

## 11 Soils and Geology

### 11.1 Introduction

For the purpose of this chapter, distinction is made between the site of the proposed power supply project development i.e. the location of the towers, underground cable routes the 220kV substation and MV switchrooms and ancillary elements, referred to as the Site, and that of the Apple data centre site. The Apple data centre site refers to the 197ha Coillte forestry site. Refer to **Figure 11.1**, in which the Site and the Apple data centre site are indicated. It should be noted that the proposed power supply development Site is partially contained within the Apple data centre site.

The proposed towers are to be located in the north-eastern section of the Site. The underground cable route is to be installed within the north-eastern section of the Site and extend southwards and to the west into the Apple data centre site. The 220kV substation, the MV switchrooms and the ancillary elements will be located within the south western part of the Site and are completely contained within the Apple data centre site boundary.

Reference is made to the EIS submitted to Galway County Council with the planning application for the Apple data centre site in 2015.

This chapter describes the existing soils and geology environment in the area of the proposed power supply development and its immediate surroundings. The chapter also describes and assesses the likely impacts on the soils and geology associated with both the construction and operational phases of the proposed development.

Potential impacts of the proposed power supply development are identified and residual impacts and cumulative impacts are described. The chapter initially sets out the assessment methodology used, describes the available baseline data for the existing soils and geology environment and examines the potential impacts of the proposal and associated mitigation measures.

A detailed description of the proposed power supply development is provided in Chapter 3 and is summarised in **Section 11.4** of this Chapter.

### 11.2 Methodology

This chapter has been prepared using the following guidelines:

- Institute of Geologists of Ireland (IGI), 2013. *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*.
- Environmental Protection Agency (EPA, 2002). *Guidelines on the Information to be contained in Environmental Impact Statements*;
- Environmental Protection Agency (EPA, 2003). *Advice Notes on Current Practice in the Preparation of Environmental Impact Statements*;

- Environmental Protection Agency (EPA, 2015). *Advice Notes on Current Practice in the Preparation of Environmental Impact Statements Draft September 2015*;
- Environmental Protection Agency (EPA, 2015) *Revised Guidelines on the Information to be contained in Environmental Impact Statements Draft September 2015*;
- National Roads Authority (NRA), 2008. *Environmental Impact Assessment of National Road Schemes – A Practical Guide*.
- National Roads Authority (NRA), 2008. *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*.

The main guideline reference used for this chapter is the most recent publication by the IGI (2013) which outlines the assessment methodology for Soils, Geology and Hydrogeology. The NRA guidelines are used to rate the site attributes and assess the significance of the impacts.

### 11.2.1 Application of Methodology

The potential impact of the proposed power supply development on the soils and geological environment has been assessed by classifying the importance of the relevant attributes and quantifying the likely magnitude of any impact on these attributes.

This impact assessment methodology is in accordance with the guidance outlined in *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements* published by the IGI in 2013.

This document outlines a methodology, which has four distinct elements, as follows:

- Element 1: Initial Assessment
- Element 2: Direct and Indirect Site Investigation and Studies
- Element 3: Mitigation Measures, Residual Impacts and Final Impact Assessment
- Element 4: Completion of the Soils, Geological and Hydrogeological Sections of the EIS

The initial assessment as outlined in **Section 11.3** describes the existing regional topographical, geomorphological and geological environment and presents a description of the past and present uses of the site and other neighbouring sites. This section also describes the nature of the site based on both site specific and neighbouring site investigations. Site investigation data from the surrounding area was obtained from publicly available sources.

Where specific features e.g. quarries, are identified, their importance is ranked in line with the IGI Guidelines, which follows the NRA criteria. These criteria are presented in **Appendix 11.1**.

The outcome from examining this available data is the Conceptual Site Model (CSM) which is outlined in **Section 11.3.3**.

**Section 11.4** establishes the activities associated with the proposed power supply development and the following section (**Section 11.5**) lists the potential impacts associated with the development of the site. The magnitude of the potential impact is ranked in accordance with the NRA Guidelines (**Appendix 11.1**) and this allows the Significance of the Impact to be determined.

Following the assessment of impacts, specific mitigation measures have been developed to avoid, reduce and, if possible, remedy any negative impacts on the soils and geology. These are described in **Section 11.6**. Cumulative impacts are also addressed in **Section 11.6**.

Residual impacts are described in **Section 11.7**. The magnitude and significance of these residual impacts have also be classified based on the NRA Guidelines.

## 11.2.2 Baseline Data Collection Sources

The information presented in this Chapter is based on information obtained from the following sources:

### Publicly Available Information

The publically available sources of information are as follows:

- Online geological mapping Geological Survey of Ireland (GSI) ([www.gsi.ie](http://www.gsi.ie))
- ‘Geology of Galway Bay 1:100,000 Bedrock Geology Map series Sheet 14’ GSI
- Karst Database, GSI
- Aggregate Potential Mapping, GSI
- Teagasc Subsoils map ([gis.epa.ie/Envision](http://gis.epa.ie/Envision) )
- Aerial Photographs; ([www.bing.com](http://www.bing.com); [www.epa.ie](http://www.epa.ie); [www.osi.ie](http://www.osi.ie))
- Historical and Current Pits and Quarries, GSI.
- Geological Heritage Areas, GSI.
- Historical Maps, Ordnance Survey of Ireland ([www.osi.ie](http://www.osi.ie)).
- IPC, Industrial emissions and waste licenses, Environmental Protection Agency (EPA).
- Natural Heritage Areas (NHA) and Proposed Natural Heritage Areas (pNHA), The National Parks and Wildlife Service (NPWS).
- Special Areas of Conservation (SAC), NPWS.
- Special Protection Areas (SPA), NPWS.
- Archaeology ([www.archaeologyireland.ie](http://www.archaeologyireland.ie))
- Radon Map ([www.rpii.ie](http://www.rpii.ie))

- Flood Maps ([www.floodmaps.ie](http://www.floodmaps.ie))

### Site Specific Information

The following site specific information sources were available for use in this assessment:

- Arup (April 2015): Environmental Impact Statement, Apple Data Centre Development, Athenry, Co. Galway, Ireland
- Fugro (July 2014): Geological and Geohazard Desk Study for Geotechnical Fatal Flaw Analysis
- McCarthy Hyder Tobin Consultants (August 2006): Environmental Impact Statement, N18 Oranmore to Gort, Co. Galway, Ireland

The following project specific investigations were carried out to provide additional information on the site and surrounding area:

- IGSL Ltd (2015): Ground Investigation: Project Antioch – Phase 2 Geotechnical Factual Report (included in **Appendix 11.3b**)
- IGSL Ltd (2014): Site investigation: Project Antioch Site Investigation Factual Report (included in **Appendix 11.3a**).
- Apex Geoservices Ltd (2014): Report on the Geophysical survey for the Antioch Project for Arup Consulting Engineers (included in **Appendix 11.3c**).
- Walkover surveys: Arup carried out four walkovers of the site and surrounding area in July, September and November 2014 and in October 2015.
- Karst survey: Arup carried out a detailed karst survey on the site and surrounding area from public roads (within a 2km radius of the Site). This was both desk and site based.

### 11.2.3 Consultation

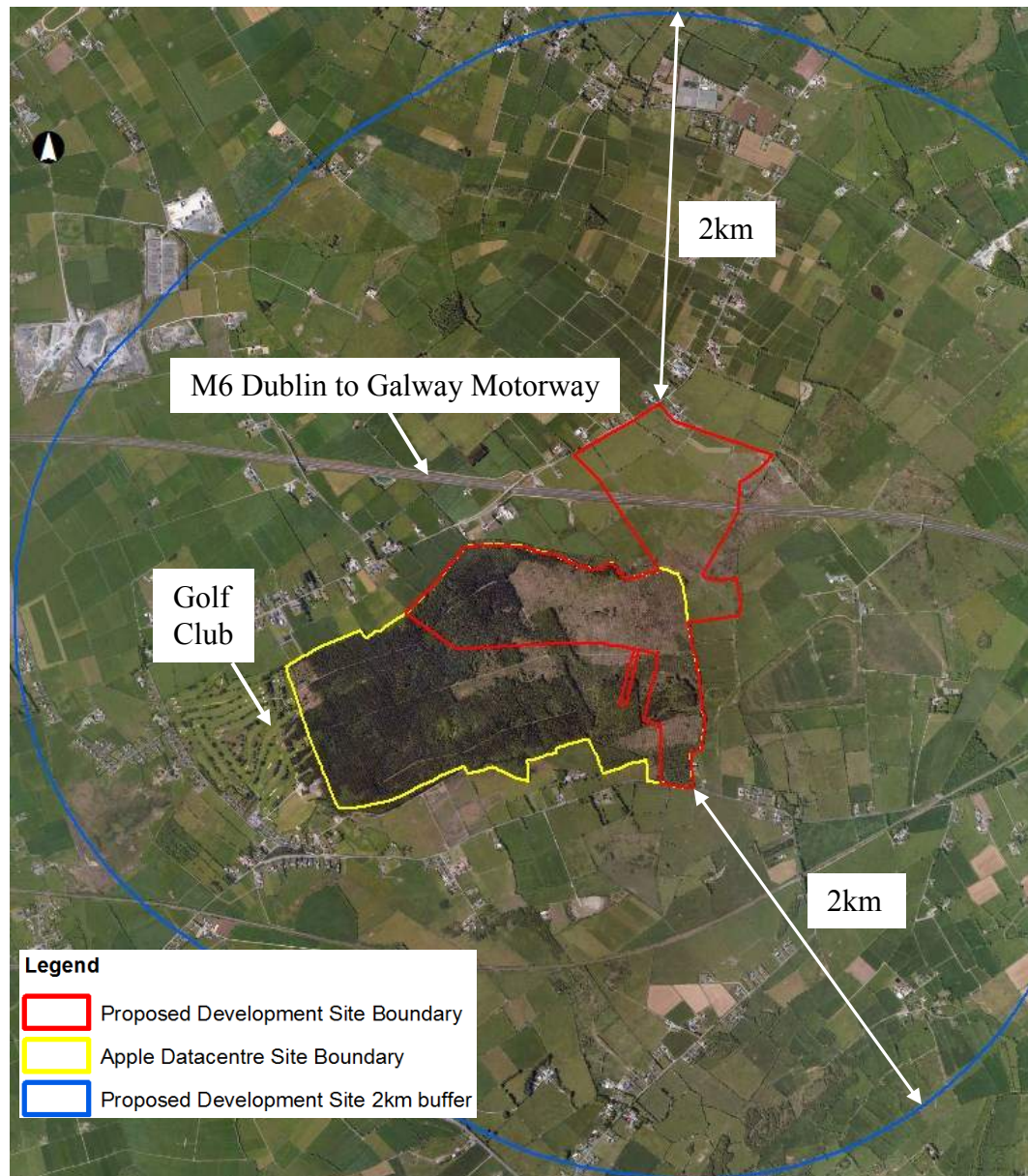
Consultation was carried out with the following relevant bodies to identify any soils and geological features which may be impacted upon by the proposed development:

- Geological Survey of Ireland (GSI)
- Galway County Council

## 11.3 Existing Environment

This section provides an overview of the existing environment on a regional and local scale. The regional review of geological conditions covers a zone of 2 km from the Site boundary, as suggested in the IGI guidelines. The location of the proposed power supply development Site is presented in **Figure 11.1**





**Figure 11.1 Proposed Development Site Location Map** | Not to scale [Source: Bing]

### 11.3.1 Existing Environment

#### 11.3.1.1 Site Location and History

The proposed development is located in the vicinity of Caraunduff, Rathmorrissy and Toberroe, Co. Galway, approximately 12kms east of Galway City and 4kms west of Athenry.

The northern part of the Site is made up of pastoral agricultural land, bordered by rural roads and private dwellings, and bisected by the M6 Dublin to Galway motorway. The lands in the southern part of the Site are within the Apple data centre site which is currently under coniferous forestry. The Athenry Golf Club is located directly to the west of the Apple data centre site. Houses are located along

the majority of the surrounding rural roads and in particular are concentrated at a cluster of private dwellings to the south west and west of the Apple data centre site.

The OSI historical mapping, available on the OSI web page ([www.osi.ie](http://www.osi.ie)) provide 6" (1827 to 1841) and 25" (1897 to 1931) maps of the area. These indicate that the land was principally used for agricultural uses.

The forestry site was acquired by the Forestry Service (the forerunner to Coillte) circa 1925 with planting carried out in phases in the 1940s, 50s, 60s and 70s.

### 11.3.1.2 Topography

The regional topography gently falls from north east to south west from 70m OD east of the town of Athenry to 10m OD at the coast adjacent to Galway Bay. The local Site topography and the immediate surrounding area generally falls from north east to west/south west from 57mOD to 42m OD. In the north eastern section of the Site, the topography falls from 57mOD to 44mOD, with local rises north and south of the M6. The topography over the footprint of the cable trenches and the 220kV substation falls to the west from 46mOD to 42mOD. There is a local rise called Knocknacreeva (73mOD) to the north of the Site.

### 11.3.1.3 Area of Conservation

As discussed in **Chapter 10 Ecology/Biodiversity**, the Galway Bay Complex is a designated candidate Special Area of Conservation (cSAC) and a Proposed National Heritage Area (pNHA), which is located approximately 5km from the Site and outside the study area.

### 11.3.1.4 Surrounding Relevant Land Use

A quarry, Coshla Quarries, is located approximately 2km to the north west of the Site. Available data suggests that the ground level at the quarry is around 30m OD and excavated depths within the quarry are of the order of 15-20m. It is assumed that some dewatering system is required for operation of the quarry.

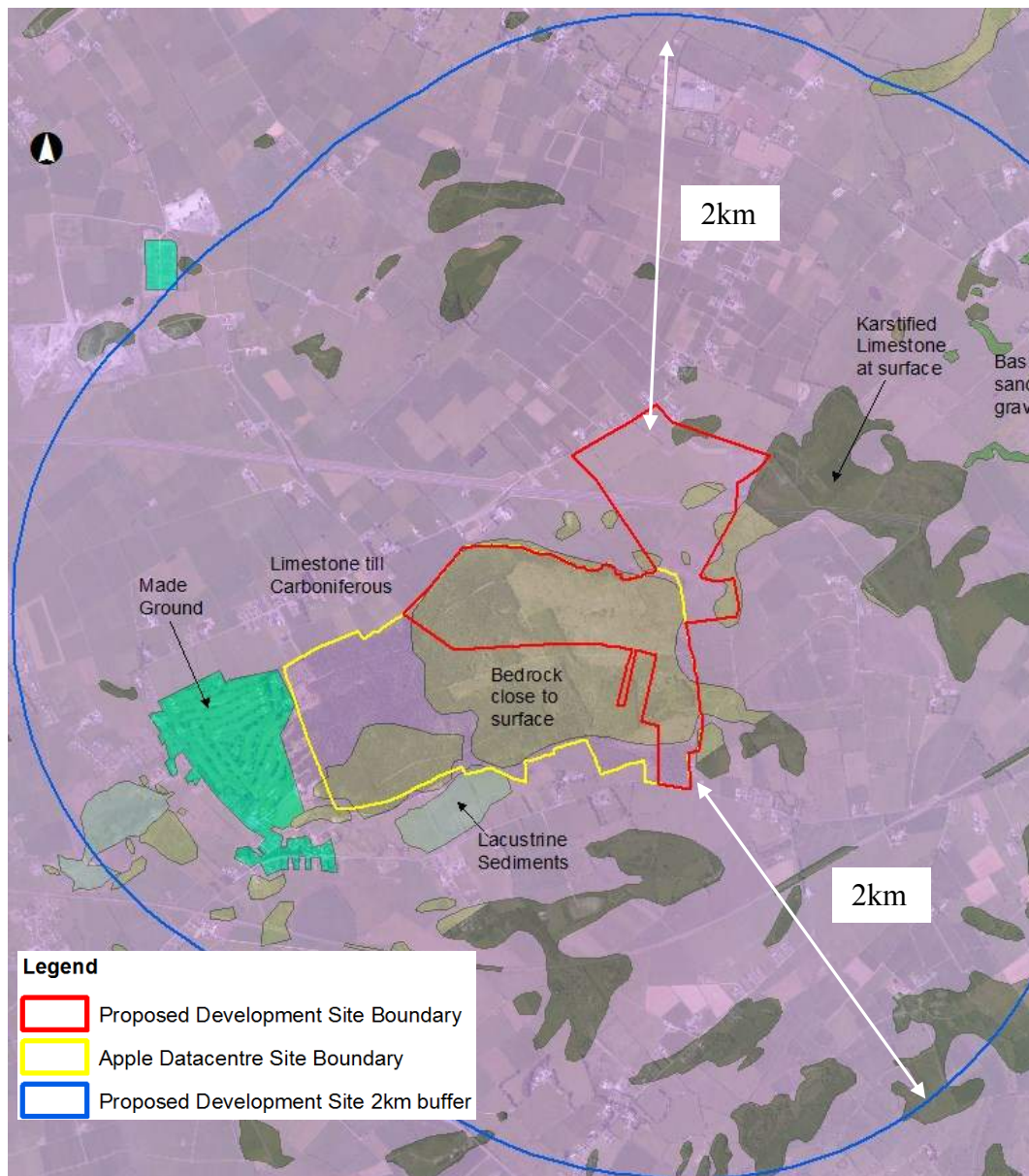
The quarry produces aggregates for construction and civil works from the Visean Undifferentiated Limestone.

### 11.3.1.5 Soils and Subsoils

The agricultural soils where present on the Site of the proposed development and in the surrounding study area comprise basic shallow poorly drained Brown Earths, Renzinas, Lithosols, Podzolics, Gleys and Peat.

**Figure 11.2** indicates the subsoil underlying the Site, the Apple data centre site and the surrounding area based on the Teagasc subsoils maps available on the EPA's Envision online mapping service.

The subsoils, where present, comprise glacial till, which is typical of the region and derived from glaciation processes.



**Figure 11.2 Subsoils Geology Map of the development and study area | Not to Scale**  
[Source: [www.epa.ie](http://www.epa.ie)]

To the south of the Apple data centre site, outside the Site boundary, an area of lacustrine lake marl deposits has been recorded. Lacustrine or lake sediments tend to be variable and generally comprised clay rich, low permeability soils which can often contribute to flooding issues.

Made ground underlies the golf course to the west of the Apple data centre site and is likely to comprise subsoil imported to construct the golf course. Subsoils, where present on the Site, comprise of Limestone (Carboniferous) till deposited as a result of glaciation processes during the Quaternary period.

Where subsoil is absent at the Site, this has been recorded as bedrock or karstified limestone at surface.



Site investigation information from the Apple data centre site indicates the presence of 0.6m to 2.3m of overburden. Site investigation information from the M17/M18 road project, 500m to the east of the Apple data centre site, indicates similar ground conditions with 0.30m to 2.5m of overburden along that particular section of the route corridor.

**Table 11.1** presents the soil profile recorded for the Apple data centre site investigations to date, while the soil profile recorded on the M17/M18 site is shown in **Table 11.2**

**Table 11.1 Soil profile recorded at the Apple data centre site**

Depth to Top of Stratum (mbgl)	Stratum Description	Thickness (m)
Ground Level	Topsoil (can be peaty in places)	0.15 – 0.30
0.15 – 0.80	Grey very sandy clayey GRAVEL with cobbles	0.40 – 0.90
0.15 – 1.20	Brown very gravelly CLAY with frequent angular to sub-rounded cobbles and boulders (up to 500mm)	0.45 – 1.10
0.15 – 0.30	Light brown sandy CLAY with occasional cobbles	0.15 – 0.40
0.10 – 2.3	Grey very sandy GRAVEL/COBBLES/BOULDERS (weathered bedrock)	0.30 – 0.90

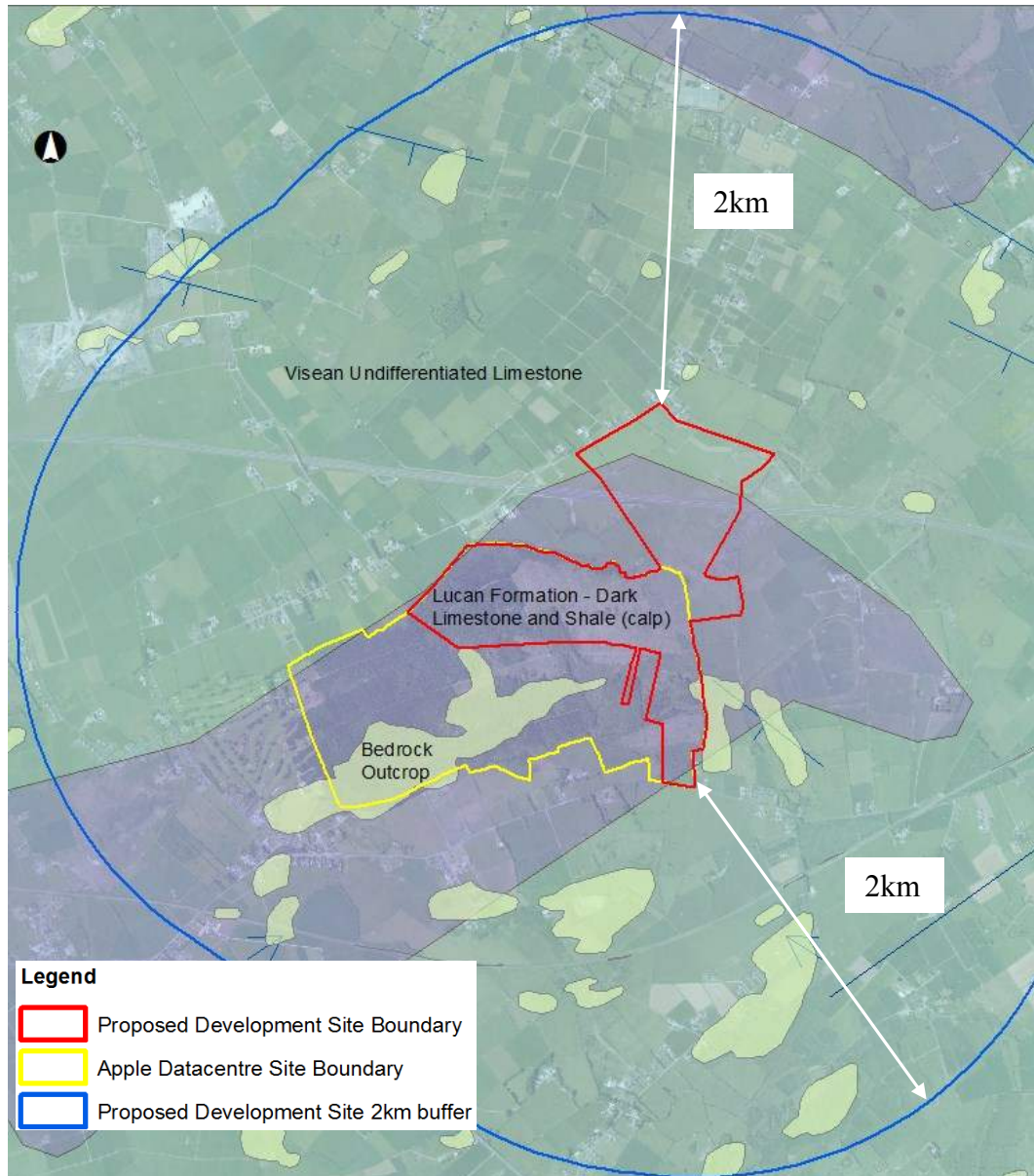
**Table 11.2 Soil profile recorded along the proposed M17/M18 route**

Depth to top of stratum (mbgl)	Stratum Description	Thickness (m)
Ground Level	Black silty organic SAND and GRAVEL	0.15 – 0.45
0.20 – 0.30	Grey very sandy gravelly CLAY with occasional cobbles	0.80
0.15 – 0.25	Grey angular limestone COBBLES	0.85 – 2.55
Ground Level - 0.45	Grey, brown slightly silty very sandy GRAVEL with many angular limestone cobbles and boulders. Boulders up to 450mm long.	0.4 – 2.2

### 11.3.1.6 Bedrock Geology

The GSI bedrock mapping for the proposed development and study area indicates the area is dominated by two Carboniferous rock formations both of Visean age as shown in **Figure 11.3**.





**Figure 11.3 Bedrock Map of the development and study area** | Not to Scale [Source: [www.gsi.ie](http://www.gsi.ie)]

The Visean Undifferentiated Limestone underlies a portion of the north eastern section of the Site while the Lucan Formation underlies the remainder of the Site. The 2km study area boundary is underlain by both formations.

The GSI 1:100,000 bedrock geology map, sheet 14 describes the Lucan formation as dark limestone and shale. The main lithologies of the Lucan Formation are dark argillaceous limestones, shales and calcareous mudstones with some skeletal units and common chert and pyrite. Deep marine calcareous mudstones and siltstones which represent distal turbidites are also present. (*Fugro, July 2014*).

Site investigation undertaken in the Lucan Formation for the Apple data centre site described the bedrock as strong to very strong thickly to thinly bedded grey/bluish fine grained, fresh to locally slightly weathered, locally fossiliferous limestone with chert content throughout.

The mineral exploration hole (GN-1), recorded on the GSI database drilled 8.2km north east from the Site boundary in the Lucan formation comprises argillaceous dark grey limestone with nodular chert and shale beds typically 0.50m thick. Cavities (probably solution features) are present near the surface of GN-1 (*Fugro, July 2014*).

The mineral exploration hole (GN-2), recorded on the GSI database drilled 9.2km north east from the Site includes calcilutite limestone, which is a limestone composed of predominantly either clay or silt sized carbonate grains which possibly represents the Visean Undifferentiated Limestone formation (*Fugro, July 2014*).

The term ‘undifferentiated’ is applied to bedrock for which it is not possible to specify finer age divisions within the geological Epochs. The desk study report (*Fugro, July 2014*) tentatively suggests that the Undifferentiated Visean Limestones are younger than the Lucan formation which indicates that it is possible that the Site and the surrounding area is an inlier. An inlier is a geological term where older rocks are surrounded by younger rocks. Inliers are typically formed by erosion, faulting or folding. It is possible that the Lucan formation outcrops on the Site due to the presence of an anticlinal fold and erosion of the overlying younger bedrock in the area. The nearest geological fault to the Site is 2.4km to the south east.

### Aggregate Potential

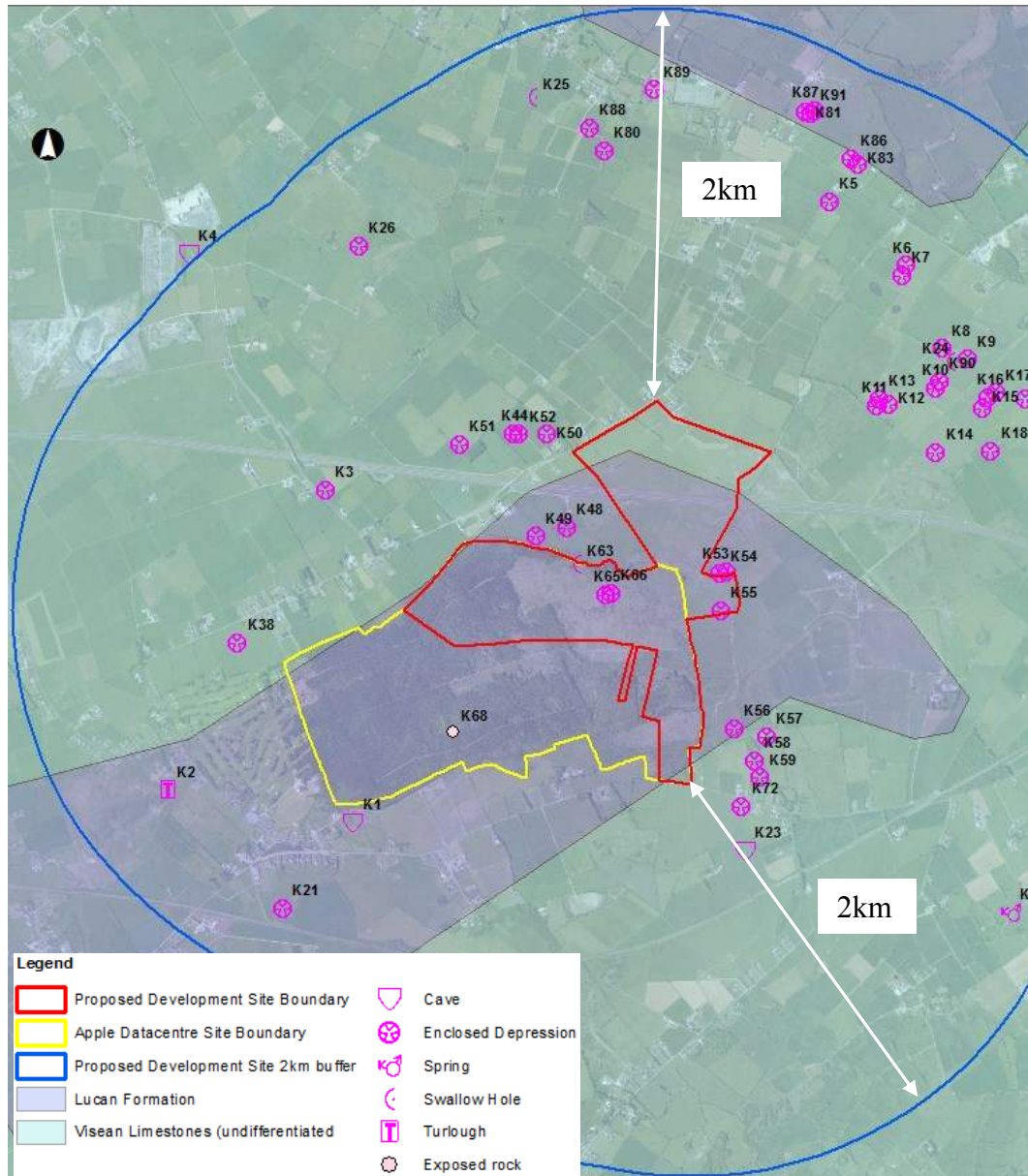
Coshla Quarry has been identified to the north west of the Site. This quarry produces aggregates for construction and civil works which is quarried from the Visean Undifferentiated Limestone. While the majority of the Site is set on the Lucan Formation which has significantly lower aggregate potential, a portion of the north eastern section of the Site is underlain by Visean Undifferentiated Limestone. The Mineral Section of GSI provides dataset of Aggregate Potential Mapping (APM) which identifies sand, gravels and rock resources that are considered useful to be aggregates in the construction industries. The current publically available APM does not yet extend to County Galway, however consultation with GSI revealed that the Site is located in an area of high to very high crushed rock potential.

#### 11.3.1.7 Karst

This section considers the potential for karst features to have an influence on the topography, ground surface and ground stability. The surface water and groundwater interaction of karst features is discussed in **Chapter 12 Hydrology and Hydrogeology**.

Mapping of the spatial distribution of karst at the project site and its surrounds was done initially at a desk study phase, which was followed up by a site walk over. This section presents the desk study investigation, which was undertaken using public databases (GSI), historical maps, existing reports and aerial photographs, and complemented by the findings from the site walkover.

The karst features identified to date are presented below in **Figure 11.4** and listed in **Appendix 11.2**.



**Figure 11.4 Karst features identified to date** | Not to Scale [multiple sources]

## GSI Database

The GSI karst database was used to identify any karst features on the Site and within a 2km radius from the Site. The GSI records a total of 31 karst features within 2km of the Site boundary and each of these is given a reference number in this chapter (K1-K19 and K80-K91).

## Historical Mapping

OSi historical mapping was used to identify any karst features in and within a 2km radius from the Site. A total of 6 karst features were identified within 2km of the Site boundary from historical mapping, and each of these are given a reference number in this chapter (K21, K23-K27).

## **Aerial Photographs**

Aerial photographs were used to review features identified in the GSI database as well as those on OSi mapping. Aerial photographs identified an additional 2 karst features within a 2km radius of the site and are referenced K38 and K44 in this chapter.

## **Other Sources**

A previous desk study conducted by Fugro (Fugro, 2014) was used to identify any karst features on the Site and within a 2km radius from the Site. A total of 12 karst features were identified from the Fugro desk study either on the Site or within a 2km radius of the Site. Each of these is given a reference number in this chapter (K48-K59).

## **Site Walkovers**

Arup undertook site walkovers in July, September and November 2014 and in October 2015 to ground truth the identified Karst features from the desk study.

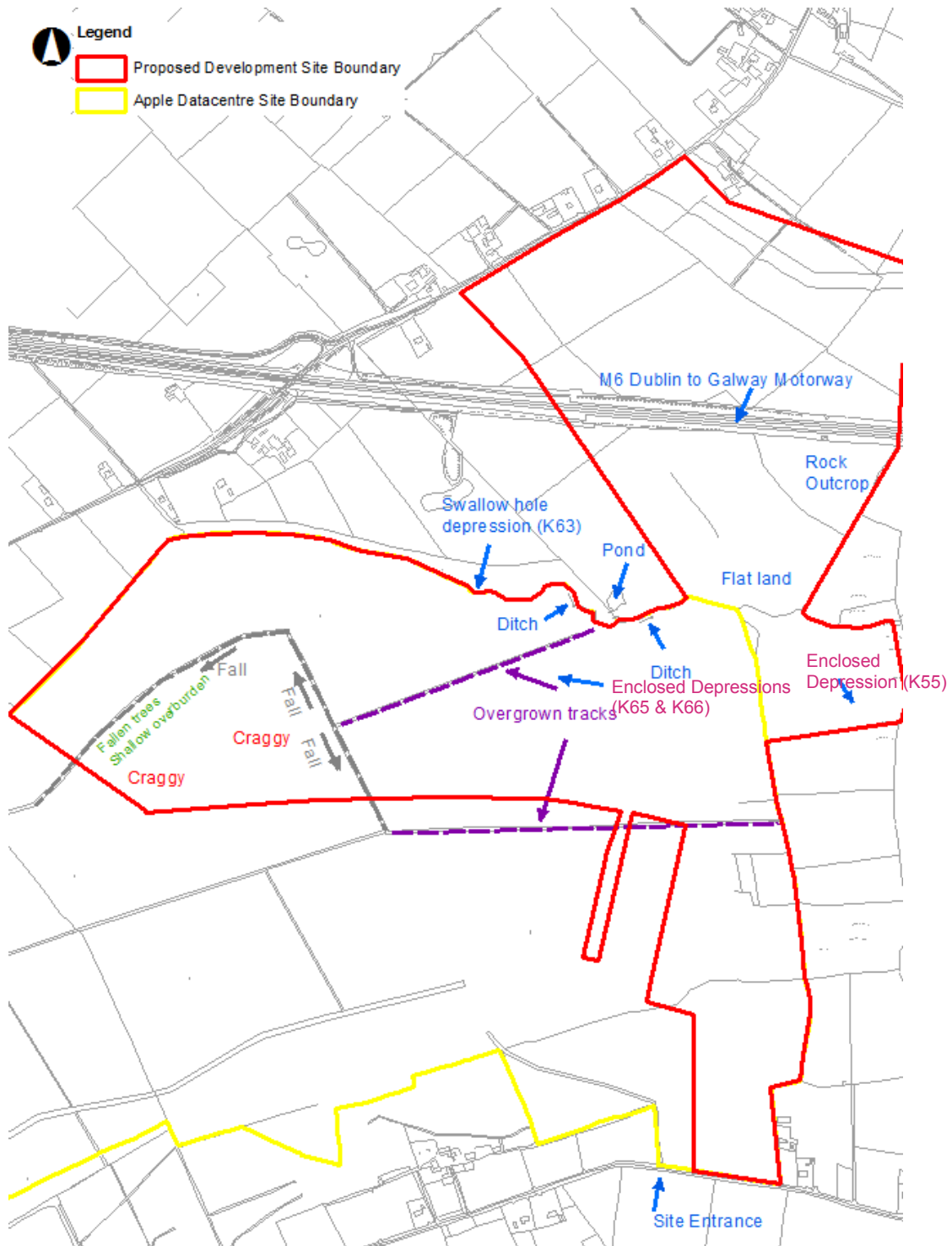
A total of five karst features were identified on the Site and within a 2km radius from the Site during the site walkovers, and are given the reference numbers K63, K65, K66, K68 and K72 in this chapter.

## **Karst Features Identified on Site**

From the various elements of the desk study and site walkovers discussed above, a total of four karst features were identified on the Site. K55 is an enclosed depression, located in the eastern of the Site, K65 and K66 are also enclosed depressions, located in the centre of the Site. The fourth karst feature identified on the site is a swallow hole (K63). All other karst features referenced above are outside of the Site boundary, but within a 2km radius of the Site.

The main findings relevant to the proposed development are discussed below and indicated in **Figure 11.5**.





**Figure 11.5 Map of Site Walkover** [Source map© Ordnance Survey Ireland Licence No. EN 0002815 © Ordnance Survey Ireland/ Government of Ireland]

A pond is identified north of the north eastern part of the Apple data centre site boundary (refer to **Figure 11.6** and **Figure 11.7**). Bedrock is absent at the location and the ground is marshy and hummocky. The feature does not appear to be karst and is more likely to be surface water perched locally on clayey subsoils. A 0.5m to 0.75m deep dry ditch was noted to the south of the pond but rock was not evident.



**Figure 11.6 Pond, adjacent to the north-eastern corner of the Apple data centre site (view from south) during July 2014**



**Figure 11.7 Pond, adjacent to the north-eastern corner of the Apple data centre site (view from north) during October 2015**

Approximately 200m west of the pond there is a moderate sized enclosed depression that straddles the northern boundary of the Apple data centre site (Figure 11.8 to Figure 11.10). This enclosed depression correlates with the



location of the swallow hole marked on historical mapping and is referred to as K63 in the karst survey database. The nature of the karst landform is discussed further in **Chapter 12 Hydrology and Hydrogeology**, which also addresses the ecological assessment of this feature.



**Figure 11.8 Swallow hole feature (K63) during July 2014**



**Figure 11.9 Swallow hole feature (K63) during November 2014**



**Figure 11.10 Swallow hole feature (K63) during October 2015**

### **11.3.1.8 Landslide Risk**

A review of past landslides in Ireland was undertaken by consultation of the GSI website. No historic landslides have been recorded within the study area. The topography of the area indicates that landslides are not likely to feature.

### **11.3.1.9 Geological Heritage Areas**

Geological Heritage Areas (GHA) are designated as part of the Irish Geological Heritage Programme, which is a partnership with the Geological Survey of Ireland (GSI) and the Department of Environment, Heritage and Local Government. The aim of the programme is to identify, document and protect the wealth of geological heritage in Ireland.

There are no GHA sites listed in the geological heritage dataset on the Site or in the study area. GHAs will not be considered further as part of this assessment.

### **11.3.1.10 Regional Potential for Contaminated Land**

A review of the existing and historic, licenced and illegal, relevant waste activities from the EPA web site has been carried out to identify any potential contamination sources present in the area. This will allow the identification of any possibly contaminating activities near the Site.



## Waste Licences and Permits

The National Waste Collection Permit Office (NWCPO) issue Waste Collection Permit for all of the Waste Management Regions in Ireland. According to the NWCPO records, within 2km radius of the Site, one permit is issued for Coffey Construction Limited (NWPCO-09-03623-02), which is located approximately 1.9km north east of the Site. The waste collection permitted for this site includes concrete, brick, bituminous mixtures, soil, stones and septic tank sludge.

## Integrated Pollution Control and Industrial Emission Licences

According to the EPA records, there are no IPC or industrial emissions (either current or historic) which have been issued within a 2km radius of the Site.

## Illegal Dumping

No unauthorised waste activity has been noted at or within 2km radius of the Site.

## Contamination in Surrounding Sites

The surrounding area generally comprises ribbon development along regional and local roads with a number of farms also in the vicinity. Any contamination within the soil is likely to be localised and associated with residential and agricultural activities.

### 11.3.1.11 Geological Environment

Based on review of the existing available information for the site and the region, the site is classed as a Type D geological environment in accordance with the IGI guidelines. A type D environment is considered as a 'sensitive geological environment e.g. 'potentially unstable geological environment, karst'.

## 11.3.2 Direct and Indirect Site Investigation and Studies

The following sections discuss the studies and investigations carried out to provide site specific information. These comprised the following:

- Site walkovers
- Site Investigations
  - Initial Site Investigation for the Apple data centre site including:
    - Rotary drilling
    - Trial pitting
    - Geotechnical and chemical laboratory testing
    - Soak away tests
    - Geophysical survey
  - Site Investigation for the proposed development Site including:
    - Trial pitting
    - Geotechnical and chemical laboratory testing

These investigations and studies informed the soils and geology conceptual model for the Site.

### 11.3.2.1 Site Walkover

As discussed in **Section 11.3.1.7** multiple site walkovers have been undertaken at different times during both the reconnaissance for the Site and the Apple data centre site.

During the recent site investigation works in November 2015, it was noted that at the site of the new proposed tower P3, in the eastern part of the Site, the ground is particularly wet, with localised water ponding possibly due to cattle trafficking in the area. The wet ground conditions were confirmed during the excavation of TP-06, in which peat and shallow seepage (0.6m bgl) were encountered. The remaining tower locations were noted as being generally dry on the day of the walkover.

A rock outcrop was noted at the site of the proposed tower P6 in the north east of the site. (Refer to **Figure 11.11.**)



**Figure 11.11 Evidence of bedrock outcrop adjacent to TP-05 (November 2015)**

### 11.3.2.2 Site Investigation

To date, two site investigations have been undertaken by IGSL Ltd on the site of the proposed power supply development. One under the footprint of the proposed towers and substation (8 October 2015) and the second on the Apple data centre site between July 2014 and August 2014 which encompassed the footprint of the proposed 220kV substation.

The factual reports for these investigations are presented in **Appendix 11.3a, 11.3b and 11.3c.**

The 2014 site investigation on the main Apple data centre site encompassing the 220kV substation comprised:

- 5 No Trial Pits (TP4, TP5A, TP6, TP7 and TP14) to depths of 0.6m bgl to 1.5m bgl.
- 1 No. Rotary Corehole (BHD) to 20.0m bgl.
- Geotechnical soil laboratory testing.
- Surface Geophysical Survey (2 D Resistivity and ERT).

The 2015 site investigation on the Site comprised:

- 7 No. trial pits (TP-01, TP-02, TP-03, TP-04, TP-05, TP-06 and TP-07) to depths of 0.50m bgl to 1.60m bgl.
- Geotechnical soil and rock laboratory testing.

The site investigations undertaken to date indicate that the ground conditions across both the Site and the Apple data centre site are similar.

The locations of the site investigations related to the proposed power supply development are shown on **Figure 11.12.**





Figure 11.12 Map showing the location of site investigations | Not to Scale

### 11.3.2.3 Soil and Subsoils

The soil profile encountered on Site is detailed in **Table 11.3** below.

Soak away infiltration tests were undertaken in the gravel/weathered bedrock stratum during the 2014 site investigation (TP5A, TP6 and TP7) to establish the infiltration values of the superficial deposits. Values are outlined in **Table 11.3** below.



**Table 11.3 Soil profile for the Site**

Depth to Top of Stratum (mbgl)	Stratum Description	Thickness (m)	Infiltration Values (f m/sec)	Groundwater
Ground Level	Topsoil (can be peaty in places)	0.05 – 0.40		Water seepage was recorded in TP-06 (2015) at 0.60m bgl. No water strikes were recorded in any of the other trial pits
0.10 – 0.20	Firm brown sandy to very sandy very gravelly CLAY with occasional cobbles and boulders (not sampled at all locations)	0.35 – 0.50		
0.10 – 0.60	Brown clayey gravelly SAND with low to medium cobble and boulder content (not sampled at all locations)	0.30 – 1.30		
0.10	Soft plastic dark brown pseudofibrous to amorphous PEAT with frequent rootlets (TP-06 (2015) only)	0.35		
0.70	Firm occasionally soft light grey slightly sandy gravelly slightly clayey SILT with occasional rootlets and a low to medium cobble and boulder content (TP-06 (2015) only)	0.60		
0.05 – 1.9	GRAVEL/COBBLES/BOULDERS of slightly weathered LIMESTONE locally with clayey sand and gravelly clay (weathered bedrock)	0.30 – 0.90	$6.42 \text{E}10^{-5}$ – $1.22 \text{E}10^{-4}$	
0.50 – 2.30	Competent LIMESTONE BEDROCK	n/a		

### 11.3.2.4 Bedrock

Bedrock (weathered and or competent) is generally shallow across the Site, ranging from 0.05m bgl in the north western part of the Site to 1.9m bgl in the south eastern part of the Site. A rock outcrop was noted in the north eastern of the Site.

According to the GSI bedrock map, most of the Site is underlain by the Lucan Formation while the Visian Undifferentiated Limestone underlies a portion of the north eastern section of the Site.

Depth to bedrock is variable across the Site. It is deepest in the south eastern part and generally becomes shallower towards the northern and western parts of the Site. A rock outcrop was identified during the site walkover in October 2015 in the north eastern part of the Site.

The rotary corehole record (BHD) indicates that there is up to 0.9m of weathered bedrock over strong to very strong thickly to thinly bedded grey/bluish fine grained, fresh to slightly weathered, locally fossiliferous limestone with local

stylolites, locally plastically sheared and with chert formation throughout. The Rock Quality Designation which is a measure of the quality of the bedrock, ranges from 36% – 100% and 82% on average for borehole BHD. Trial pit records indicate a greater range of weathered bedrock, between 0.1m to 1.3m bgl. The thickness of weathered bedrock across the Site is found to be variable, with no particular section of the Site indicating a pattern. The geophysical survey undertaken during the 2014 SI reveals the bedrock to comprise saturated fissured karstified clay-filled limestone to 30-55m bgl underlain by jointed tight limestone. In the most southern part of the site, bedrock is mainly jointed tight limestone at 5-10m bgl to > 60m bgl. The geophysical report also indicates the presence of potential faulting within the bedrock across the southern section of the Site. A large possible fault is identified in a north-south direction in the south east of the Site.

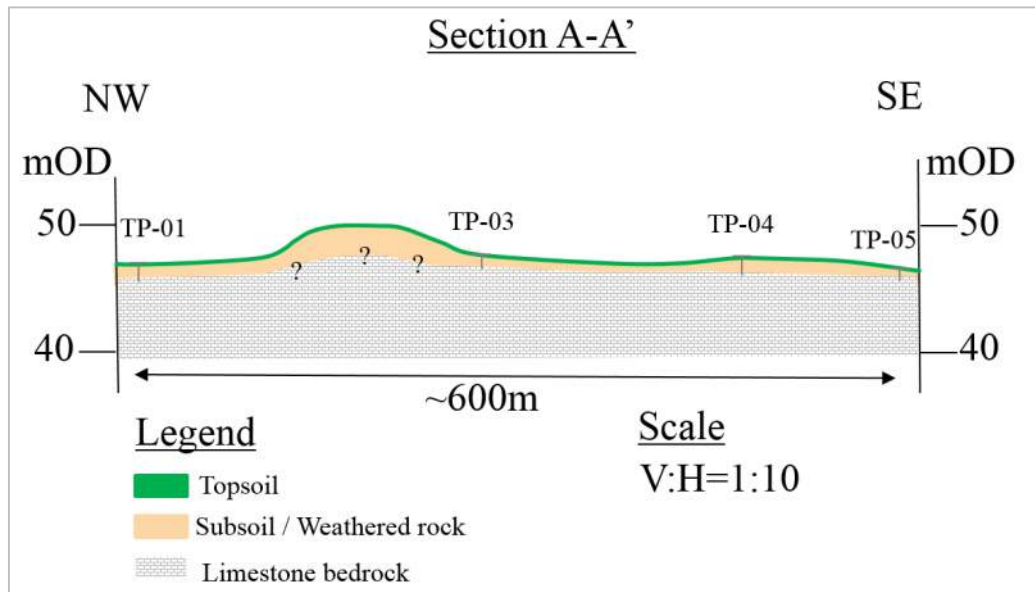
As indicated by the GSI bedrock geology map, the Lucan formation underlies the majority of the Site with the Visean Limestone dominating the north eastern area. Detailed site investigation will be required to accurately identify these lithologies on the Site.

### 11.3.3 Conceptual Site Model

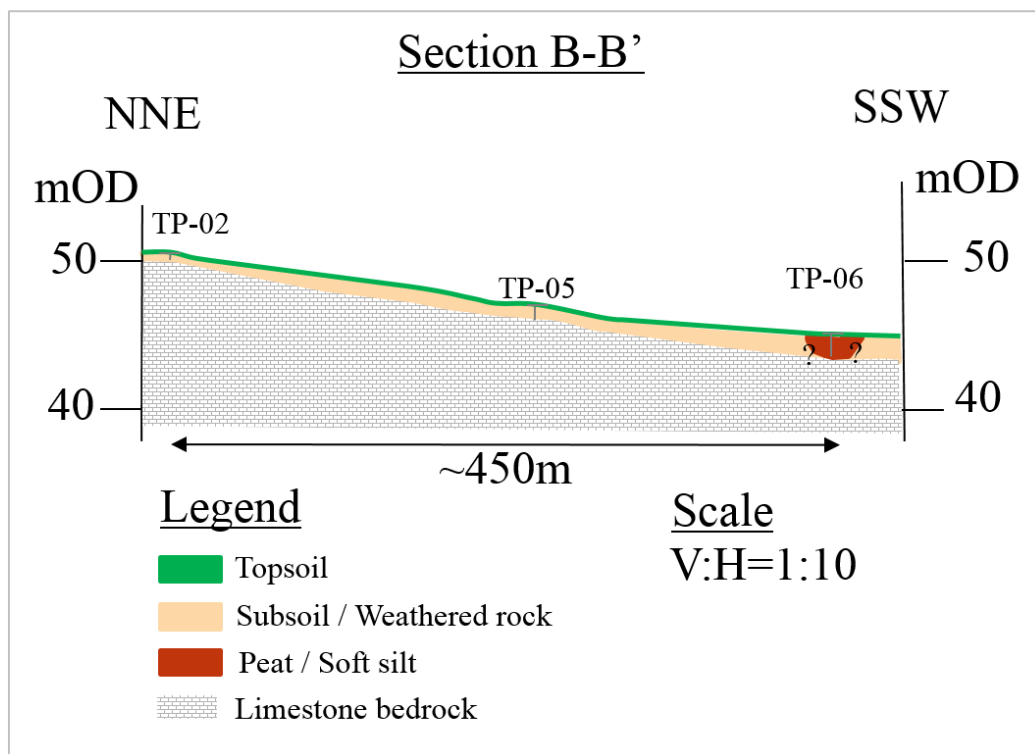
Following the site walkover and site investigations undertaken on the site, interpretative cross sections were compiled showing the depth and extents of overburden and bedrock profile. The cross sections are presented in **Figure 11.13** to **Figure 11.16**. (Noted that the symbol “?” on the cross sections indicates that, as is normal practice, the bedrock surface has been interpolated between trial pits.)



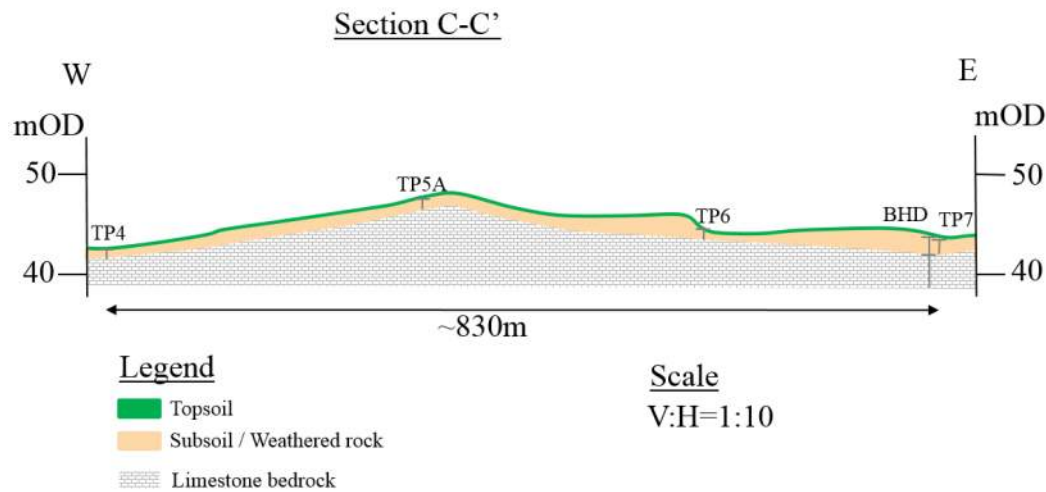
**Figure 11.13 Site cross sections – Plan**



**Figure 11.14 Site cross sections – Section A-A'**



**Figure 11.15 Site cross sections – Section B-B'**



**Figure 11.16 Site cross sections – Section C-C'**

### 11.3.4 Summary of Geological Feature Importance

The main features of geological importance uncovered on the Site and in the study area are:

- The possible presence of pockets of deeper soils in isolated areas throughout the site as identified by the thicker layers of overburden in the east of the Site in trial pit TP-06 (2015) and borehole BHD (2014).
- Shallow weathered and competent limestone bedrock across the site.
- Limestone bedrock outcrops.
- Karst Features: Possibility of encountering karst voids or cavities on the site and the presence of karst features within the study area such as the swallow hole (K63) and the enclosed depressions (K55, K65 and K66) which were observed within the Site boundary.
- Coshla Quarry located north west of the site within the study area.
- Regionally Important Aquifer underlying a portion of the northern part of the Site (**Chapter 12 Hydrology and Hydrogeology**).

## 11.4 Proposed Development

The proposed power supply development will comprise a 220kV electrical substation, towers, underground cable network, MV switchrooms and ancillary elements, which will supply power to the proposed data centre development.

The elements of the proposed power supply development are described in **Section 3.5**.

It is anticipated that the foundations for the 220kV substation, towers and other elements will be founded on bedrock. Excavation of the trenches for the underground cable network will extend into the bedrock.



Below is a list of site activities that relate to the construction phase and that have the potential to impact the soils and geological environment:

- Enabling works and site clearance works
- Excavation of soil and bedrock.
- Earthworks (Soil and Bedrock)
- Cutting slopes
- Building foundations
- Associated infrastructure
- Trenching for underground services
- Establishing access roads

#### 11.4.1 Activities/Environment Matrix

The Environment Type and Site Activities have been identified as per the guidance of the IGI Guidelines, as follows:

- Environment Type: D Sensitive geological/hydrogeological environments.
- Activities: Earthworks, excavations of materials above and below the water table.

The following table outlines the required activities based on the environmental type and different activities which will be undertaken on site and the works which have been carried out to address those activities.

**Table 11.4 Details of works required under the IGI Guidelines and how they have been undertaken on the Site**

Activity	Details of Works completed on the Site
<b>Earthworks</b>	
Invasive site works to characterise nature and thickness of soil and subsoil e.g. trial pits	Refer to <b>Section 11.3.2</b> for details of site investigations performed to date.
Works to determine groundwater level, flow direction and gradient e.g. monitoring in standpipes, piezometers, or boreholes.	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>
Works to determine groundwater – surface water interactions.	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>
Identify location and abstraction rate of nearby groundwater abstractions.	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>

Activity	Details of Works completed on the Site
Regional study of karst in an area, including identified karst features (both mapped and identified during site walkovers).	Refer to <b>Section 11.3.1.7</b> for details. Regional karst and local karst features have been identified during all phases of the studies to date including the site walkover, desk study, geophysical survey and intrusive site investigation. The potential karst on site has been delineated insofar as is possible. If karst features are encountered, foundations will be designed to account for such ground conditions.
Map bedrock topography	Refer to <b>Section 11.3.2</b> for details. The bedrock topography has been established during all phases of the studies to date including site walkovers, desk study, geophysical survey and intrusive site investigations. Earthworks requirements are controlled by the bedrock topography.
Geotechnical assessment of risk of landslide or subsidence	Through identification of the bedrock topography and potential for karst a geotechnical assessment of the risk of subsidence has been carried out.
<b>Excavation of materials above and below the water table</b>	
Site works to characterise nature, thickness, permeability and stratification of soils and subsoils e.g. trial pits, augering	Refer to <b>Section 11.3.2</b> for details. Soil permeability data is available within the weathered bedrock encountered within the Apple data centre site. As the material encountered across the Site appears to be these permeability values have been used for the Site discussed in this section.
Site works to fully characterise the bedrock geology and in order to define the resource volume/weight according to The PERC Reporting Standard e.g. trenching, drilling, geophysics	Bedrock geology for Apple data centre site was characterised by logging, sampling and testing the rock core obtained during the 2014 site investigation. Representative reusability laboratory testing has been undertaken on the bedrock, namely the Lucan formation and will be used to define the material for reuse onsite.
Works to determine groundwater level, flow direction and gradient; e.g. monitoring in stand pipes, piezometers, or boreholes.	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>
Characterisation of groundwater chemistry and quality.	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>
Full detailed hydrogeological assessment required in this situation	Refer to <b>Chapter 12 Hydrology and Hydrogeology</b>
Geotechnical assessment of risk of landslide or subsidence	Through identification of the bedrock topography and the potential for karst a geotechnical assessment of the risk of subsidence has been carried out.

## 11.5 Potential and Predicted Impacts

An analysis of the potential impacts of the proposed power supply development on soils and geology during construction and operation is described in the following sections. The assessment considered geological features within a 2km boundary of the Site.

The impact assessment criteria are outlined in **Section 11.2** of this chapter.

### 11.5.1 Do Nothing Scenario

If the development is not constructed, there would be no impacts on the soils or geology on the Site or the surrounding area.

### 11.5.2 Construction Phase

The potential impacts on soils and geology during the construction phase are presented in this section.

#### Excavation of Bedrock

The site investigation information and site walkover observations indicate that bedrock is relatively shallow across the Site with weathered rock on average encountered at 0.5m bgl, with an average thickness of 0.6m. The weathered bedrock is underlain by more competent bedrock.

The excavation/formation level of the 220kV substation is 44.7m OD with an overdig of an additional 500mm. As the current topography at the site of the 220kV substation is 50m OD in the east dropping to 42mOD in the west, approximately two thirds of the proposed substation will be in a cut, with the remaining third on fill. Construction of the platform and foundations for the proposed substation will require rock excavation to a maximum thickness of 6m.

In the case of the towers in the north eastern part of the Site, foundations are required to be excavated to approximately 3.5m bgl per tower leg. Therefore the towers will be founded in bedrock with rock excavation required.

Trenching in bedrock is required for the underground cable routes. Each of the trenches for the underground cables running from the towers to the substation are 1.3m below ground level (bgl) and 1m wide. A total of eight trenches will be excavated (two trenches per cable route). These trenches will require excavation of both weathered and competent bedrock.

The MV switchrooms and the temporary 10kV substation will have strip foundations. The excavations for these will not exceed 1.2m in depth.

The weathered bedrock can be ripped using an excavator. However the more competent bedrock will have to undergo alternative methods of removal, such as blasting (Refer to **Section 4.4.2**).

The significance of this impact is expected to be locally moderate due to the potential requirement to excavate up to 6m of bedrock.

## Rock Slopes

Formation of the platform for the 220kV substation will result in the excavation of rock slopes. The finished yard level of the substation is 45.90mOD, therefore the maximum height of the proposed rock slopes will be 4m.

Rock slopes will comprise a sequence of weathered limestone bedrock over more competent limestone bedrock. Each individual rock cut will require a detailed stability assessment. Common rock slope stabilising methods include slope grading and benching, trenching, shotcrete, rock anchors and netting, will be used.

The impact on the soils and geology due to the construction of rock slopes as a result of the proposed development is expected to be slight.

## Soil Slopes (1m – 2m)

It is unlikely that there will be significant soil slopes on the site. Site investigation records indicate that soils depth range from 0.40m to 1.90m bgl. In instances where soil slopes greater than 2m are excavated, the stability of the slopes will be individually assessed and a stability design solution proposed and implemented.

The impact on the soils and geology due to the construction of soil slopes as a result of the proposed development is expected to be slight.

## Karst Limestone

Karst features were identified within and in proximity to the Site and the Apple data centre site during the onsite survey and the site investigation. Karst landforms in the Lucan Formation are generally more likely to form isolated, shallow features while more significant features will occur in the Visian Limestone Formation. Two enclosed depressions (K65 and K66) have been identified within the central east section of the Site, through which the underground cable route is to be constructed. Excavation of these trenches and the proposed earthworks on the Site may impact Karst features by altering or enhancing water flow through certain areas of the Site, therefore reactivating and creating instability.

With the implementation of the design measures and construction supervision and surface water management measures described below, the power supply development is expected to have minimal impact on the karst features.

The hydrogeology of the karst features is discussed in **Chapter 12: Hydrology and Hydrogeology**.

## Areas of Fill

Fill will be required at the western end of the 220kV substation to bring the existing ground up to the proposed 44.70m OD formation level. Overlying this a copper earth mat will be installed in a layer of imported soil followed by site won crushed rock to bring the levels up to 45.50mOD.

A layer of loose stone chippings/capping layer is required between 45.5m OD and 45.9m OD across the full area of the 220kV substation.



The deposition of fill material may impact on the soils and geology environment by compressing the existing subsoil and potentially impacting on the groundwater flow. This may, in turn, contribute to the infilling of flow paths by mobilisation of sediment or alternatively the mobilisation of fill to reactivate flow paths (such as opening karst voids).

The impact on the soils and geology as a result of soil compression due to fill on site is expected to be imperceptible due to the minimal soil cover.

### **Earthworks Balance**

The proposed development will require cut and fill works to be undertaken on the Site.

It is intended that where possible material excavated will be reused on site. Importation of material will be minimised, and if required, (i.e. if material on site when tested is found to be unsuitable for use as structural fill), will be sourced from quarries registered under Section 261 of the Planning and Development Act 2000, as amended and will be in accordance with the material property acceptability limits as per the earthworks specification.

The impact on the soils and geology from importing materials to the proposed scheme is expected to be imperceptible.

### **Deeper soil deposits and soft ground**

Soft soil deposits were not uncovered during the site investigation undertaken in 2014. Peat and soft silt were encountered within TP-06 to a depth of 1.3m bgl during the 2015 site investigation in the eastern section of the Site where Tower P3 is to be located. Competent bedrock was however encountered at 1.3m bgl in this location. As the depth of the tower foundations and cable trench excavation at this location is expected to be deeper than 1.3m bgl, a requirement to mitigate against soft soils by additional excavation works is not expected. The soft soil excavation is therefore expected to be limited to that required for the P3 tower foundations only.

Where soft surface ground is encountered in the vicinity of the access roads, such as may be the case in the eastern section of the Site adjacent to Tower P3, roads with stone or wooden sleepers may need to be constructed.

If soft soils are uncovered during construction on the Site elsewhere, they will require excavation and replacement with suitable site won material. The excavated soft soil will be re-used on site as landscaping material, where possible.

The impact of the proposed development on the soils and geology due to the presence of encountering soft soils is expected to be imperceptible as they are unlikely to be widespread.

## **11.5.3 Operational Phase**

The operational phase of the proposed development will have an overall neutral long-term impact on the soils and geology within the study area. Potential impacts from the operational phase are as follows:

- Exposure to weather and seasonal variations in temperature will inevitably cause an element of spalling on the rock and soil slopes and as a result annual maintenance of rockfall trenches, benches or netting will be required. Spalling may also be enhanced by water seepages on the slopes which may occur during periods of heavy rainfall. Appropriate drainage measures and slope maintenance will mitigate against this. Soil slopes will be top soiled and seeded to mitigate against erosion.
- Appropriate design and construction of foundations on karst limestone will mitigate against ground instability problems associated with the underlying karst limestone during the operational phase.

There is the potential for contamination of soil around the proposed development from wastewater or hydrocarbon spills. Implementation of the mitigation measures listed below will ensure that the power supply project will have a negligible impact on soils and geology during the operational phase.

## 11.6 Mitigation Measures

### 11.6.1 Construction Mitigation Measures

#### Excavation of Bedrock

The presence of shallow bedrock on the site will require excavation in rock to construct the platform for the proposed 220kV substation, tower foundations and rock trenching for the underground cable installation.

Rock will be excavated using either rock splitting or blasting. A combination of both may also be required. Refer to **Section 4.4.2** for details of these methods.

Specialist contractors will be required to determine the most feasible rock removal methods for the development given its environmental constraints.

#### Rock Slopes

Generally rock slopes will be designed for slope gradients of 1:1 or shallower depending on their location, proximity to buildings and available land take. Each slope will undergo a rock stability assessment and if required suitable measures such as slope grading and benching, trenching, shotcrete, rock anchors and netting will be provided.

#### Soil Slopes

Individual soil slopes will undergo a stability assessment to establish if slope stability design measures will be required. Slopes where soil overlies bedrock will be constructed to a stable slope angle and seeded or planted to allow for erosion control.

#### Karst Limestone

Evidence from the site walkovers and the desk study indicate that there are karst features present on the Site and in the surrounding study area, both in the Lucan formation and the Visean Limestones that underlie the Site.

The site investigation and geophysical survey have delineated as much as possible the areas of the Site where karst is likely to be present.

Two enclosed depressions (K65 and K66) have been identified within the central east section of the Site, through which the underground cable route is to be constructed.

To mitigate against ground instability, any surface water ingress or groundwater will be diverted from the excavations at these locations and foundations will be designed for karst conditions. Formations of all foundations will be inspected by a suitably qualified Geotechnical Engineer and probing of the ground under the foundations will be undertaken on a grid basis. If local weak spots are encountered geogrids and/or stone platforms will be used to bridge across these areas, if required.

### **Material Balance**

Importation of material from offsite will be required for the earth mat under the 220kV substation and it is envisaged that site won material will be used for the remainder of the filling operations.

Soil which is not re-used will be disposed of to an appropriately permitted facility. In the unlikely event of soil contamination being found during work on Site, the appropriate remediation measures will be employed. Any work of this nature would be carried out in consultation, with the Environmental Department of Galway County Council.

## **11.6.2 Operational Mitigation Measures**

### **11.6.2.1 Slopes**

Spalling of exposed rock and soil slopes may occur due to seasonal variations in air temperatures and poor weather conditions. Rock trenches, benches and netting will be cleared of debris and monitored by a suitably qualified person on an annual basis.

The slope stabilising measures for both soil and rock will be monitored also to ensure they are performing as designed.

### **11.6.2.2 Treatment of Sanitary Waste Water**

The only source of sanitary waste water will be the facilities in the 220kV substation control buildings. Sanitary waste water will be collected in sealed holding tanks and will not be discharged on site. Refer to **Section 3.8.11**. This will ensure that there will be no soil or bedrock contamination from sanitary waste water.

### 11.6.2.3 Containment of Spills

Any areas where there is a risk of a spill or leak of hydrocarbon will be contained and the rainwater run-off will pass through a hydrocarbon interceptor prior to discharge to ground. Refer to **Section 3.8.11**.

## 11.7 Cumulative Impacts

The potential for cumulative impacts with the following existing and proposed developments was considered:

- The construction and operation of the power supply project.
- The construction and operation of the proposed Apple data centre phase 1.
- The construction and operation of 7 future data halls and associated site roads and infrastructure.
- The construction of the M17/M18 Gort to Galway motorway.

Once construction of the M17/M18 has been completed, there is no potential for it to have a cumulative impact on soils and geology with the power supply project.

The M6 has been included as part of the existing baseline environment with respect to soils and geology. Additional cumulative impacts are not expected to arise.

There is no potential for a cumulative impact with any other development.

The data centre phase 1 project and the seven future data halls are described in **Chapter 3**. Information on the M17/M18 was obtained from the EIS for that project.

### 11.7.1.1 Construction of Power Supply Project and First Phase of the Apple Data Centre

The potential for cumulative impacts during the construction of the proposed power supply project and Phase 1 Apple data centre is addressed below.

The construction of the first phase of the Apple data centre, which is the subject of a separate planning application, will be undertaken at the same time as the proposed power supply development. The construction of the first phase of the Apple data centre is expected to use the similar earth moving, rock excavation and construction methodologies as the proposed power supply development. The similar mitigation measures will be used to reduce the risk of pollution and negative impacts during the construction phase. The construction of the first phase of the Apple data centre is expected to have a locally moderate to imperceptible impact on soils and geology. No significant in-combination effects have been identified. The cumulative impact of the power supply project and the first phase of the Apple data centre on soils and geology is expected to be locally moderate to imperceptible.



### **11.7.1.2 Construction of Power Supply Project, First Phase of the Apple Data Centre and M17/M18**

Construction of the M17/M18 will happen at the same time as construction of the power supply works and Phase 1 Apple data centre. Any impacts on soils and geology from the construction of the M17/M18 will be localised. The construction of the tower foundations, cable sealing compounds and access tracks, are the only parts of the power supply project in the vicinity of the M17/M18. The data centre phase 1 works will not be close to the M17/M18. The impacts on soils and geology, likely to arise from the excavations for the foundations of the new towers and the construction of the access tracks, end sealing compounds and tower foundations, are likely to be imperceptible and very localised. There is not expected to be a significant cumulative impact on soils and geology due to the construction of the M17/M18, the power supply works and Phase 1 Apple data centre.

### **11.7.1.3 Power Supply Project, First Phase of the Apple Data Centre, and Seven Additional Data Halls**

The power supply project and phase 1 of the data centre will be in operation when the subsequent data halls are under construction. There will be also data halls in operation, when the later data halls are under construction. Construction of the M17/M18 will be completed at that stage.

The construction of the subsequent data halls is expected to use similar earth moving, rock excavation and construction methodologies as the proposed power supply development. Similar mitigation measures will be used to reduce the risk of pollution and negative impacts during the construction phase. The construction of each subsequent data halls is expected to have a locally moderate to imperceptible impact on soils and geology.

Phase 1 of the data centre and the subsequent data halls will have the same potential operational impacts as the operational impacts of the power supply project. The logistic/admin building and the first data hall will each have a waste water treatment plant in which sanitary effluent will be treated on site to a very high standard, before discharge to a raised percolation area. Sanitary effluent from the subsequent data halls will be pumped to the effluent treatment plant of the logistic/admin building. Rainwater run-off from any areas, in which there is a risk of a spill or leak of hydrocarbon, will pass through a hydrocarbon interceptor prior to discharge to ground. Implementation of these proposed mitigation measures will ensure that the operation of phase 1 of the data centre and the operation of all subsequent data halls will, individually, have a negligible impact on soils and geology.

No significant in-combination effects have been identified. The operation of the power supply project and phase 1 of the data centre and construction and/or operation of all subsequent data halls will not have a significant cumulative impact on soils and geology.

## 11.8 Residual Impacts

It is predicted that, with the implementation of the mitigation measures, described above, there will not be a significant negative residual impact on the soils and geology as a result of the construction and operation of the proposed power supply project. There will not be significant cumulative impacts.

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