid container, and storage locations where leaks may have occurred.
- Potential reusability of ballast and soil materials likely to be arising during construction.

This factual geo-environmental information is summarised in the table below, identifying key criteria in relation to contamination. Where a parameter exceeds the Inert criteria in line with the limits accepted by licenced landfills, which are defined by the Environmental Protection Agency as part of their operating licence obligations, it would be designated as contaminated waste and is unlikely to be accepted at most Irish inert landfill facilities unless considered to be stable, non-reactive and within specific criteria (non-hazardous waste). The material does not need to be designated as waste unless it is necessary to excavate it and in that case it must be removed from the construction site and disposed of at an appropriate facility. However, if excessively high contamination is present, the material would potentially be designated as hazardous waste and would need to be removed to the relevant waste treatment or disposal facilities.

The following tests were carried out;

- 191 no. total suites of environmental/contamination laboratory testing;
  - 85 no. Engineers Ireland Suite E - Soil sample.
  - 47 no. Engineers Ireland Suite H - Inert waste landfill.
  - 59 no. Engineers Ireland Suite I - Non Hazardous/Hazardous WAC.
- 174 no. Organic Matter Content, Loss on Ignition.
- 612 no. Acid Soluble Sulphate, Total Sulphate.
- 330 no. pH and Sulphate.
- 3 no. Resistivity, Redox Potential; spread along the project sections as summarised in Table 9-11.

Table 9-11 Distribution of geo-environmental suites along the Study Area / project zones

Area	Zone	Suite E	Suite H	Suite I	Total
Connolly / GSWR	A	10	8	13	31
Docklands / Spencer Dock / MGWR	B	17	10	25	52
Mainline	C to F	52	29	21	102
Total	A to F	79	47	59	185

The most sensitive sections from an environmental and contamination perspective are in Zones A and B where the levels of pollution in the ground below the railway and its vicinity were assumed to be higher, consistent with historical uses in these areas.

9.4.8.3 Discussion of laboratory analyses

The results from the above Suites of environmental testing show high concentrations of a parameter or determinant is present in potentially contaminated soils from the Made Ground (clay) layer, which was typically sampled from between 0.5 and 3.0 m BGL.

In the Connolly and Docklands areas (parts of Zones A and B), the samples contained high levels of:

- Total petroleum hydrocarbons (C5-40) (many results including a maximum of 13,938 mg/kg).
- Total organic carbon (maximum of 9.61%).
- Mineral oil (some results including a maximum of 10,302 mg/kg).
- Total dissolved solids (maximum of 8,414 mg/kg).
- Sulphate (total) and sulphate as SO_4 (maximum of 4,691 mg/kg).
- Aliphatics and aromatics (maximum of 2,636 mg/kg).

- Cadmium (many results including a maximum of 6.6 mg/kg well in excess of the higher percentiles (>90%) of values observed in SURGE Project of 2.9 mg/kg).
- Chromium (many results including a maximum of 270 mg/kg well in excess of the higher percentiles (>90%) of values observed in SURGE Project of 52 to 57 mg/kg and maximum value of 262 mg/kg).
- Molybdenum (many results including a maximum of 0.78 mg/kg).
- Nickel (a single result of 126.8 mg/kg well in excess of the higher percentiles (>90%) of values observed in SURGE Project of 42 to 65 mg/kg).
- Zinc (maximum of 1,978 mg/kg, consistent with the higher percentiles (>90%) of values observed in SURGE Project of 1,740 to 2,330 mg/kg at Docklands and farther along the mainline route at Ratoath Estate).

In the GSWR & MGWR areas (remainder of Zones A and B), samples contained high levels of:

- Total organic carbon (maximum of 6.97%).
- Total dissolved solids (maximum of 2,180 mg/kg).
- Aliphatics and aromatics (maximum of 1,807 mg/kg).
- Mercury (maximum of 4.1 mg/kg, two samples well in excess of the higher percentiles (>90%) of values observed in SURGE Project of 0.9 to 1.5 mg/kg).
- Molybdenum (many results including a maximum of 0.90 mg/kg).
- Lead (maximum of 1,949 mg/kg, consistent with the higher percentiles (>90%) of values observed in SURGE Project of 1,510 mg/kg at Docklands but less than other maxima around the city of 3,120 mg/kg).

Elsewhere along the mainline (Zones C to F), samples contained high levels of:

- Total organic carbon (maximum of 5.32%).
- Total dissolved solids (maximum of 2,180 mg/kg).
- Aliphatics and aromatics (maximum of 1,807 mg/kg).
- Cadmium (many results including a maximum of 6.1 mg/kg well in excess of the higher percentiles (>90%) of values observed in SURGE Project of 2.9 mg/kg).

9.4.8.4 Implications for waste management

The GI and testing information confirms that where waste materials are arising due to the project, it will most likely lead to some contaminated waste materials requiring disposal. It must be noted that the determining factor in such cases is related more to the leachate derived from the waste materials. The analyses available from the investigations indicate that despite the high concentrations of heavy metals, these did not result in leachate during the analyses and hence do not affect result in exceedances of the Waste Acceptance Criteria (WAC) limits as provided (i.e. they appear to be immobile).

Waste Classification and WAC analysis will inform the appropriate disposal route. WACs were undertaken for the purpose of determining which landfill can receive generated waste. The Engineers Ireland Suite I and Suite H testing include both Solid Waste and Leachate Waste Acceptance Criteria, with results from Leachate used to determine where a sample is less than or greater than a landfill facility's licenced Inert Limit.

In some locations where elements were observed to be in excess of inert limits, comparisons with background concentrations according to the National Geochemical Atlas (2007) suggest that the surrounding areas typically do contain such high levels. Where a local or regional level has been observed in excess of inert limit for a determinant or element alone, it has not been deemed to be non-inert if this is the only criteria that has been observed, i.e. where a national study has analysed and identified local materials having a background concentration in excess of the defined limit for a particular element, the soil is assumed to be in line with natural regional characteristics as explained below, unless other potential contamination sources and elements are also identified.

Examples of constituents that are naturally high compared to the inert limits in the study area of national readings include:

- Molybdenum for which the order of 75% of the country exceeds the 'Inert' value and the identified value is close to the median.
- Nickel which is abundant across the country and city, in particular where underlain by impure limestone typically exceeds 22 mg/kg.
- Antimony, which has in excess of 1.1mg/kg in Dublin and Meath.
- Selenium which is often introduced via coal burning and is often assessed in excess of 1 mg/kg where underlain by impure limestone.
- Zinc which often exceeds 100 mg/kg in soils mirroring underlying impure limestones.

While organic carbon can be naturally occurring for many reasons, it can lead to differing behaviour in chemical reactions with the other constituents present. Dissolved Solids and Sulphate levels are often indicative of significant disturbance in Made Ground soil materials, regardless of original source material characteristics. Mineral Oil and Polycyclic Aromatic Hydrocarbons (PAHs) are also significant in several locations.

The majority of the above contaminants are typical of the eastern urban area due to the history of urban and industrial developments, leaks of Mineral Oil, potentially coming from underground heavy-duty electrical cables or other mechanical or industrial sites, various historic land-uses such as Vitriol works, Timber yards, and licenced waste facility will explain the presence of Sulphur and PAH.

9.4.8.5 Identification of hazardous materials

For the most significant areas of the site as mentioned above, the results of the investigation WAC samples were assessed using the HazWasteOnLine™ assessment tool by the ground investigation contractor to classify the potential for samples to meet soil recovery, inert, hazardous, or non-hazardous landfill criteria.

This is not a conclusive or final determination of the exact quantities or proportions of waste that will arise but is a suitable indicator of the potential quantities expected to arise and may be used to guide further design decisions and investigations to manage the waste arising from this location.

It is noted that the two holes with the worst categories in trackside areas within Zones A and B (OP1-OBD227 and S2-WSDP-01) are both close to adjacent industrial sites that were historically contaminated and comprise localised made ground deposits, albeit the former contained the TPH (C6-C40) petroleum concentration of 0.111% at shallow depth immediately under the ballast and the latter had slightly higher TPH (C6-C40) petroleum concentration of 0.147% several metres deeper down.

Within the Zone A Docklands area, the two worst categories assessed were at DCK-BH03A and DCK-BH04B, both at depths of 2.0m and likely to relate to prevalent water table levels and presence of hydrocarbons and contaminants and also causing the presence of notable ground gas concentrations including methane and carbon monoxide. The potential contaminated ground in this area is considered to be of high importance due to the significant degree of soil contamination on a local scale.

Within the Zone A Connolly Station, a number of sample waste categories identified hazardous contaminants, namely at CNLY-OP01, CNLY-OP02, CNLY-OP04, CNLY-OP05, WS04, CNLY-WS05, and CNLY-WS02. The hazardous contaminants identified from these samples are carcinogenic and mutagenic TPH (C6 to C40) petroleum group materials, effectively from rail diesel engines, fuel storage or spills, leaks of mineral oils/hydraulic fluids associated with the railway and adjacent site uses. The potential contaminated ground in this area is similarly of high importance due to the significant extent of soil contamination on a local scale.

As a result of these classifications, the assessment of reuse from materials arising in Zones A and B are assumed to be lower than elsewhere, allowing for an assumed volume representing approximately 15% of the arisings that would be considered as requiring disposal or treatment. Comparatively, the resulting assessment of potential waste categorisations and assignment of indicative sample waste categories for Zones C-F can also be seen in Table 9-12. Based on the HazWasteOnLineTM waste assessment, the samples in the areas of Zones C and D were found to fall within Category A and are classified as being free from contamination. The ground in this area is of low importance as the extent of soil contamination is minor on a local scale.

Asbestos fibres were detected in a single sample in Zone E but were below the hazardous level of 0.1% (GII, 2021). Asbestos was also tested in several locations in the areas of the M50. Extensive off-track environmental testing in Zones C-F is still ongoing, however trackside testing has been mostly complete, and the results can also be seen in Table 9-12.

Table 9-12 Sample waste categories in Zones A to F following assessment HazWasteOnLine™ waste acceptance criteria (GII, 2021)

Sample ID	Sample Depth (m)	Material Type	LoW Code	Waste Category
Zones A and B				
WSDP3425	1.20	15/12/2020	17 05 04	Category B1
OP1-OBD227	0.50	12/12/2020	17 05 03	Category D
WS01220	0.80	12/12/2020	-	No Category
WSOBD223	1.20	16/12/2020	17 05 04	Category B1
WSOBD277	1.20	16/12/2020	17 05 04	Category B2
WSOBD224	1.20	17/12/2020	17 05 04	No Category
WSOBD225	1.20	19/12/2020	17 05 04	No Category
WSOBD227A	1.20	19/12/2020	17 05 04	No Category
WS01800	2.20	19/12/2020	17 05 04	No Category
STU-05	0.50	05/01/2021	-	No Category
STU-006	0.50	06/01/2021	17 05 04	Category B1
WSDP-01770	0.50	06/01/2021	17 05 04	Category B1
STU-015	0.50	08/01/2021	-	No Category
OP2-OBD227	0.50	08/01/2021	17 05 04	Category B1
WS0BD227B	1.20	05/01/2021	17 05 04	No Category
WS0BD227B	2.00-3.00	05/01/2021	17 05 04	No Category
WS01250	1.20	06/01/2021	17 05 04	Category B1
WS01170	1.20	07/01/2021	17 05 04	No Category
S2WS01	1.20	14/01/2021	17 05 04	Category B1
S2WS01	2.00-3.00	14/01/2021	17 05 04	Category B2
S2WS01	3.00-4.00	14/01/2021	17 05 04	Category D
S2WS01	4.00-5.00	14/01/2021	17 05 04	Category C
OP2OBD222	0.67	15/01/2021	17 05 04	No Category
Docklands (Zone A)				
DCK-BH03A	0.50	Made Ground	17 05 04	No Category
DCK-BH03A	1.00	Made Ground	17 05 04	Category B1
DCK-BH03A	2.00	Made Ground	17 05 03	Category D
DCK-BH03A	3.00	Made Ground	17 05 04	Category B2
DCK-BH02B	0.50	Made Ground	-	No Category
DCK-BH02B	1.00	Made Ground	-	No Category
DCK-BH02B	2.00	Made Ground	17 05 04	Category B2
DCK-BH02B	3.00	Made Ground	17 05 04	Category B2
DCK-BH04B	1.00	Made Ground	17 05 04	Category B1
DCK-BH04B	2.00	Made Ground	17 05 03	Category D
DCK-WS05B	1.50	Made Ground	17 05 04	Category B2

Sample ID	Sample Depth (m)	Material Type	LoW Code	Waste Category
DCK-WS05B	2.00-3.00	Made Ground	17 05 04	No Category
DCK-WS05B	3.00-4.00	Made Ground	-	No Category
DCK-WS06B	1.40	Made Ground	17 05 04	No Category
DCK-WS06B	2.00-3.00	Made Ground	-	No Category
DCK-WS07B	1.00-1.20	Made Ground	-	No Category
DCK-WS07B	2.00-3.00	Made Ground	17 05 04	
DCK-WS07B	3.00-3.30	Made Ground	17 05 04	No Category
DCK-WSDP08A	2.40-2.90	Made Ground	17 05 04	Category B1
DCK-WSDP08A	3.60-4.00	Made Ground	-	No Category
DCK-WSDP06A	1.90-2.10	Made Ground	-	No Category
DCK-BH06B	1.00	Made Ground	17 05 04	No Category
DCK-BH06B	2.00	Made Ground	-	No Category
DCK-WS07A	1.70-2.70	Made Ground	-	No Category
DCK-WS07A	2.70-3.40	Made Ground	17 05 04	Category B1
DCK-WS05B-1	1.50-2.50	Made Ground	17 05 04	Category B2
DCK-WS05B-1	2.50-3.50	Made Ground	-	No Category
DCK-WS05B-1	3.50-4.50	Made Ground	17 05 04	No Category
DCK-WS08B	1.90-2.00	Made Ground	17 05 04	No Category
DCK-WS05B	1.50	Made Ground	17 05 04	Category B2
DCK-WS05B	2.00-3.00	Made Ground	17 05 04	No Category
DCK-WS05B	3.00-4.00	Made Ground	-	No Category
DCK-WS06B	1.40	Made Ground	17 05 04	No Category
DCK-WS06B	2.00-3.00	Made Ground	-	No Category
DCK-WS07B	1.00-1.20	Made Ground	-	No Category
DCK-WS07B	2.00-3.00	Made Ground	17 05 04	
DCK-WS07B	3.00-3.30	Made Ground	17 05 04	No Category
DCK-WSDP08A	2.40-2.90	Made Ground	17 05 04	Category B1
DCK-WSDP08A	3.60-4.00	Made Ground	-	No Category
DCK-WSDP08A	1.90-2.10	Made Ground	-	No Category
Connolly (Zone A)				
CNLY-OP01	0.00-1.00	Made Ground	-	No Category
CNLY-OP01	1.60-1.70	Made Ground	17 05 03	Category D
CNLY-OP02	0.00-1.00	Made Ground	17 05 04	No Category
CNLY-OP02	1.30	Made Ground	17 05 03	Category D
CNLY-OP03	0.00-1.00	Made Ground	-	No Category
CNLY-OP03	1.50-1.60	Made Ground	17 05 04	Category B1
CNLY-OP04	0.00-1.00	Made Ground	17 05 04	No Category
CNLY-OP04	1.50	Made Ground	17 05 03	Category D
CNLY-OP05	0.00-1.00	Made Ground	-	No Category
CNLY-OP05	1.30	Made Ground	17 05 03	Category D
WS04	2.40-2.60	Made Ground	17 05 03	Category D
WS04	3.40-3.60	Made Ground	17 05 03	Category D

Sample ID	Sample Depth (m)	Material Type	LoW Code	Waste Category
CNLY-WS05	1.40-1.60	Made Ground	17 05 04	No Category
CNLY-WS05	2.40-2.60	Made Ground	-	No Category
CNLY-WS05	3.40-3.60	Made Ground	17 05 03	Category D
CNLY-WS01	2.40-2.60	Made Ground	17 05 04	Category B1
CNLY-WS01	3.40-3.60	Made Ground	17 05 04	No Category
CNLY-WS02	1.40-1.60	Made Ground	17 05 04	No Category
CNLY-WS02	2.40-2.60	Made Ground	17 05 03	Category D
CNLY-WS02	3.40-3.60	Made Ground	-	No Category
CNLY-WS03	2.40-2.60	Made Ground	-	No Category
WS03A	1.00-1.20	Made Ground	-	No Category
WS03A	2.00-2.30	Made Ground	17 05 04	Category B1
CNLY-OP07	0.85	Made Ground	17 05 04	Category B2
CNLY-OP06	0.90	Made Ground	-	No Category
Zone C (Broombridge to Ashtown)				
7TH LOCK ST03A	0.70	05/02/2021	15 05 04	No Category
7TH LOCK ST03A	0.80			
WS01600	1.90-2.90	Made Ground	15 05 04	No Category
WS02680	1.90-2.90	Made Ground	15 05 04	No Category
WS2180	1.30-2.30	Made Ground	15 05 04	No Category
WS02180	3.00-3.80	Clay	15 05 04	Category A
WSDP03590	1.17	Made Ground	15 05 04	No Category
WS03590	1.90-2.00	Clay	15 05 04	No Category
WSDP03205	0.67	Made Ground	15 05 04	Category A
WSDP03205	1.90-2.00	07/04/2021	15 05 04	Category A
OBG5B-ST02C	0.77	07/04/2021	15 05 04	No Category
Zone D (Dunboyne)				
DB-WS00540	1.20-1.50	Made Ground	17 05 04	No Category
DB-WS01150	1.00	Made Ground	17 05 04	No Category
DB-WS04880	0.80	Made Ground	17 05 04	No Category
WS06880	1.20	Made Ground	17 05 04	No Category
DB-WS07100	1.90	Clay	17 05 04	No Category
WS02840	1.90-2.30	Clay	17 05 04	No Category
DB-WS02360	1.20	Made Ground	17 05 04	No Category
Zone E (OBG13, OBG14, OBG16 & OBG18)				
WS11180	1.90	Made Ground	17 05 04	No Category
WS11500	0.70	Made Ground	17 05 04	Category A
OBG13-ST02A	1.20-1.60	Clay	17 05 04	Category A
OBG13-ST03B	0.70	Made Ground	17 05 04	No Category
WSOBG13	0.80	Made Ground	17 05 04	No Category
WS14100	0.60		17 05 04	Category C1
WS14270	0.70		17 05 04	No Category
WSOBG14	0.70		17 05 04	Category C

Sample ID	Sample Depth (m)	Material Type	LoW Code	Waste Category
WSOBG14	1.20		17 05 04	Category A
OBG14-OP01	0.70		17 05 04	No Category
WS14100	1.90		17 05 04	Category A
WS14100	2.90		17 05 04	No Category
WS14270	1.90		17 05 04	Category A
WS14270	2.90		17 05 04	No Category
WS14540	3.50		17 05 04	No Category
WS15520	2.50-3.00		17 05 04	No Category
WS15680	1.20		17 05 04	No Category
WS15680	2.00		17 05 04	Category A
WS15960	1.40-2.00		17 05 04	Category A
WS16090	2.10-2.40		17 05 04	Category A
WS16035	1.90-2.10		17 05 04	No Category
WS16710	0.97		17 05 04	No Category
WS16710	1.90-2.40		17 05 04	No Category
WSOBG16A	1.90		17 05 04	No Category
LOUISE-ST03C	1.17		17 05 04	No Category
STU062	0.95		17 05 04	No Category
WS16090	2.10-2.40		17 05 04	No Category
WSOBG18	0.60	Made Ground	17 05 04	No Category
WS18600	0.60	Made Ground	17 05 04	No Category
WS01600	1.90-2.90	Clay	17 05 04	No Category
WS02680	1.90-2.90	Clay	17 05 04	No Category
WS2180	1.30-2.30	Made Ground	17 05 04	Category A
WS0BG18	1.20-1.60	Made Ground	17 05 04	No Category
WS19320	1.90-2.90	Clay	17 05 04	No Category
ST01(B)-OBG18	0.65	Made Ground	17 05 04	No Category
WSDP20910	1.90-2.70	Clay	17 05 04	Category A
WSDP21000	2.05-2.90	Clay	17 05 04	No Category
WS21390	1.90-2.20	Made Ground	17 05 04	No Category
Zone F (Maynooth - Kilcock)				
OBG21ST01B	0.87	Made Ground	17 05 04	No Category
OBG23-ST03B	0.97	Made Ground	17 05 04	No Category
OBG24-ST01A	0.87	Made Ground	17 05 04	No Category
OBG24-ST03A	0.77	Made Ground	17 05 04	Category A
WSOBG21	1.90-2.20	Made Ground	17 05 04	No Category
EXT-WS01480	1.90-2.50	Made Ground	17 05 04	No Category
WS03220	1.90-2.15	Clay	17 05 04	No Category
EXT-WS03470	0.77	Made Ground	17 05 04	No Category
EXT-WS03470	1.90-2.00	Clay	17 05 04	No Category

Table 1 Potential Waste Categories for Disposal/Recovery

Waste Category	Classification Criteria
Category A Unlined Soil Recovery Facilities	Soil and Stone only which are free from[5] anthropogenic materials such as concrete, brick, timber. Soil must be free from "contamination" e.g. PAHs, Hydrocarbons[6].
Category B1 Inert Landfill	Reported concentrations within inert waste limits, which are set out by the adopted EU Council Decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 and Annex II of Directive 1999/31/EC (2002). Results also found to be non-hazardous using the HWOL[7] application.
Category B2 Inert Landfill	Reported concentrations greater than Category B1 criteria but less than IMS Hollywood Landfill acceptance criteria, as set out in their Waste Licence W0129-02. Results also found to be non-hazardous using the HWOL application.
Category C Non-Haz Landfill	Reported concentrations greater than Category B2 criteria but within non-haz landfill waste acceptance limits set out by the adopted EU Council Decision 2003/33/EC establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 and Annex II of Directive 1999/31/EC (2002). Results also found to be non-hazardous using the HWOL application.
Category C 1 Non-Haz Landfill	As Category C but containing < 0.001% w/w asbestos fibres.
Category C 2 Non-Haz Landfill	As Category C but containing >0.001% and <0.01% w/w asbestos fibres
Category C 3 Non-Haz Landfill	As Category C but containing >0.01% and <0.1% w/w asbestos fibres.
Category D Hazardous Treatment	Results found to be hazardous using HWOL Application.
Category D 1 Hazardous Disposal	Results found to be hazardous due to the presence of asbestos (>0.1%).

Figure 9-4 Waste Classification Categories (GII, 2021/2022)

Such contaminated materials, if arising from these worst locations, are anticipated to require disposal as hazardous waste unless the level of pollution can be successfully mitigated or assessed to be use on site within acceptable levels, i.e., assessing potential risks posed to human health, flora and fauna in the environments consistent with the needs of the proposed development.

9.4.9 Waste Handling / Landfill Sites

Several licenced waste handling sites are identified from EPA mapping, predominantly in the North Wall area.

Further details of waste management and transport to suitable licensed waste handling facilities are discussed in Chapter 19 Material Assets: Resource and Waste Management.

9.5 Description of potential impacts

9.5.1 Do Nothing Scenario

In the Do-Nothing scenario, ongoing maintenance and renewal of the existing mainline infrastructure is likely to require more frequent intervention and replacement of materials such as ballast, particularly where soft subgrade and/or flooding or contamination are present.

In the current conditions, some of the potentially contaminated materials present in the ground could be subject to ingress of water spreading the contamination further below the ground or allowing it to disperse up to the surface and into the adjacent canal. This is perceived to be a negative Do-Nothing effect, on the adjacent soils and also on canal hydrological regime and the associated ecosystems.

There is no impact assessed on land and soils at the existing level crossings in the Do-Nothing scenario.

9.5.2 Potential construction impacts

9.5.2.1 Structures

9.5.2.1.1 Bridge Structures

The construction of new bridges and works on existing bridges along the railway corridor will require excavation of the in-situ ground, as well as retaining structures, foundations and approach ramps with associated works. These bridges and modifications of other existing structures are listed below:

- OBD228 (Zone A) – a multi-span bridge where 5 spans will be moved and reconstructed, with new piers and piled foundations.
- Ashtown Footbridge (Zone C) – a new footbridge is proposed for a shared use of pedestrian, PRMs and cyclists will be constructed in CORTEN steel structure providing a minimal maintenance in the future. The structural set are composed by a ramp system developed in two sections above both platforms. The Northern ramp partially overlaps the Canal which will receive the piles to support the structure. Dewatering of the canal will be required.
- Ashtown Underpass (Zone C) – an underpass is proposed on the Dublin to Sligo Railway Line (the Connolly to Maynooth line) between Ashtown Station and Navan Road Parkway Stations. The construction sequence of the Ashtown Underpass has been split in two sections: the rail underbridge, and the canal aqueduct. For the dewatering works, approx. 50 m length of canal will be dewatered to facilitate the construction of the underpass and aqueduct. The canal is retained by two temporary new clay dams either side of the structure.
- Coolmine (Zone C) – a single-span pedestrian, cycle and mobility bridge will be supported on reinforced concrete spread foundations and with an approach viaduct ramp forming the lower sections. It is not envisaged that dewatering the canal will be required.
- Porterstown (Zone C) – a two-span structure is proposed to cross the railway and canal. This will have reinforced concrete spread foundations. The southern ramped approach will begin as a reinforced earth / retaining wall structure running parallel to the railway line. The northern ramped approach will tie in to the old Porterstown Road.
- Clonsilla (Zone C) – a two-span bridge with ancillary approach ramps comprising reinforced concrete walls and reinforced earth, which rise parallel to the railway line. The structure is to be supported on spread foundations. The pier is envisaged to require dewatering and damming of the canal.
- OBG14 Cope bridge (Zone E) – this bridge is located east of Leixlip Confey Station and consists of a 7.6 m wide span bridge operating as a single lane shuttle system. OBG14 will require deck modification to allow the required clearance for the line electrification, which requires the removal of the upper part of the existing arch bridge and maintaining the vertical walls. The precast concrete wall blocks shall be placed and anchored to the existing walls. Lastly, the precast concrete arch deck shall be placed on the concrete wall blocks. Additionally, two new pedestrian and cycle bridges are proposed alongside the existing historic bridge, spanning both the railway line and the Royal Canal.

- Barberstown (Zone E) – this is a single-span bridge to be founded on skeletal type abutments with approach embankment filling requiring import materials and reinforced concrete and/or reinforced earth wingwalls.
- OBG23A (Zone F) – this bridge facilitates an alternative access road to the Depot. It is a five-span precast concrete bridge, which will require approach embankments on both sides, retaining wingwalls as well as abutments.
- OBG24 (Zone F) – Overbridge OBG24 requires demolition and replacement with a new structure built in a new location to facilitate a new access point.

The above structures will likely have a *small adverse, permanent* effect in relation to material excavation requirements to achieve the required foundations. These shall have a secondary or indirect small adverse effect to provide the required imported fill materials from suitably licensed quarries or other on-site sources, where acceptable fill materials are present.

The bridges requiring approach embankments shall each require a much larger volume of acceptable general fill materials to be imported to site or brought from other sources where suitable transport routes are present for haulage. Although the volumes required for these routes are considered modest, the impact of moving such large volumes of material over long distances can be more significant if suitable sources of materials cannot be identified from either within or from close proximity to the site.

The estimated volumes of earthworks and ballast materials arising due to the removal of these structures and required to be imported for the new construction are presented in Table 9-16.

There are also *small adverse, not significant temporary* effects during construction, most likely where excavating for foundations within the linings of the canal.

9.5.2.1.2 OHLE Foundations

The standard foundation for the Overhead Electrification System (OHLE) will generally be concrete bored pile foundations. Other types of foundations will be used where there are constraints such as different ground conditions or existing utilities that would be potentially at risk of being damaged during construction. In other cases, the OHLE will be anchored directly to existing walls along the MGWR (Zone B). Table 9-13 presents the estimated volumes of arisings on assumed pile lengths. This estimate is based on a preliminary pile length of typically 6m to 9m, the longer being required in the eastern parts of Zones A and B where glacial till and rock were observed to be deeper.

Table 9-13 OHLE estimated materials arising

Estimated Materials Arising from OHLE Foundations Piling			
Zone	Estimated Bored Volumes - Arisings (m^3)	Ballast Strip (m^3)	Total Estimated Material Volumes (m^3)
Zone A	100	100	200
Zone B	1,500	700	3,200
Zone C	2,100	1,100	3,200
Zone D	1,800	1,400	3,200
Zone E	1,700	1,600	3,300
Zone F	2,000	300	2,300
Total	9,200	5,200	14,400

For the vast majority, except those few cases where an anchored structural solution will be adopted, the indirect effect caused by the excavation of material to allow the construction of foundations along the proposed development will have a *small adverse*, *not significant* effect to soils and geology of the area. Where possible the arisings may be suitable for reuse on site subject to meeting materials classification and specification requirements however a further refinement is required to identify the proportions of these volumes arising that may contain contaminated materials requiring disposal to a suitably licensed facility.

As mentioned in Section 9.4.6 of this chapter, the presence of pyrite may locally be anticipated within the bedrock deposits, which may be susceptible to expansion when exposed to air, moisture, and heat. The potential presence of pyrite within the bedrock deposits may result in swelling following any chemical interactions that may occur during construction of the piles. However, the conditions are unlikely to lead to exposure to air and therefore the potential for such reactions is considered to be of low likelihood. It is also expected that these must be concreted and filled in promptly during the construction due to the constraints present and likely working arrangements.

9.5.2.1.3 Connolly Station (Zone A)

The construction works for the new Connolly Station will involve using reinforced concrete pile caps with micropiles and micropiles inside the walls for future columns. There is a potential risk the piling could create vertical pathways for any pre-existing contamination, or any accidental contamination introduced during construction. This could also result in disturbance to groundwater however, subject to specification and design for piling, as well as the selection of plant equipment and methodology, the resulting significance of this *small adverse* impact is slight.

9.5.2.1.4 Spencer Dock Station (Zone B)

A new station is proposed at Spencer Dock. Track lowering is proposed to accommodate the new alignment under Sherriff Street Upper Bridge, with platforms and subsurface construction to accommodate sufficient structural and OHLE clearance. The overall change from existing ground level to proposed track level is approximately 2.4 metres however the structural envelope will also require deeper and wider excavations.

Works in the Spencer Dock area will include construction of the new Spencer Dock Station, compounds, an access ramp to the Docklands compound, Spencer Dock attenuation tank, Spencer Dock substation and permanent way works.

The construction works for the Docklands compound will include fill / made ground requiring removal of successive soil layers until the required surface level is reached. Construction of the Spencer Dock Station will require retaining walls as the platform level is located below the station entrance. The foundation of the station will be constructed as a raft foundation that will be connected to the retaining walls. The raft foundation is designed to compensate for the ground water pressure beneath the station. During the construction works groundwater management will be required, which is discussed in Chapter 5 Construction Strategy of this EIAR.

The Spencer Dock attenuation tank will be constructed north of OBD228 Sheriff Street bridge. The stormwater attenuation tank will share the piled wall with permanent way constructions however, the rest of the perimeter will be constructed with new piled walls.

As discussed in Section 9.4 of this chapter, the area around Spencer Dock is underlain by extensive deposits of limestone derived gravel units. The gravels can act as effective aquifers however, due to the history of development in the area including past industrial activities, groundwater contained within the gravels is known to be contaminated. The importance of the potentially contaminated ground is high and the excavations in the area may require treatment resulting in a *small adverse* magnitude of impact.

The proposed development of the Station and the track lowering at Spencer Dock will require an excavation of approximately 100,200 m^3. 50% of the volume from track lowering earthworks and 35% of the Spencer Dock Station earthworks was estimated as suitable for construction and is assumed that this will be reused as embankment fill elsewhere along the route unless more suitable local material sources and destinations can be identified. Due to the possibility of contamination in this area the assumed reuse is reduced.

The proposed development of the new station at Spencer Dock in the Docklands will have an *indirect slight permanent* adverse effect due to the required disposal and treatment of the excavated materials. The material will be reused and/or treated where economically / environmentally desirable as fill material on the development to minimise the disposal impacts. This may be dependent on a suitable haulage method to locations on site requiring such materials where present and/or treated to achieve acceptable criteria meeting specification requirements.

Table 9-14 Estimated earthworks balance –Spencer Dock Station

Estimated earthworks balance in the New Spencer Dock Station				
New Spencer Dock Station	Estimated Volumes - Arisings (m³)	Estimated Reusability	Estimated Reused Volumes (m³)	Disposed Volume (m³)
Station (including attenuation tank)	74,200	35%	26,000	48,200
Track lowering	26,000	50%	13,000	13,000
Total	100,200	39%	39,000	61,200

9.5.2.1.5 Underpass Structures (Zone C)

The project requires construction of the new underpass crossing beneath the Royal Canal and the railway in Ashtown. The construction phase will involve temporary works to allow the underpass to be built, such as temporary cofferdams, and disruption of the normal flow within the canal. The underpass will effectively consist of two bridges: a rail underbridge adjacent to a canal aqueduct. Both of their super and sub-structures will be structurally independent from one another.

A significant part of the design is the approach retaining walls which will require embedded pile construction with permanent linings in an area where high groundwater levels are known to be present. The structure will include piled retaining walls, kingpost retaining walls and reinforced concrete retaining walls from each side of the alignment below the canal and railway, with the foundation of the road to be provided on a reinforced concrete slab. The construction of the underpass will result in a *small adverse* impact to soils and rock of the site. To reduce the waste arisings, these materials may be suitable for use as general embankment fill at another part of the site depending on the construction programme and suitable haulage route(s).

9.5.2.1.6 Depot Access Road and OBG23A (Zone F)

The new depot will include a wide area of 32.6 Ha. The proposed development site will require the excavation of the existing topsoil and large volume of earthworks will be needed in order to facilitate the construction of the EMU depot and the access road.

Table 9-15 Estimated earthworks balance – New Depot

Estimated earthworks balance in the Depot						
New Depot	Estimated Volumes - Arisings (m³)	Estimated Reusability	Estimated Reused Volumes (m³)	Fill (m³)	Local Balance (+surplus-import)	Disposed Volume (m³)
Depot	109,930	65%	71,460	280,000	-208,540	38,470
Compensatory Storage Area	123,000	65%	79,950	0	79,950	43,050
Access Road (L5041 & OBG23A)	12,940	65%	8,410	191,330	-182,920	4,530
Total	245,870	65%	159,820	471,330	-311,510	86,050

These volumes as presented in Table 9-15 assume no appreciable excavation below existing ground levels other than for topsoil strip to remove any soft and organic deposits in advance of construction. It is generally unlikely that all arising materials are 100% suitable for reuse plus some normally require a modest amount of excavation and replacement of soft soils, which would further increase the estimated fill requirement volumes.

Ground improvement measures such as surcharging and/or construction hold periods are assumed to be provided to control the primary consolidation of the compressible materials and any associated secondary or long-term creep. Despite this potential mitigation, large volumes of earthworks materials will still need to be sourced and brought to site from suitably licensed locations. The fill import required represents a *moderate to significant* impact dependent on the availability of land and materials that can be exploited and brought to site economically.

While materials may be available elsewhere on the site, it is unlikely that such volumes can be brought around the site unless transported by rail which would be in itself a moderate significant short-term construction stage impact and this may not necessarily be feasible given associated operational constraints, particularly at level crossings.

The importance of land in this area is medium to high and the current agricultural use is reliant on the use of the topsoil. The excavation and removal of topsoil will result in a *moderate to significant adverse and permanent* effect to soils and geology of the depot area, with such a large area being locally sealed and compacted. There will also be an *indirect significant negative* effect, in finding and transporting suitable materials to site to fill to the required levels. The buildings and service slab will be built on isolated concrete foundations.

There are gravels in the western part of the depot area, which can be reused for embankment construction where possible.

9.5.2.1.7 New Technical Buildings

Proposed Substations

Substations will be constructed on site with standard construction methods and with standardized dimensions of 50 x 13 m and 6 m height. Each structure will require relevelling of the site and removal of material to build shallow foundations. Overall, the effect of the substations will be likely *small and imperceptible* to soils and geology of the site.

Proposed SER/REB, TER, PSP & ASP Buildings

All the technical buildings will be prefabricated, they will need land levelling and excavation under the building footprint to allow the pouring of lean concrete base. Therefore, it will constitute a *negligible, and imperceptible* effect for the ground.

9.5.2.2 Compensatory storage area (Zone F)

The compensatory storage in the area of OBG23 and within the lands of the proposed depot will require approximately 123,000 m^3 of overburden. The proposed compensatory storage at OBG23 will involve modest reductions in topographic levels, with a local piece of raised ground being lowered by up to 3m to the east of Lyreen River.

Within the proposed depot lands realignment of the watercourse itself is required in addition to a proposed flood compensatory storage. Due to the predominantly flat topography of the area, a larger land take is required compared to the compensation storage near OBG23. The most suitable lands for the proposed flood compensation storage are identified as the lands between and adjacent to the historic channel and the current route of the channel. Further details on the construction of the proposed compensation storage area are discussed in Chapter 5 of this EIAR.

There is potential for pollutants derived from construction materials to be mobilised by flood waters. Given its susceptibility to flooding and the considerable volume of earthworks required, the works required for the compensatory storage poses the greatest risk of pollution as a result of flood events.

9.5.2.3 Track lowering along the route in general

Where the railway will be lowered a new drainage system or drainage modifications are provided to drain surface water, preventing the track formation from becoming softened and reducing the flooding of the track, as well as reducing potential contamination from the railway line going into the canal.

Most of the excavated material may be suitable for use as general embankment fill at another part of the site depending on the construction programme and suitable haulage route(s). The impact of the unsuitable soil for reuse will result in a *negligible, imperceptible, and permanent* effect to soils and geology.

Table 9-16 Estimated earthworks balance – Track lowering & at associated new structures

Zone	Estimated Volumes Arising (m^3)	Estimated Cut – Ballast (m^3)	Estimated Cut - Soil (m^3)
Zone A	3,370	1,470	1,900
Zone B	56,460	10,260	46,200
Zone C	58,800	340	58,460
Zone D	4,810	1,410	3,400
Zone E	9,920	720	9,200
Zone F	57,120	3,260	53,860
Total	190,480	17,460	173,020

9.5.2.4 Track lowering adjacent to retaining walls

In Zone B, where the MGWR will be lowered locally, there is a *negative, moderate adverse, locally significant* effect on the stability of the existing retaining walls. Such walls are designed to historic requirements, which were essentially established via empirical observations and refinement of principles devised by engineers based on lessons learned from other sites, trials and failures such as Burgoyne (1853).

If assessed in accordance with modern design procedures, lowering of the tracks will reduce the passive stability of the mass gravity masonry retaining wall structures, particularly on the southern side of the MGWR where the canal embankments are also present and pose a significant additional retained height plus the geotechnical risks inherent in having high water levels above the structure and retained soils. Design mitigation measures are assumed to be required locally to demonstrate or maintain stability.

9.5.2.5 Bridge deck reconstruction and deck lifting

Bridge deck reconstruction or lifting the deck were considered as alternative solutions, where feasible, instead of lowering the track. Both solutions aimed to create more clearance and provide a better solution. The decisions on these designs do not result in any significant effect on soils and geology, although minor amounts of fill or surfacing materials may be required to realign pavements or footpaths on the approaches.

9.5.2.6 Organic matter, compaction and sealing

Organic matter is present in topsoils at shallow depth and supports growth. These will be removed and stored for reuse which will have neutral effects assuming this is stored properly and spread to meet landscaping or agricultural requirements. There will also be *slight to moderate adverse* construction effects during the stockpiling, temporary to short term in duration and essentially reversible when the topsoil is reused.

The proposed development will include approach embankments for level crossings as well as amendments to existing embankments and cuttings, that would induce the compaction of in-situ material. As a result, there will be compaction of the soils from the construction due to the filling and the activity of machinery at the surface. Sealing of the existing soils will also occur. The effects due to compaction and sealing from the proposed development will range from *not significant to slight*.

At the depot and associated lands for compensatory flood storage, significant changes in the soils will be required, sealing and compacting over a large area. The soils present on the margins of the flood area may also be susceptible to local erosion depending on the underlying soil type, ground cover and velocity of flows around the margins of soil slopes.

9.5.2.7 Spillages of Fuel and Oil

Unmitigated, there is a potential risk of localised contamination from construction materials leaching into the underlying soils by exposure, dewatering or construction related spillages resulting in a permanent negative impact on the soils. There is also the potential for hydrocarbon release during construction works and the use of vehicle and construction plants, which may contaminate the soils. In the case of soils, the impact is *negative and slight* as the requirement of good construction practices will necessitate the immediate excavation / remediation of any such spillage resulting in a very low risk of pollution to the soils and consequently the underlying aquifers.

There is a potential risk of localised contamination of groundwater bodies due to construction activities i.e., construction spillages, leaks from construction plant and material etc. resulting in a temporary, small impact on these water bodies.

With the electrification of the proposed development and its consequent reduction of pollution from Fuel and Oil, via leaks onto the tracks there will no longer be a pathway for this type of contamination in the soil (railway line ballast) to a sensitive receptor (in the canal) during periods of flooding. This will result in a *minor beneficial, indirect, slight to moderate, and permanent* effect to soils and geology of the area.

9.5.2.8 Disposal and Reuse of Material

The materials to be reused will be most likely combinations of previously made ground that is not potentially contaminated and as much of the glacial till / boulder-clay / gravels or sand deposits arising from the required excavations. Some of these are unlikely to be suitable without some processing hence the reusability percentage as assumed in preceding sections above. All suitable material excavated within the cut sections shall be used to the greatest possible degree as fill material on the development to minimise both the disposal impacts and import requirements, where programming and mass haulage constraints allow. It is assumed that arisings may be temporarily stored in some of the construction compound areas and moved to a suitable location for filling. The unsuitable material will be disposed of in a suitable licensed facility, in accordance with current regulations. Overall, there will be a likely *negative, slight and permanent* effect on the soils and geology of the area.

Contaminated arisings from some of the sites may exceed the likely advised Geochemically Appropriate Levels (GALs) identified by the Geological Survey for Soil Recovery Facilities (SRF) based on research on the National Soil Database on the defined geochemical domains related to underlying subsoil and bedrock units (Glennon et al., 2020). This report identified levels consistent with background levels in Irish soils and rocks where previous EPA recommendations (2017) did not necessarily give practicable levels due to natural variations in metals contents.

The Land Quality Management / Chartered Institute of Environmental Health Suitable 4 Use Limits (S4Uls) Human Health Risk Assessment provides a framework for assessing the suitability of materials to be reused within a project site despite exceedances in soil geochemical constituents but dependent on the setting and associated source-pathway-receptors. Implementation of assessments in accordance with these criteria can help to identify uses elsewhere within a site boundary that can be achieved with materials that would otherwise have to be sent to landfill if removed from the site.

Where material is to be removed from the site it will have to be undertaken by a Contractor competent to handle such works and using appropriately licenced facilities. Considerable additional testing may be required along the various sites to manage this process and/or to allow transfer of materials, whether destined to be waste brought to a landfill or treatment facility or to be used as fill elsewhere on the project.

9.5.2.9 *Imported fill*

Structural fill will be required at and around concrete foundations, abutments, embankments and retaining walls, as well as at reinforced earth walls used at Coolmine and in other level crossings. The requirements of imported material will result in a moderate adverse permanent effect. General fill requirements are also provided in Table 9-17, excluding those arising at the depot and associated compensatory storage area.

The volume of imported fill is derived assuming between 50% and 65% reuse of materials arising from within the site. This is a conservative assumption allowing for lower values where more made ground and potential contamination is present on-site and expecting that the glacial till soils should broadly be reusable as excavated except where soft deposits are present.

Table 9-17 Estimated earthworks balance Zones A to F

Earthworks balance in the project								
Zone	**Estimated Excavation – Arisings (m^3)**	**Estimated Excavation – Ballast (m^3)**	**Assumed Reusability**	**Estimated Reused Volumes (m^3)**	**Total Fill Required (m^3)**	**Local Balance (+surplus-import)**	**Estimated Import – Ballast (m^3)**	**Estimated Disposal Volume (m^3)**
Zone A	2,020	1,570	50%	1,010	720	290	720	2,580
Zone B	47,700	10,960	50%	23,850	18,120	5,730	7,860	34,810
Spencer Dock Station	73,000	0	35%	25,550	0	25,550	0	47,450
Zone C	60,560	1,400	65%	39,360	14,300	25,060	340	22,590
Zone D	5,200	2,740	65%	3,380	2,500	880	1,140	4,560
Zone E	10,870	2,320	65%	7,070	127,100	-120,030	720	6,130
Zone F	48,540	3,570	65%	31,550	244,710	-213,160	19,400	20,560
Depot	109,930	0	65%	71,450	280,000	-208,550	0	38,480
Compensatory storage area	123,000	0	65%	79,950	0	79,950	0	43,050
Total	480,820	22,560	-	283,170	(-)687,450	-404,280	30,180	220,200

The table shows that of the volumes arising on-site, there is a net deficit of the order of 404,280 m^3 however this volume is dependent on the sequencing of mass haul which may be dependent on excavations, transport and filling is possible within the site. Approximate volumes of soil arisings requiring disposal are of the same magnitude at 220,200 m^3.

9.5.3 Potential operational impacts

Aside from the general and selected import fill materials to be provided, the main soil materials to be used in an ongoing basis during operations will be ballast. The construction will require excavation works to remove any existing materials containing potential contamination. Once in service, the operational removal of ballast is much less likely to be affected by contamination from diesel materials in particular and the materials will therefore remain cleaner than is currently required in the Do-Nothing scenario. On this basis, after construction there will likely be *positive, slight* effects over the existing conditions.

9.6 Mitigation measures

9.6.1 Mitigation by design

9.6.1.1 Earthworks footprint and material demands

The construction works will be carried out with the least feasible disturbance of soils, minimising the footprints and hence the amounts of excavated soils and fill materials as a core objective of minimising the demands of the project. Examples include the assessment of options where other nearby roads are available as alternative routes for vehicular traffic and the accessibility requirements of pedestrian, cyclists and other e.g., non-motorised users are proposed to be met by a local overbridge when the level crossing is closed.

The inert excavated soil will be re-used on site insofar as possible. Assumptions on the likely quantities and potential material types have been informed by investigations along the route. The reuse of materials arising from excavations in other locations, mainly ballast and made ground materials, can be specified including ground improvement and treatment techniques. In Zones C to F, the majority of soil conditions are generally reasonably good with some soft deposits in local areas. In Zones A and B, the soil profile is much deeper and requires deep foundations or removal for installation of other measures, including the provision of slabs and design against flotation due to tidal / groundwater levels.

The quantities of imported backfill at and around concrete foundations, abutments, embankments and retaining walls will be provided from suitably licenced quarries and suppliers. The designs of such structures will be engineered to specific and efficient requirements. A preliminary assessment of the volumes of materials arising and estimated to suit reuse or potentially require disposal has been provided.

A Construction Environmental Management Plan (CEMP) (see Appendix A5.1 in Volume 4 of this EIAR) will address the contractors plans to manage the excavations, temporary stockpiling, haulage and placement of materials, particularly in respect of how the soils will be contained and transported to suitable locations during construction. This is likely to contain several constituent elements such as a Sediment and Erosion Control Plan (SECP) to manage aspects like the potential for soil pollution of watercourses and control of dust.

9.6.1.2 Geotechnical risk management

Preliminary assessments of the geotechnical risks associated with the project will be developed further as the project evolves, aiding the identification of items for investigations and design mitigation. The various investigations conducted to date to characterise the site including the advance geophysical survey and ground investigation contract.

Design mitigation measures are assumed to be required locally associated with geotechnical risks to demonstrate or maintain stability of existing structures or for settlements due to new construction.

9.6.2 Construction mitigation

9.6.2.1 Availability of suitable materials

It is assumed that the majority, if not all imported material will be sourced from the nearest possible and most economic locations by the Contractor. A number of suitable active quarries with all necessary permits meeting the required specifications are present in the region. The requirements of the specifications can be tailored to meet project requirements while maximising the potential to reuse acceptable materials arising on-site.

For select materials, there are suitable sources such as quarries in the wider region that can supply suitable products in order to meet the demands of the project.

Assessment of the presence of pyrite may be required in the area of excavations, particularly where works involve piling and deep cuttings, to account for potential swelling properties and environmental risks and to inform potential reuse options. This would have to be taken into consideration during the construction sequence and when considering the use of concrete and other materials. Material will be required to comply with an appropriate specification for earthworks such as the NRA Specification for Road Works Series 600 – Earthworks (TII 2013) and specification for concrete such as the Specification for Road Works Series 1700 – Structural Concrete (TII 2017).

9.6.2.2 Treatment of unacceptable earthworks and construction demolition materials for reuse

The excavated soil arising on-site will be screened and re-used within the scheme where possible however this may be dependent on having suitable areas for the stockpiling and processing operations. Materials to be excavated where structures are to be demolished may also provide suitable sources subject to crushing and testing to meet specific requirements. There is also a likelihood that some materials requiring excavation could also contain excess contamination and thus require disposal or treatment of the offending elements prior to establishing criteria inside the contamination thresholds (to date mainly due to petroleum hydrocarbons).

The reusability of a soil will depend upon both its physical or engineering behaviour as well as the chemical constituents and classifications harm. In accordance with the requirements specified by the design, a soil can be classified as environmentally acceptable where the criteria for individual the Generic Assessment Criteria or Suitable for Use Levels (S4ULs) are not exceeded. These are most forgiving where materials can be improved in-situ, do not require excavation and does not have inherent pollutant linkages via end-uses such as residential homegrown produce or allotments.

Where the soil exceeds the threshold imposed and it is excavated it will have to be disposed as non-hazardous or hazardous waste and it will not be possible to improve it by treatment for re-assessment of suitability for re-use. This is also relevant where the end-use of an area could be affected by proximity to flood waters for example. Limitations on such uses and potentially specifications and detailing would be required in the detailed design to ensure such materials are only left in appropriate places.

Whenever the excavated / potentially treated soils do not meet the requirements, it will have to be disposed of by the Contractor who will ensure that all subsurface materials excavated during the construction phase of the proposed development are managed in accordance with the relevant waste management legislation, including the Waste Management Act 1996 (as amended).

The successful Contractor will have to ensure that all unsuitable materials are removed from the site and sent to authorised waste management facilities (i.e. which hold all relevant, valid permits / licences) which accept the corresponding types of waste.

9.6.2.3 Ground treatment to reduce excavations of soft ground

Where it is feasible by design or specification, waste will be avoided particularly with alternatives to the excavation and replacement of soft material, considering ground improvement treatments such as surcharging to mitigate consolidation and settlements, or mixing in situ with lime or cement additions to manage the effects of moisture and plasticity and improve the compaction achieved.

9.6.2.4 Protection of materials from erosion and seepage

The embankments and structures proposed to be built adjacent to the rivers and canal where high flood flows may be anticipated shall be protected from erosion by the provision of granular shoulders, separating materials and a basal drainage blanket to avoid the potential for the development of high pressures to either erode the soil materials present or cause piping through the embankment.

9.6.2.5 Potential transport of materials by rail

There are several parts of the site that are separated by circuitous and heavily trafficked routes that are likely to be affected temporarily by the works. Trafficking of bulk earthworks materials by road is an effective process and often offers contractors the optimal flexibility in how they arrange mass haulage. There are several discrete locations that are potentially suited to rail haulage in close proximity to the sources that could supply large quantities directly to the locations of earthworks deficit however there are significant operational issues and risks to implement this.

9.6.2.6 Potential pollution pathways due to piling at new Spencer Dock Station

Subject to detailed design of the system for the structural foundations, the resulting specification can mitigate the potential to cause spreading of pollution during the secant wall construction. The selected system should either provide telescopic construction for the borings required to construct the piles, continuing through a sealed concrete plug at the base of the made ground to provide a suitable way of constructing the piles required to transfer the load through to the required toe level without encouraging flow. Refer to section 9.5.2.1.4.

9.6.2.7 Potential pollution pathways due to piling at Connolly Station

Subject to detailed design of the system for the structural foundations, the resulting specification can mitigate the potential to cause spreading of pollution during the micropile construction. The selected system should either provide telescopic construction for the borings required to construct the micropiles, continuing through a sealed concrete plug at the base of the made ground or install an alternative type of micropile that provides a suitable way of transferring the load through to the required toe level without encouraging flow. Refer to section 9.5.2.1.6.

9.7 Monitoring

Monitoring measures are subject to detailed design requirements and construction methodologies. Depending on the treatment or ground improvement options chosen later in the design and construction process, the suitability of materials and treatments may need to be controlled or limited to avoid local e.g., chemical interactions involving cement and pyrite or processing of materials in areas of the site susceptible to flooding for example.

Monitoring of existing historic structures and earthworks to the activities during construction may also be required to ensure their stability and durability. The construction sequence and specifications to be followed must be sympathetic to the potential range in behaviour of these elements.

There must also be monitoring of the geo-environmental criteria for materials to track what types of materials are being brought around the site and to exclude materials that could be harmful to the water environments, flora and fauna or human health for reuse at locations where the fill is, for example – to be placed within levels subjected to flooding or canalised, to be returned to agriculture, use in allotments or landscaping. The monitoring of materials movement is expected to ensure appropriate disposal sites are used.

It would be expected the project construction material specifications would be developed to manage this and that other key project specific works documentation such as a Construction Environmental Management Plan and a Sediment and Erosion Control Plan.

9.8 Residual effects

The large area of land at the new depot and adjacent compensatory flood area shall experience changes due to compaction of soils and losses in topsoil cover as a residual effect after the proposed development. It is not proposed to seal over the compensatory flood area therefore the long-term groundwater regime is not anticipated to be altered.

There is a potential negative impact on groundwater levels due to deep excavations, construction of walls and possible induced settlements in the Docklands area.

The presence of contaminants within the subsoil has been identified in some areas, particularly near Connolly and Spencer Dock station. Potential impacts on soils and geology could occur during movement of any contaminated materials on site and due to intrusive construction activities, that may create pathways for contamination. Leaching of contaminants in soil may also occur due to change in groundwater and strata condition following the construction activities. There is also a potential for encountering unknown contamination at the surface or subsurface within the site area during construction.

There is a potential impact of consolidation or removal of ground adjacent to earthworks and proposed structures. Mitigation will be implemented in the form of limitation on the rates of construction along with potential monitoring of critical sections.

Other improvements in the treatment of ground contamination and enabling more electrified services are likely to result in a benefit to the wider environment with less contamination of ballast due to diesel combustion.

9.9 Cumulative effects

The totality of the earthworks required for the proposed development is assessed in Section 9.5.2 of this chapter. The assessment shows that of the volumes arising on-site, there is a net deficit of the order of 313,000 m^3 however this volume is dependent on the sequencing of mass haul which may be dependent on excavations, transport and filling is possible within the site.

The cumulative assessment of relevant plans and projects is undertaken separately in Chapter 26 of this EIAR.

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