Emerging Best Performing Technology Option Report

Document no: CSG-JAC-TR-0001
Version: Final

EirGrid
CP1233

Sranangh to Clogher Project

Emerging Best Performing Technology Option Report

Client name:	EirGrid		
Project name:	Srananagh to Clogher Project		
Client reference:	CP1233	**Project no:**	321084AT
Document no:	CSG-JAC-TR-0001	**Project manager:**	Andy Scott
Version:	Final	**Prepared by:**	Sophie Cai
Date:	Sep 2025	**File name:**	CSGU-JAC-TR-0001-Technology Option Report

Document history and status

Version	Date	Description	Author	Checked	Reviewed	Approved
FINAL	Sep 25	Final Version	H Collins	S Cai	N Edwards	A Scott

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Executive Summary

This report is the Emerging Best Performing Technology Option Report for Capital Project 1233. It is intended to help select the best technology option for the project.

Capital Project 1233 is a proposed electricity development that will help to meet a network strengthening need identified in the northwest of the country along the Clogher – Srananagh network corridor. The need for the CP1233 project is a thermal transmission network issue relating to the transfer of power across the existing 110 kV transmission network corridor between Clogher and Srananagh. The issues encountered are thermal capacity problems on this corridor during high wind power output conditions and following the unplanned loss of the existing 110 kV circuits in the same network corridor. The violations observed are in breach of the Transmission System Security and Planning Standards (TSSPS) and require to be addressed by a new 220 kV high voltage connection into Donegal. This level of voltage is not currently present in Donegal. Donegal is connected to the Irish Transmission system through 110 kV circuits with a far smaller transfer capacity. This lack of capacity is a constraint on the network and creates problems in terms of security of supply, technical issues, and robustness. A new high voltage connection is needed to bring the 220 kV network from Srananagh to a key substation in Donegal.

This need was previously highlighted in both Tomorrow's Energy Scenarios (TES) 2019 and Shaping Our Electricity Future (SOEF). The limitations of the existing transmission system in this area are also driven by the integration of renewable generation in the northwest part of the country. A reinforcement in this region would play an important role in meeting the Government's renewable electricity target for 2030.

EirGrid follow a six-step approach to develop and implement the best performing solution option to any identified transmission network problem. The six steps are shown on a high-level below.

EirGrid's Six-Step Framework for Grid Development

Capital Project 1233 has entered Step 3 and there are three possible technology options which will resolve the need. The assessment of the options in Step 3, for linear projects, is based on a study area. Any required routes will be developed in Step 4 and any and all possible route obstructions are to be identified.

Technical Options

The technical options brought forward for further investigation are as follows:

- **Option 1**: New 220 kV Overhead Line;
- **Option 2A**: Upgrade an existing 110 kV Overhead Line to 220 kV and install a 110 kV Underground Cable on land; and
- **Option 2B**: Upgrade an existing 110 kV Overhead Line to 220 kV and install a 110 kV Underground Cable on land and at sea.

An option of providing a 220kV underground cable between Clogher and Srananagh was also assessed, however is considered not technically feasible.

Further detail for the feasible options is provided below:

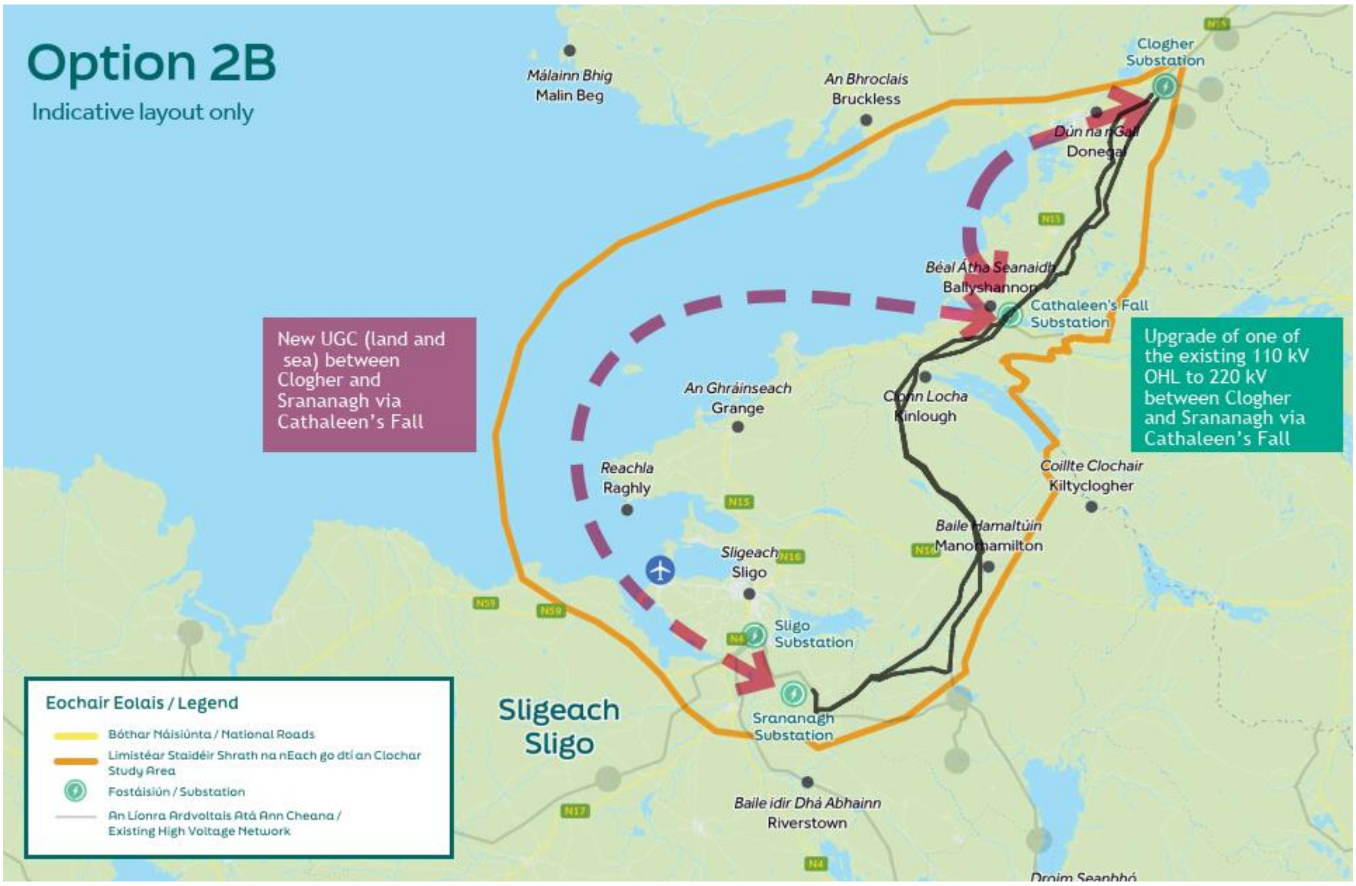
Option 1 - New 220 kV Overhead Line

- Install a new Clogher – Srananagh 220 kV Overhead Line circuit.
- Create a new 220 kV station at Clogher with two transformers.

Option 2A - Upgrade of an existing 110 kV Overhead Line to 220 kV, and install a new 110 kV Underground Cable

- Upgrade the voltage from 110 kV to 220 kV on one of the two existing 110 kV Overhead Lines between Clogher – Cathaleen's Fall – Srananagh.
- Install a new 110 kV Underground Cable **on land (terrestrial)** between Clogher - Cathaleen's Fall - Srananagh.
- The UGC requires installation of reactive compensation at both ends of the new 110 kV Underground Cable at Srananagh, Cathaleen's Fall and Clogher substations.
- Install power flow control devices at Srananagh and Clogher on the new 110 kV Underground Cable.
- Create a new 220 kV station at Clogher with two transformers.

Option 2B - Upgrade of an existing 110 kV Overhead Line to 220 kV, and install a new 110 kV Underground Cable



- Upgrade the voltage from 110 kV to 220 kV on one of the two existing 110 kV Overhead Lines between Clogher – Cathaleen's Fall – Srananagh.
- Install a new 110 kV Underground Cable **on land and in sea (terrestrial and marine)** between Clogher - Cathaleen's Fall - Srananagh.
- The UGC requires installation of reactive compensation at both ends of the new 110 kV Underground Cable at Srananagh, Cathaleen's Fall and Clogher substations.
- Install power flow control devices at Srananagh and Clogher on the new 110 kV Underground Cable.
- Create a new 220 kV station at Clogher with two new transformers.

The key difference between Option 2A and Option 2B is the route of the underground cable. The proximity of the sea means that it is possible to route the underground cable between Clogher and Srananagh on the seabed. Part of the route will need to be on land to get from the coast to the inland substations. For both Option 2A and 2B, the underground cable must be routed through Cathaleen's Fall substation for technical reasons.

Why is a 220 kV Underground Cable between Clogher and Srananagh not possible?

EirGrid has determined that a new 220 kV extra high voltage (EHV) circuit is needed; however it is not technically feasible to accommodate this as a 220 kV underground cable between Clogher and Srananagh. The transmission network in the North West and in Donegal is an area of lower load levels and is made up of lower capacity, high impedance circuits with lower connectivity than other parts of the network. This makes this area of the transmission network more susceptible to instability following faults and disturbances.

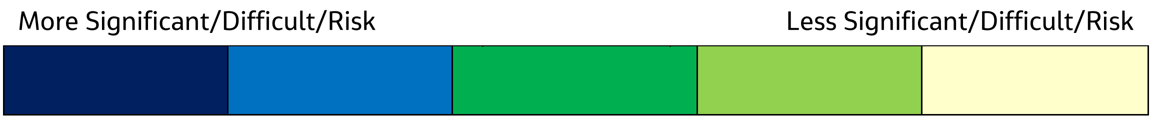
Extra high voltage underground cables have different electrical characteristics to overhead lines. Long EHV cable circuits are highly capacitive while the surrounding network, largely made up of overhead lines, is highly inductive. This creates electrical resonances, which in weaker areas of the network like Donegal, can lead to instabilities, equipment damage and operating complexity. Long lengths of underground cables also require large amounts of equipment for voltage control purposes[1]. This makes the cable difficult to energise, increasing operational complexity and risk.

An alternative technology using High Voltage Direct Current (HVDC) cable was also considered in Step 2. This was rejected, however, as an HVDC solution has significantly higher costs than Alternating Current (AC) solutions, would not integrate with the existing AC grid, and would not provide a platform for the future expansion of the transmission network in the area.

MCA Summary

A Multi-Criteria Analysis (MCA) was undertaken for the identified feasible options, assessing them against EirGrid's five assessment criteria. This analysis was used to determine the Best Performing Option to take forward.

This scale is quantified by: High (Dark Blue), Moderate - high (Blue), Moderate (Dark Green), Low - moderate (Green) and Low (Cream).



Each option was assessed using the following main criteria and sub criteria:

- **Technical criteria**: (1) *Safety Standard Compliance;* (2) *Expansion or Extendibility*; (3) *Technical Operational Risk; (4) Security & Planning Standard compliance, (5) Reliability performance, (6) Headroom, (7) Repeatability*.
- **Economic criteria:** (1) *Implementation Costs*.
- **Environmental criteria**: (1) *Biodiversity (flora & fauna, ornithology)*; (2) *Soil and Water*; (3) *Climatic Factors;* (4) *Landscape & Visual*; (5) *Planning Policy and Land Use*; (6) *Archaeology and Cultural Heritage*; (7) *Noise and Air*.
- **Deliverability criteria**: (1) *Implementation Timelines*; (2) *Project Plan Flexibility*; (3) *Dependence on Other Projects*; (4) *Risk of Untried Construction Technology*; (5) *Constructability*; (6) *Supply Chain Constraints*; (7) *Permits & Wayleaves*.
- **Socio-economic criteria**: (1) *Settlements & Communities*; (2) *Recreation & Tourism*; (3) *Humans and Human Health*; (4) *Traffic and Transport*; (5) *Telecommunication & Aviation*; (6) *Utilities*.

[1] Reactive compensation equipment to improve the power factors and stabilise voltage levels, amongst other issues.

Conclusion

A new 220 kV connection is required to meet the need and objectives of the CP1233 project. The option of a 220 kV underground cable cannot be built as the grid cannot accommodate it – there would be significant issues with its operation, safety, and its reliability. Of the feasible options, Option1 was found to be the Emerging Best Performing Option. Option 1 has been selected because of the following reasons:

- **Economic and Deliverability -** Option 1 entails constructing a new 220 kV OHL, whereas for Option 2, an existing 110 kV line is to be upgraded to 220 kV, and in addition a new 110 kV underground cable and other additional equipment (power flow control devices, reactive compensation and potential harmonic filters) are to be installed. Option 2 therefore results in additional work and thus a longer construction programme (with associated increased costs):
    - approximately four years for Option 1;
    - approximately eight years for Option 2A; and
    - approximately six years for Option 2B.
- **Technical -** OHLs (like Option 1) are widely adopted in Ireland and therefore operation and maintenance are well practiced. The OHL line can also be upgraded in the future depending upon system ratings, e.g. increasing the thermal rating of the existing conductors. Options 2A and 2B would require additional equipment (like reactive compensation and power flow control) compared to Option 1 to resolve technical challenges.
- **Environment and Socio-Economics -** Option 1 may interact with scenic routes and other such areas of visual prominence, as well as potential for setting impacts on known archaeology, architectural heritage and cultural heritage assets. The adoption of new composite pole technology could reduce the potential visual impact of the new OHL. There are also environmental designations with both geological and hydrogeological elements that could be affected by new OHL foundations, depending on their siting. Some of these risks will be greater for the underground cable element of Options 2A and 2B. Options 2A and 2B will have increased socio-economics effects due to the increased construction duration and additional construction traffic.

Option 2B competes closely with Option 2A. Option 2B has broadly equivalent environmental and socio-economic performance, with the majority of the route being marine based, thus resulting in less impact on archaeology, traffic and utilities. However, the submarine option has higher economic and technical risks due to the newer, more costly technology.

The table below summarises the findings of the MCA for the five key criteria for each feasible Option.

Summary Table of MCA for all Technology Options

	Technical	Economic	Environmental	Deliverability	Socio-economic
Option 1					
Option 2A					
Option 2B					

Acronyms

Acronym	Description
AA	Appropriate Assessment
ABP	An Bord Pleanála (now called An Coimisiún Pleanála)
ACSR	Aluminium Conductor Steel-Reinforced
AIS	Air Insulated Switchgear
CENELEC	European Committee for Electrotechnical Standardisation
EIA	Environmental Impact Assessment
EHV	Extra High Voltage
EMF	Electromagnetic Field
ESB	Electricity Supply Board
ESBN	Electricity Supply Board Networks
GIS	Gas Insulated Switchgear
HDD	Horizontal Directional Drill
HGV	Heavy Goods Vehicle
HTLS	High Temperature Low Sag
IEC	International Electrotechnical Commission
KV	Kilovolt
MCA	Multi-Criteria Analysis
MSC	Maritime Area Consent
MVA	Megavolt Ampere
OHL	Overhead Line
OPGW	Optical Ground Wire
ROW	Right-of-Way
SAC	Special Areas of Conservation
SID	Strategic Infrastructure Development
SOEF	Shaping Our Electricity Future
STDC	Standard Transmission Development Cost
TES	Tomorrow's Energy Scenarios
TII	Transport Infrastructure Ireland
TR	Thermal Resistivity
UGC	Underground Cable

1. Introduction

1.1. What is Capital Project 1233?

Capital Project 1233 is a proposed electricity development that will help to meet a network strengthening need identified in the northwest of the country along the Clogher – Srananagh network corridor. The need for the CP1233 project is a thermal transmission network issue relating to the transfer of power across the existing 110 kV transmission network corridor between Clogher and Srananagh. The issues encountered are thermal capacity problems on this corridor during high wind power output conditions and following the unplanned loss of the existing 110 kV circuits in the same network corridor. The violations observed are in breach of the Transmission System Security and Planning Standards (TSSPS) and require to be addressed by a new 220 kV high voltage connection into Donegal. This voltage level is not currently present in Donegal. Donegal is connected to the Irish Transmission system through 110 kV circuits with a far smaller transfer capacity. This lack of capacity is a constraint on the network and creates issues in terms of security of supply, technical issues, and robustness. A new high voltage connection is needed to bring the 220 kV network from Srananagh to a key substation in Donegal.

This need was previously highlighted in both Tomorrow's Energy Scenarios (TES) 2019 and Shaping Our Electricity Future (SOEF). The limitations of the existing transmission system in this area are also driven by the integration of renewable generation in the northwest part of the country. A reinforcement in this region would play an important role in meeting the Government's renewable electricity target for 2030.

The existing transmission network in the North West is shown in Figure 1. The corridor between Clogher 110 kV and Srananagh 220 kV stations is highlighted.

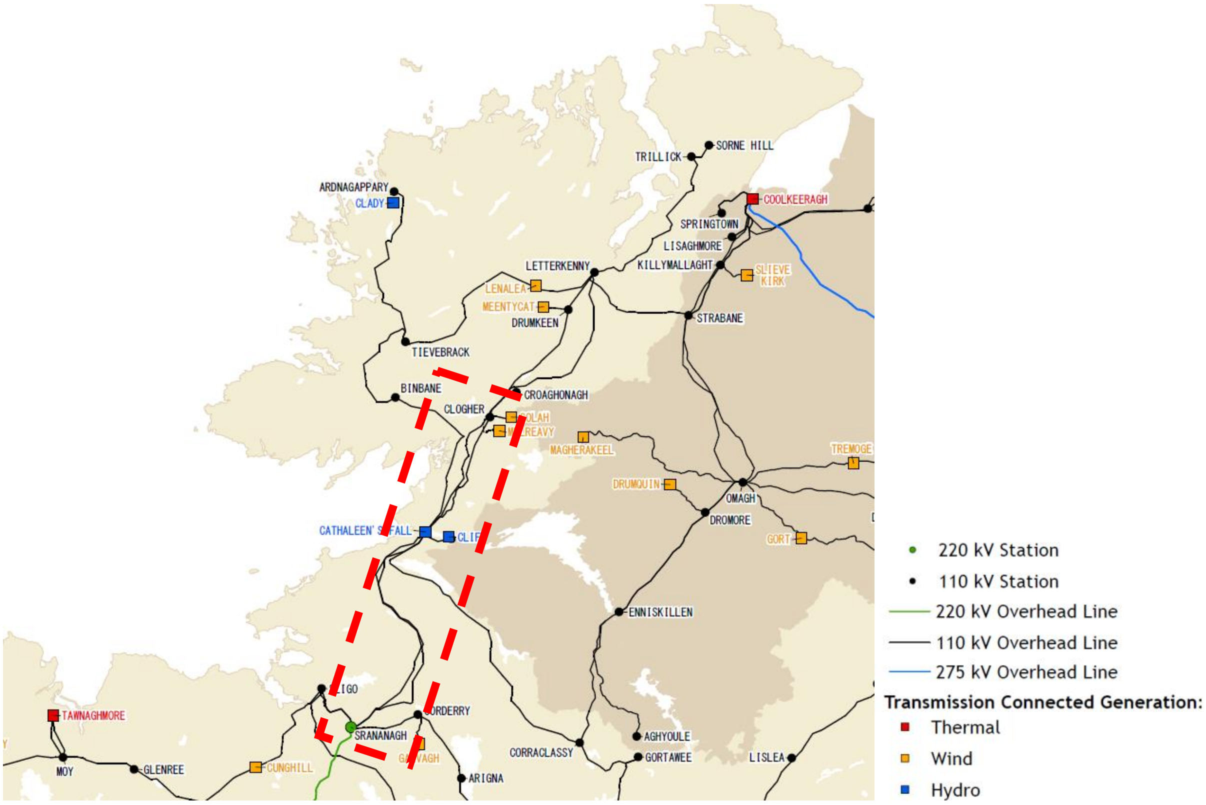


Figure 1: Location of Need

The northwest part of the National Grid is considered a relatively weak part of the transmission network, with only three points of supply, two of which are the existing Clogher – Cathaleen's Fall – Srananagh 110 kV circuits, the other being the existing Cathaleen's Fall – Coraclassy 110kV circuit. The existing Letterkenny - Strabane 110 kV circuit is used only during maintenance scenarios or in emergency situations where either the Ireland or Northern Ireland transmission system needs to support the other.

All appropriate technologies to resolve the identified need have been assessed and have been used in the initial creation of options. This includes technologies from the approved toolbox and any innovative technologies, yet to be approved.

The technology overview for this project also considered maximising the utilisation of existing infrastructure where spare capacity may exist using power flow controlling equipment; but these were found not to provide the required capacity. Based on this, the development of options must involve additional circuits and/or changes to existing circuits to increase their capacity to transmit power.

As per strategy statements, EirGrid is committed to making best use of existing assets before considering investing in new assets. The technology overview also confirmed that 110 kV thermal upgrading would not be considered as all the existing 110 kV circuits between Clogher, Cathaleen's Fall and Srananagh transmission stations have already been upgraded to the standard 110 kV overhead line (OHL) rating.

The technology used to make best use of the existing assets is upgrading the voltage using existing steel lattice towers or a new technology, composite pole sets. The latter technology involves replacing key components of the existing circuit to safely accommodate a higher operating voltage along the existing OHL alignment.

1.2. Framework for Grid Development Explained

EirGrid follows a six-step approach to develop and implement the best performing solution option to any identified transmission network problem. The six steps are shown on a high-level below, Figure 2.

Figure 2: EirGrid's Six-Step Framework for Grid Development

Capital Project 1233 has entered Step 3, where the technology options and the study area are considered in more detail to determine a best performing option. Information on the analysis methods used is provided.

Three technology options have been identified which will meet the project need. The assessment of the options in Step 3, for linear projects, will be based on a study area. Any required line routes will be developed in Step 4 but any and all possible route obstructions are to be identified at Step 3.

1.3. Aims and Contents

Three technology options were brought forward for more detailed analysis in Step 3. All options involve transmission network reinforcements centred on strengthening the network between the existing Clogher and Srananagh stations.

In Step 3, the solution options will be investigated based on five main criteria, namely:

- Technical performance;
- Economic performance;
- Environmental aspects;
- Deliverability aspects; and
- Socio-economic aspects.

The criteria will be broken down further into sub-criteria and a multi-criteria evaluation matrix will be used to identify the best performing option that will be brought forward to construction and energisation (see Section 3 for further details).

1.4. Relationship to other Projects

Projects CP1233 and CP0982 are interlinked and share a common connection point at the existing Srananagh 220 kV substation. CP0982 project entails the reinforcement of the existing transmission system in the northwest of Ireland specifically to reinforce the grid between Flagford, Srananagh and Sligo Substations.

Two options have been considered for the CP0982 project:

- Option 1: Voltage upgrade to 220 kV of the existing Flagford – Sligo 110 kV overhead line; and
- Option 2: Thermal uprate of the existing Flagford – Sligo 110 kV overhead line plus a new Flagford – Srananagh 220 kV UGC.

Option 1 has recently been announced as the Emerging Best Performing Option for CP0982.

A second 220/110 kV 250 MVA transformer will also be required in Srananagh station as part of the CP0982 project. These projects need to be coordinated in Step 4 with regard to works at that site. This option assessment factors in the outline design information provided from CP0982.

2. The Project

2.1. Project Study Area

The Project study area is defined as the area investigated for the possible installation of any of the technologies identified in Step 2. The identified area is shown in Figure 3 below.

Figure 3: Project Study Area

This study area has been determined by considering a variety of factors, including the technical requirements of the project, road network presence, settlements, physical constraints e.g. motorway, river or rail crossings and some environmental constraints.

The overall study area has been identified to allow for flexibility when considering route options for 'the different technology options, and connections into the substations, ensuring that identified hazards can be avoided through routing.

The Northern Ireland border defines a large part of the eastern boundary of the study area. It would not be practicable for the project to extend into Northern Ireland because of the licensing agreements set by national governments of both jurisdictions. The area towards Lough Derg (see Figure 3) and towards Scraghey in County Tyrone has been avoided because of hills and bogs to the east of the study area. These would not be feasible/practical for either OHL or UGC routing.

The extent of the marine environment has been considered. It extends west from the coastline to accommodate any potential marine cable routes and allow enough freedom to avoid adverse ground and associated hazards during route selection. This includes rock outcrops which are present on the seafloor between Inishmurray and Mullaghmore. While it is possible to engineer solutions through the rock, having a larger study area will enable various route options to be assessed. This is advantageous as it allows for longer but less hazardous routes to be identified.

The study area has also been extended in both the northern and southern areas to include options for the land-based cable sections connecting the substations to the marine cable. From Clogher substation in the north, the study area extends west of Donegal and Mountcharles, providing a larger area for suitable landfall sites. Similarly, the southern section has been extended past Meenashammer, to provide potential landfall sites either side of Ballysadare Bay.

2.2. Technologies Being Considered

Three potential technology options have been brought forward from Step 2 for further consideration:

- **Option 1**: New 220 kV Overhead Line;
- **Option 2A**: Upgrade an existing 110 kV Overhead Line to 220 kV and install 110 kV Underground Cable on land; and
- **Option 2B**: Upgrade an existing 110 kV Overhead Line to 220 kV and install 110 kV Underground Cable on land and at sea.

The initial technical investigations during Step 2 determined that a full EHV UGC solution option cannot be accommodated into the transmission network in the North West due to the length of the circuit required in combination with topology and the characteristics of the existing network in the North West and Donegal, which is largely low capacity 110kV OHL. An EHV UGC of the lengths needed is highly complex to operate and could result in significant instabilities and damage to the national grid arising from the following phenomena:

- zero-miss phenomenon - Circuit breakers may fail to interrupt, leading to damage to the grid and major safety issues;
- harmonic distortion – the national grid operates at a certain frequency; distortions result in instability and shut-downs; and
- temporary over voltages (TOVs) – these result in serious risks to insulation and system stability.

Issues with any of the phenomena above negatively impact transmission system reliability, security, and operability.

An alternative technology using High Voltage Direct Current (HVDC) cable was also considered in Step 2. This was not brought forward as a viable technology as an HVDC solution would not integrate with the existing AC grid and would not provide a platform for the future expansion of the transmission network in the area, in addition to having a significantly higher cost than AC solutions.

The above work informed the identification of Option 1 and Option 2A. Given the potential geographical constraints in the area, a **submarine cable** route (Option 2B) for the new 110 kV circuit was also considered. A preliminary screening exercise as part of the subject study indicated a difference in character but a comparable level of potential constraints risk between the terrestrial and marine areas of the study area, justifying the scoping of a potential submarine cable route.

There are some common requirements for all options, and it should be noted that a second 220/110 kV 250 MVA transformer is needed in Srananagh station; this is captured in the Capital Project 0982 scope, which is further progressed along the EirGrid network development framework.

The options identified that can solve the need in the area are as follows:

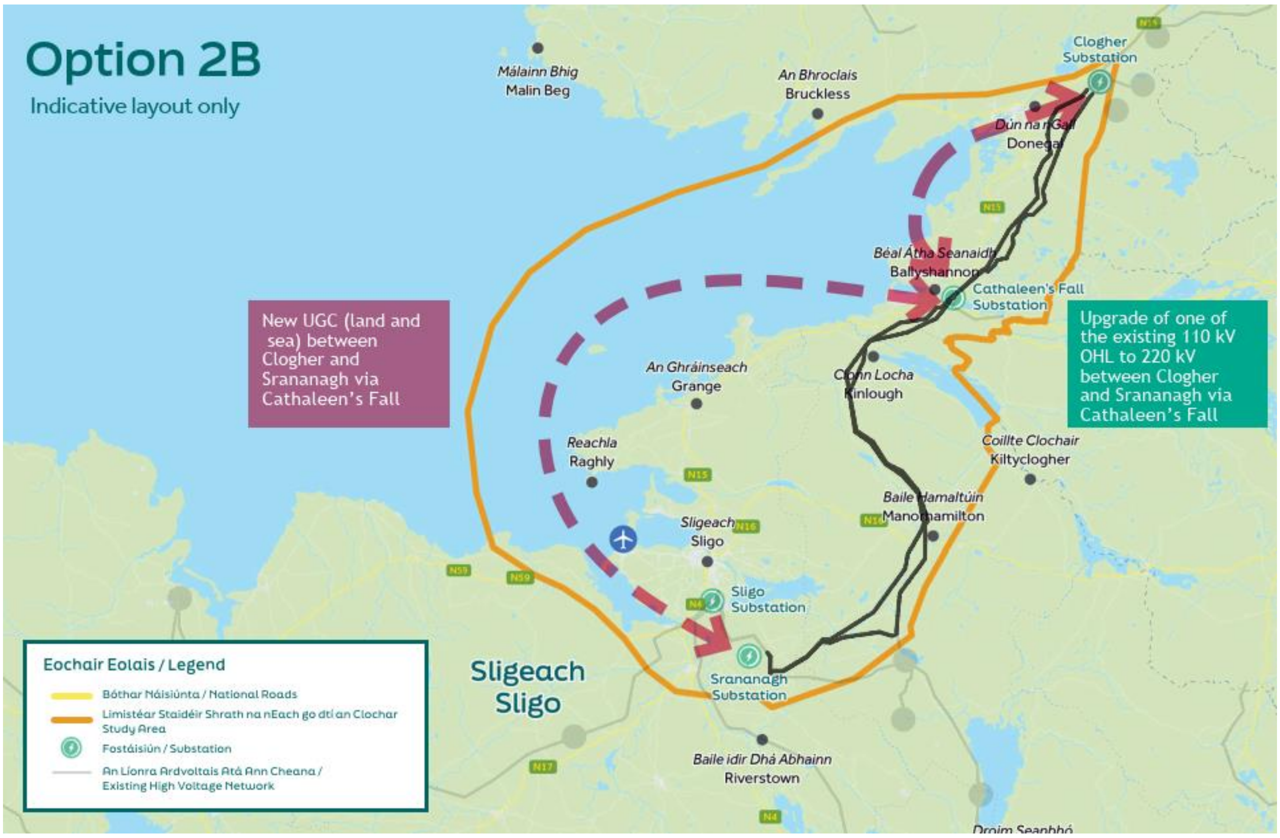
Option 1 - New Clogher – Srananagh 220 kV Overhead Line:

- Install a new Clogher – Srananagh 220 kV Overhead Line circuit.
- Create a new 220 kV substation at Clogher with two new transformers.

Option 2A - Upgrade of an existing 110 kV Overhead Line to a 220 kV Overhead Line, and install a new 110 kV Underground Cable circuit:

- Upgrade the voltage from 110 kV to 220 kV on one of the two existing 110 kV Overhead Lines between Clogher – Cathaleen's Fall – Srananagh.
- Install a new 110 kV Underground Cable **on land (terrestrial)** between Clogher - Cathaleen's Fall - Srananagh.
- The UGC requires installation of reactive compensation at both ends of the new 110 kV Underground Cable at Srananagh, Cathaleen's Fall and Clogher substations.
- Install power flow control devices at Srananagh and Clogher on the new 110 kV Underground Cable.
- Create a new 220 kV station at Clogher with two 220/110 kV 250 MVA transformers.

Option 2B - Upgrade of an existing 110 kV Overhead Line to a 220 kV Overhead Line, and install a new 110 kV Underground Cable circuit:



- Upgrade the voltage from 110 kV to 220 kV on one of the two existing 110 kV Overhead Lines between Clogher – Cathaleen's Fall – Srananagh.
- Install a new 110 kV Underground Cable **on land and in sea (terrestrial and marine)** between Clogher - Cathaleen's Fall - Srananagh.
- The UGC requires installation of reactive compensation at both ends of the new 110 kV Underground Cable at Srananagh, Cathaleen's Fall and Clogher substations.
- Install power flow control devices at Srananagh and Clogher on the new 110 kV Underground Cable.
- Create a new 220 kV station at Clogher with two 220/110 kV 250 MVA transformers.

The key difference between Option 2A and Option 2B is the route of the underground cable. The proximity of the sea means that it is possible to route the underground cable between Clogher and Srananagh on the seabed. Part of the route will need to be on land to get from the coast to the inland substations. For both Option 2A and 2B, the underground cable must be routed through Cathaleen's Fall substation for technical reasons.

3. Process and Multi-Criteria Assessment

3.1. Introduction

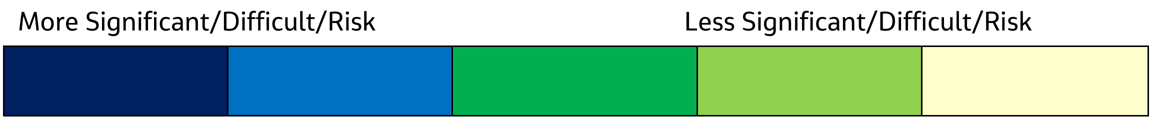
The key tool used in identifying the preferred option was the Multi Criteria Assessment (MCA) Matrix. This uses EirGrid's five assessment criteria (technical, economic, environmental, deliverability and socio-economic).

3.2. Description of Process

Each option was assessed against the aforementioned criteria and rated using EirGrid's risk scale. The effect on each criterion parameter is qualitatively determined using expert judgement and experience. This is presented by means of colour coding, along a range from "more significant"/"more difficult"/"more risk" to "less significant"/"less difficult"/"less risk".

The following scale is used to illustrate the performance of each criterion:

- High – (Dark Blue)
- High Moderate – (Blue)
- Mid-level Moderate – (Dark Green)
- Low-moderate – (Light Green)
- Low – (Cream)



3.3. Criteria Used for Comparison of Options

The main criteria and sub criteria used are listed below:

- **Technical performance criteria**: (1) *Safety Standard Compliance;* (2) *Expansion or Extendibility*; (3) *Technical Operational Risk; (4) Security & Planning Standard compliance, (5) Reliability performance, (6) Headroom, (7) Repeatability*.
- **Economic performance criteria**: (1) *Implementation Costs*.
- **Environmental criteria**: (1) *Biodiversity (flora & fauna, ornithology)*; (2) *Soil and Water*; (3) *Planning Policy and Land Use*; (4) *Landscape & Visual*; (5) *Climatic Factors*; (6) *Archaeology and Cultural Heritage*; (7) *Noise and Air*.
- **Deliverability criteria**: (1) *Implementation Timelines*; (2) *Project Plan Flexibility*; (3) *Dependence on Other Projects*; (4) *Risk of Untried Construction Technology*; (5) *Constructability*; (6) *Supply Chain Constraints*; (7) *Permits & Wayleaves*.
- **Socio-economic criteria**: (1) *Settlements & Communities*; (2) *Recreation & Tourism*; (3) *Humans and Human Health*; (4) *Traffic and Transport*; (5) *Telecommunication & Aviation*; (6) *Utilities*.

The range of sub-criteria used for the assessment of the Shortlist of Technology Options are listed and described in the following sections.

3.3.1. Technical Criteria

The sub criteria used are listed below:

(1) *Safety Standard Compliance*: The project should comply with relevant safety standards such as those from the European Committee for Electrotechnical Standardisation (CENELEC). Materials should comply with IEC or CENELEC standards.

(2) *Expansion or Extendibility*: This considers the ease with which the option can be expanded, i.e. it may be possible to upgrading an OHL to a higher capacity or a new voltage in the future.

(3) *Technical Operational Risk*: "Technical Operational Risk" aims to capture the risk of operating different technologies on the network.

(4) *Security & Planning Standard compliance*: The solution option should comply with the network reliability and security standards defined in the Transmission System Security and Planning Standards (TSSPS) (EirGrid, TRANSMISSION SYSTEM SECURITY AND PLANNING STANDARDS , May 2016) and the Operating Security Standards (OSS) (EirGrid, Operating Security Standards, January 2021). All options investigated will meet the minimum technical requirements set out in the above standards. Options which extend or enhance technical performance margins beyond minimum acceptable levels are favoured over others.

The options are assessed against the need identified, i.e. thermal overload. A short description of this is given below.

<u>Thermal overload criteria</u>

The options are assessed for compliance with the TSSPS. If thermal overload violations are identified, additional potential reinforcements will be added to the options until the enhanced option fully meets the TSSPS. For this technical criterion, the options have been assessed based on identified thermal overloads remaining after the option has been added. This will provide an indication of how the options are performing in terms of adding thermal capacity.

(5) *Reliability performance*: The technologies and equipment associated with the different options have different performance and reliability characteristics. The reliability of transmission infrastructure is associated with two categories or type of outages, namely unplanned outages and planned outages. Each technology or type of equipment is associated with faults (unplanned outages) that routinely occur. These can be represented as average failure rates usually expressed as unplanned outages/100km/year.

This criterion will also account for the mean time to repair. This is the time taken to return the equipment to service after a fault has occurred. The assessment has been based on transmission performance statistics (EirGrid, Analysis of Disturbance and Faults 2022 , March 2024) or industry standard reliability data.

This sub-criterion will also assess the typical time the options would be unavailable for during planned outages. Planned outages are normally associated with annual routine maintenance and will be based on typical outage durations taken from maintenance policies. The reliability for each option will be based on a combination of the above type of outages. The reliability of the station equipment associated with the options is assumed to be the same for all options and is therefore not included in this analysis.

(6) *Headroom:* This criterion assesses the ability of each option to accommodate increases in renewable generation in the North-West region.

Each option is compared relative to the other to determine the increase in renewable generation in the North West, that can be accommodated without further network reinforcements being required. The limit for each option can be found by increasing renewable generation in the North-West until a TSSPS limit is reached.

The headroom for each option is the difference between the renewable generation that can be accommodated by the network with that option included and the renewable generation that can be accommodated by the network with no option included.

(7) *Repeatability:* This criterion examines whether this option can be readily repeated in the Irish network. One-off or bespoke solutions carry additional system integration, operational, and maintenance complexity. For example, an OHL option is very repeatable, but a fully or partially underground cable option is less repeatable as there may be harmonic filter and reactive compensation requirements that are bespoke for each option. The amount of cable that can be integrated in certain parts of the network may also be limited.

3.3.2. Economic Criteria

The sub criteria used are listed below:

(1) Implementation Costs: Costs associated with the procurement, installation and commissioning of the grid development and therefore includes all the transmission equipment that forms part of the project's scope.

3.3.3. Environmental Criteria

The sub criteria used are listed below:

(1) *Biodiversity (flora & fauna, ornithology)*: Assessment of the potential impacts on protected sites for nature conservation, habitats, and protected species.

(2) *Soil and Water*: Potential impact on soils (geology, Irish geological heritage sites, etc) and water (water quality of surface waters and groundwater).

(3) *Planning Policy and Land Use*: Potential risks associated to land purchase and planning approvals.

(4) *Landscape & Visual*: Assessment of landscape constraints and designations and the potential impact on visual amenity.

(5) *Climatic Factors*: The potential for release of greenhouse gasses or impacts on climate change.

(6) *Archaeology and Cultural Heritage*: The potential for impacts on the cultural heritage and archaeological resources.

(7) *Noise and Air*: Potential for air pollution and vibration and operational noise impact of lines and substations, taking into account sensitive receptors.

3.3.4. Deliverability Criteria

The sub criteria used are listed below:

(1) *Implementation Timelines*: Relative length of time until energisation (assess significant differences).

(2) *Project Plan Flexibility*: Does the project plan allow for some flexibility if issues arise during design and construction?

(3) *Dependence on Other Projects*: Does the project depend on the completion of other projects?

(4) *Risk of Untried Construction Technology*: Has the technology been used by EirGrid and ESBN in the past.

(5) *Constructability*: Feasibility of construction (outage requirements?). Ease/difficulty of mitigation measures that may be required to prevent complications during construction.

(6) *Supply Chain Constraints*: Any constraints (e.g. small number of suppliers in Ireland or internationally) that would affect the procurement of materials or services (e.g. cable laying vessels waiting list lead time) to complete the project.

(7) *Permits & Wayleaves*: Various permissions and wayleaves required to proceed to construction.

3.3.5. Socio-economic Criteria

The sub criteria used are listed below:

(1) *Settlements & Communities*: The expected impact of a grid development option on towns, villages and rural housing, and the way of life of their communities, residents, workers and visitors.

(2) *Recreation & Tourism*: Impact on recreational activities (e.g. fishing, sports) and tourism during and after construction, that are not included in the other sub criteria.

(3) *Humans and Human Health*: The potential for impacts on people and their health – please see information on electromagnetic fields (EMF) below

(4) *Traffic and Transport*: Traffic disturbance and impacts that may occur during the construction phase and mitigation measures to reduce impacts

(5) *Telecommunication & Aviation*: Impact on wireless services such as radars, radio communications, TV, flight paths, etc.

(6) *Utilities*: Impact on existing utilities.

The following sections present the assessments of each option under the performance criteria, with the sub criteria demarcated with a number to correspond to those outlined above.

3.3.5.1. Electromagnetic Fields

EirGrid operates the electricity grid to stringent safety recommendations set out by the EU as well as national and international agencies. These recommendations are based on peer-reviewed medical and health studies, independent of any grid operator. The European Union recommendation (1999/519/EC)[2] outlines a set of both 'reference' and 'restriction' levels for limiting overall exposure to electromagnetic fields and ensuring an increased level of protection. The purpose of the reference levels is to prompt further investigation to ensure the restriction levels are not exceeded. EirGrid designs the electricity network to make sure that public exposure to EMFs does not exceed EU restriction levels. For both the magnetic fields and the electric fields, the levels recorded are below the restriction levels set by the International Committee on Non-Ionising Radiation Protection (ICNIRP). This is an independent body, funded by public health authorities around the world. ICNIRP has reviewed the safety of EMFs and recommended limits on exposure that are far below levels where adverse effects might occur.

The EMFs created by the electricity grid are not high enough to be considered harmful to humans. Extensive scientific research has found no hazardous effects from long-term exposure to low levels of EMFs. This includes the small amounts of extremely low frequency EMFs produced by electricity infrastructure.

[2] *1999/519/EC: Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz). Available at: https://eur-lex.europa.eu/eli/reco/1999/519/oj/eng*

4. Option 1 – New 220 kV Overhead Line

4.1. Description of Option 1

4.1.1. New 220 kV Overhead Line

Option 1 comprises a proposed 220 kV overhead line circuit from Srananagh substation to Clogher substation.

To connect this proposed circuit, a new 220 kV station at Clogher will be required with two new 220/110 kV 250 MVA transformers.

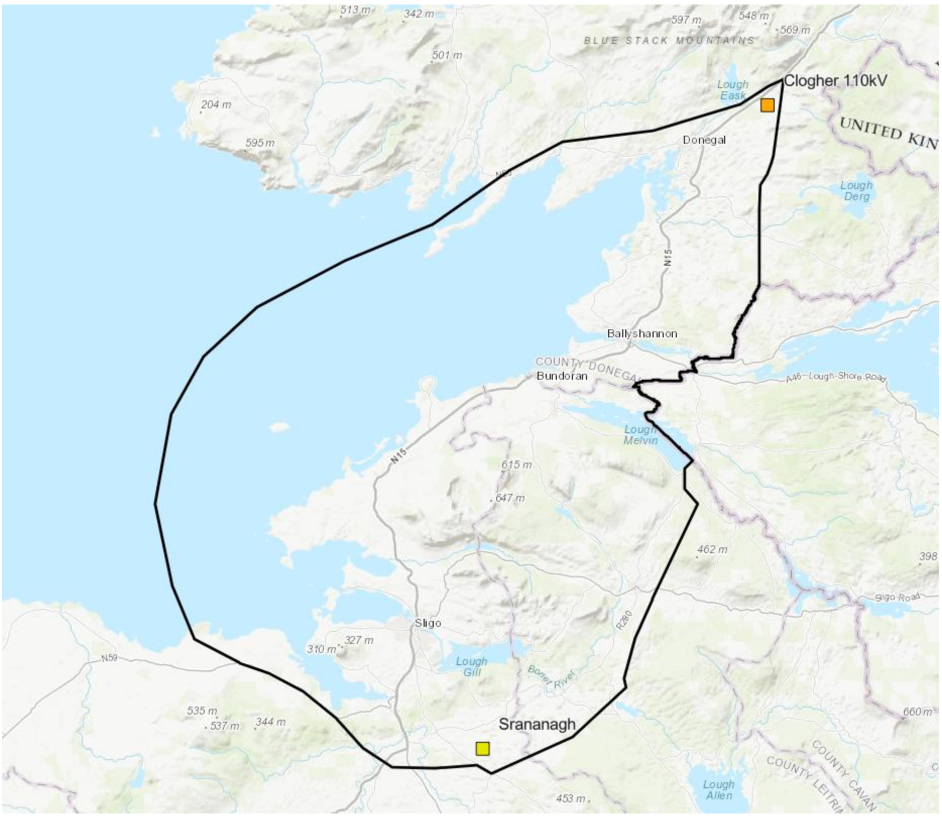


Figure 4: Location of the Substations within the Study Area to be Connected in Option 1

Figure 4 above illustrates the study area encompassing all potential route corridors for the new 220 kV OHL option.

The design of the proposed 220 kV OHL could incorporate standard lattice galvanized metallic, single circuit, steel structures, steel poles. Alternatively, composite pole sets could be considered if deemed more cost effective, constructable, or less visually intrusive.

The OHL line-section of the proposed transmission line/cable, according to a preliminary routing, will be approximately 80 km, with no major crossings of motorways and railways. The existing 110 kV OHLs will be crossed and outages should be accorded and minimised through construction methodology.

Structures will have overhead ground wires to protect the OHL against lightning strikes. This ground wire can have optical fibres (optical ground wire or OPGW) to provide communication between substations.

The conductors will meet the necessary ratings for EirGrid systems under both normal and emergency situations. Those ratings were defined by EirGrid Policy.

For metallic structures, foundations will be shallow concrete pads, with columns to connect to structure legs, whereas for poles, the lower part of the structure will be buried into the ground and secured with concrete. For areas with weak soil, concrete piles will be used.

The following sections present the assessment of Option 1 under each performance criteria and their sub criteria.

4.2. Technical Criteria

The sub criteria are listed below:

(1) Low risk to safety standard compliance, as this option uses a known technology and construction methodology for OHLs that comply with the safety standards.

(2) Low risk to expansion or extendibility, as OHL can be upgraded in the future by replacing conductor or increasing the thermal rating of the existing conductor and modifying or replacing existing structures. Although this would involve a significant scope of works, it is still less extensive than the works required for expanding or extending the cabling options.

(3) Low risk to technical operation risk, as OHLs are widely operated in Ireland, so operation and maintenance are well practiced. A hybrid OHL / UGC circuit is somewhat less common and introduces some complexities into the protection scheme.

(4) Low risk to security & planning standard compliance. The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operating Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The new 220 kV OHL option proposed will comply with the relevant system reliability and security standards referenced above. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), the loss of either of the existing Cathaleen's Fall – Clogher 110 kV circuits, leads to major thermal overloads up to 155% on 110 kV circuits in county Donegal.

When the new 220 kV OHL option is added to the system model, the overall loading of the circuits under an intact network is reduced and importantly the post contingency thermal overloads are removed.

When all aspects are considered, the new 220 kV OHL option is considered to have good compliance when assessed against the above standards and hence has been given a low impact in the assessment.

(5) Low risk to reliability performance. This criterion has been assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the solution. The reliability and outages of the station equipment associated with the circuit is assumed to be same for both options

and is therefore not included in this analysis. Similarly, as both options propose the installation of a Clogher – Srananagh 220 kV OHL, the 220 kV OHL is also not included in this analysis. Therefore, the outcome is that this analysis compares the annual availability of 110 kV OHL technology as part of Option 1 with 110 kV UGC technology as part of Option 2.

The statistics for reliability are based on EirGrid's and international failure statistics, the mean time to repair and the availability in days per 100 km per year for OHL and UGC. It has been assumed that the 110 kV OHL and UGC circuits in Options 1 and 2 respectively would be approximately 80 km in length for the purpose of this assessment, i.e. straight-line distance between the existing Clogher and Cathaleen's Fall stations plus 25% and the straight-line distance between the existing Cathaleen's Fall and Srananagh stations plus 25%.

There are 4312 km of existing 110 kV OHLs in Ireland. This length of 110 kV OHL is a sufficient sample for determining meaningful performance statistics.

Unplanned Outages

Almost all OHL faults are of short duration as a result of transient faults such as lightning strikes. If an auto-reclose function is provided for the protection of the line, it will restore the circuit shortly after the fault, generally in 0.5 – 3 seconds. Even if the line suffers physical damage, faults can be rapidly located and identified by visual inspection from the ground or air, and repairs effected in a matter of hours. Transmission system statistics indicate that 91.9 % of overhead line outages lasted less than one day.

Taking the fault statistics of the 4312 km length of 110 kV OHL for the period 2004 to 2022, gives a projected fault rate of 0.81 unplanned outages/100km/year.

Given typical repair times, of approx. 2 days, this would equate to the 80 km 110 kV OHL circuit being out of service due to a permanent fault for approx. 31 hours (which is 1.3 days) per annum. The average failure rates during normal operation, average repair times and availabilities of the main elements of a typical 110 kV OHL are set out in Table 4-1 below and adjusted to reflect the length of the proposed option.

Transient faults are not considered, as any interruptions to supply that they may cause would be of such short duration that their effect is considered to be negligible, despite being an inconvenience for electricity users.

Planned outages

Planned outages are normally associated with routine maintenance. For a 110 kV OHL, much of the required routine maintenance can be completed without an outage of the circuit. The planned outage rates and the typical outage durations taken from our maintenance policies result in an annual planned outage rate of 0.65% for 110 kV OHL, or circa 2.5 days (rounded to the nearest half day) per annum.

Combination of the planned and unplanned outages

Due to the length of the 110 kV OHL circuit in Option 1 (i.e. approximately 80 km), the total unplanned outage time per year is circa 31 hours (i.e. 1.3 days), which combined with the planned outage rate of 2.5 days sums to a total of 4 days per annum (rounded to nearest half day). This is set out in Table 4-1 below.

Table 4-1: Reliability performance of an 80 km 110 kV OHL

Summary of reliability performance of 110 kV OHL	110 kV OHL (80 km)
Reliability (Unplanned outages/100km/year)	0.81
Reliability (Unplanned outages/80km/year)	0.65
Mean time to repair (days)	Circa 2 days
Unplanned Outages Unavailability due to disturbance (days/80km/year)	1.3 days (c.31 hours)
Planned Outages	2.5 days
Total Annual Unavailability (days/80km/year) (rounded to nearest half day)	4 days

The availability rate for this OHL option is high at 98.9% over any given year and this OHL option is deemed to have a low risk of introducing additional reliability issues in the system.

(6) Low risk to headroom. Both options provide the same transmission capacity and therefore accommodate the same amount of renewable generation in the North-West region. Hence, both options have been given a low impact in the assessment.

(7) Low risk to Repeatability. Overhead line (OHL) technology is already in use on the Irish transmission system with more than 6,500 km of circuit length. This criterion is assessed on a technical basis and there are few technical issues with OHL technology that would introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of OHL circuits on the Irish transmission system. There may of course be other challenges with OHL technology, but they are assessed under other criteria. This option is considered to have a low risk of not meeting the repeatability criteria.

4.3. Economic Criteria

The sub criteria are listed below:

(1) Low risk to implementation costs as the costs only involve a new 220 kV OHL route. However, factors such as access, third-party protection costs, and construction location could affect overall costs. Construction is estimated at 4 years and 3 months, with flexibility in the project plan for overhead options. The cost of construction in more residential and built-up areas like Ballyshannon is likely to be affected by limited access, protection requirements and traffic management in this area, whereas in rural areas, the cost of access is more likely to be orientated around ground conditions and reinstatement post construction.

4.4. Environment Criteria

The sub criteria are listed below:

(1) Low to moderate risk to biodiversity, as the constraints are localised to small areas as the towers being installed would likely not cause a detrimental effect to the surrounding area due to not having a wide footprint, and therefore the low requirement for habitat alteration to accommodate them.

(2) Low to moderate risk to soil and water. The construction of an OHL would depend on the placement of tower footings, with the localised removal of peat in some areas which would also have implications for the size of excavations required. In 70% of the area there is also groundwater vulnerability of rock near or at surface or karst which is defined as being of extreme and high vulnerability because of its physical structure, with a strong correlation with areas of high-density karst features. There are also pockets of surface water flooding around the study area, but these would not be majorly impacted by an OHL construction.

(3) Moderate risk to climatic factors, as any new option would benefit by bringing renewable energy into the electricity supply network. The use of OHLs necessitates the construction of foundations which are potentially in peat (a natural carbon sink) and use of materials with a high embodied carbon (steel). The construction of OHLs would result in multiple trips to excavate material, pour concrete, and construct the lines, which would result in a high carbon footprint. However when compared to Option 2 which would have the above plus work for an underground cable trench, the construction time is considerably shorter (approx. 4 years and 3 months instead of between 6 and 7 years) and the amount of materials required would be much smaller.

(4) Moderate risk associated with planning policy and land use. While the provision of new electricity infrastructure, is supported by the relevant development plan policies across the study area, there is a presumption in favour of undergrounding where practicable. However, as undergrounding a 220kV cable is not practicable, the Option 1 alternative (while not as compliant with policy as Options 2A and 2B) does allow grid connection at a voltage which offers further grid development opportunities. In addition, at the local level, recent case law provides precedent for greater weight in decision making to be given to national obligations over local land use policy.

(5) Moderate risk to landscape and visual due to the new 220 kV OHL on conventional towers. There is potential for effects on landscapes and views across the study area, however, the more sensitive landscapes, viewpoints and main settlements would be avoided, as far as possible, in-line with EirGrid's routing principles. This would be an effect during the operation of the OHL, but effects on landscape and views would be limited and not likely to be significant during construction. This assessment is based on the OHL elements of each option being delivered on steel lattice towers for 220 kV overhead lines. This is a mature technology in Ireland and these towers have been used throughout the country and help to blend circuits into the landscape as they are largely see-through. As part of ongoing reviews of best practice in other jurisdictions, EirGrid and ESBN have identified an alternative assembly to the steel lattice tower for 220kV overhead lines. This alternative is a new structure type called composite poles. Composite pole structures have the general appearance of wooden poles and are made of fibreglass. They are used throughout the world and have been subject to rigorous testing by EirGrid and ESBN. Steel lattice towers have been assessed at Step 3 because their construction and operational effects and impacts are known by the public and statutory consultees. While there is an existing evidence base for the uses and benefits of composite poles, for the purposes of robust assessment they have not been considered at this Step 3. However, at Step 4, it is expected their use will be integrated into routing decision making and it is expected they will provide benefits in the social impact and environmental assessments.

(6) Moderate risk to archaeology and cultural heritage, as there is potential for the impact on the setting of heritage assets during construction and operation. Given the sensitivity and number of archaeological, architectural heritage and cultural heritage assets identified within the Study Area while it may be possible to reduce impact through optioneering and design, it is unlikely that significant impacts on the setting of archaeological, architectural heritage and cultural heritage assets during operation can be completely avoided. While measures such as recording the setting of archaeological, architectural and cultural heritage assets may ameliorate impact, it is unlikely to wholly mitigate them. There is potential for physical impacts on known archaeological, architectural heritage and cultural heritage assets, and on unknown archaeological remains. It may be possible to avoid significant physical impacts through optioneering and design, and to mitigate impacts through measures such as archaeological investigations or recording of architectural heritage assets.

(7) Low to moderate risk to noise and air, as there is potential for temporary noise and vibration impacts at nearby sensitive receptors during the construction phase of this OHL option, predominantly due to traffic and construction works. There is potential for localised noise impacts at sensitive receptors during the operational phase of this option as a result of corona discharge which is particularly noticeable during wet weather. However, according to 'EirGrid Evidence Based Environmental Studies Study 8: Noise' corona noise impacts may not be likely at 220 kV and only become a significant issue at 350 kV and above. Aeolian noise can also be generated by OHLs when wind passes through the conductors, but this noise is often masked by noise from the wind itself. Both corona and aeolian noise are temporary and are not likely to result in a significant impact on sensitive receptors.

4.5. Deliverability Criteria

The sub criteria are listed below:

(1) Low to moderate risk to implementation timelines due to the 4 years and 3 months required for construction and lead time for conductor delivery.

(2) Low to moderate risk to project plan flexibility.

(3) Low risk due to dependence on other projects as this option does not depend on other projects.

(4) Low to moderate risk of untried technology, as the OHL technology has been used by EirGrid and ESBN in abundance in the past.

(5) Low risk to constructability as the OHL can be constructed predominantly offline and in rural areas/ away from residential areas in-line with EirGrid Routing's Principles.

(6) Low – moderate risk to supply chain constraints, as risks can be mitigated with different suppliers across Europe.

(7) Moderate to high risk associated to permits and wayleaves, as any potential routes could cross several private lands and environmentally sensitive areas.

4.6. Socio-economics Criteria

The sub criteria are listed below:

(1) Moderate risk on settlements and communities, due to impacts to economy and employment during construction due to the level of disturbance caused. However, there would be beneficial effects for the local economy as a result of the temporary project workforce and its associated

spend. During operation, the visual impact from the new OHL may lead to negative impacts, particularly for homeowners and tourism businesses. However, impacts can be mitigated through using routing policies. The effects on culture and community are considered to be low risk because the Project is unlikely to impact community cohesion or influence cultural practices.

(2) Moderate to high risk on Recreation and Tourism that would be moderate during construction due to the level of disturbance caused. During operation, the visual impact from the new OHL would lead to permanent negative impacts, particularly for residents and visitors. Impacts can be mitigated through using routing principles and potentially the use of composite poles, which offer a less visually intrusive alternative. As part of ongoing reviews of best practice in other jurisdictions, EirGrid and ESBN have identified an alternative assembly to the steel lattice tower for 220kV overhead lines. This alternative is a new structure type called composite poles. Composite pole structures have the general appearance of wooden poles and are made of fibreglass. They are used throughout the world and have been subject to rigorous testing by EirGrid and ESBN. Steel lattice towers have been assessed at Step 3 because their construction and operational effects and impacts are known by the public and statutory consultees. While there is an existing evidence base for the uses and benefits of composite poles, for the purposes of robust assessment they have not been considered at this Step 3. However, at Step 4, it is expected their use will be integrated into routing decision making and it is expected they will provide benefits in the social impact and environmental assessments.

(3) Low to moderate risk to humans and human health. This is because of the effects of general nuisance and disturbance during construction which would be short term (4 years and 3 months). During operation, there will be effects of associated with visual impacts.

(4) Moderate risk to traffic and transport as there is potential for adverse effects during construction as result of additional traffic. The traffic changes throughout the study area may result in larger numbers of construction vehicles across the study area which may impact local traffic flows, however these impacts will be short term (4 years and 3 months).

(5) Low to moderate risk to telecommunications and aviation due to the extent of existing utilities, however as mitigation for effects, routing principles can be adhered to.

(6) Low to moderate risk to utilities and major infrastructure due to routing taking place within the technological parameters of how cables and major infrastructure can coexist, based on agreed buffers to reduce impacts.

4.7. Summary of Option 1 Assessment

Option 1 proposes a new 220 kV OHL with established technical performance, economic favourability, and good deliverability. Socio-economic considerations include potential adverse impacts during construction and positive impacts on job creation. Disruption due to construction and impacts could result in adverse effects on recreation, tourism and heritage. These effects will require mitigation (e.g. the use of composite poles), which will be examined at the next stage of the project. The summary of the MCA can be seen in Table 4-2.

The overall **technical** performance of Option 1 carries a low risk. Building a new OHL is a well-established technology in Ireland, ensuring practiced operations and maintenance. The new OHL can be constructed using proven technologies like self-supporting steel lattice towers or composite poles. The new route will comply with safety standards, allowing potential upgrading in the future. Peat areas in the corridor require excavation or piled foundations.

The overall **economic** performance of Option 1 carries a low risk.

The overall **environmental** performance of Option 1 carries a moderate risk. This relates to the moderate risks associated with impacts to climate factors, planning policy and land use, landscape and visual and archaeology, architectural heritage and cultural heritage.

The overall **deliverability** of Option 1 carries a moderate risk. Construction duration is expected to be around 4 years and 3 months, plus conductor delivery lead time. The project plan offers flexibility for overhead options and is not dependent on other projects. This option involves offline construction with off-peak outages. Accessibility from major roads enhances safety and efficiency and limited residential area overcrossing.

The overall **socio-economic** performance of Option 1 carries a moderate risk. This is driven by the risk to recreation and tourism during construction due to the level of disturbance caused. During operation, the new OHL could cause negative impacts, as any potential route would cross private lands and environmentally sensitive areas, requiring consents and approvals. Construction would create jobs but could impact commuter routes and agriculture temporarily due to construction disruption. Adverse impacts on the community and visual aesthetics are also anticipated. These effects will require mitigation (e.g. the use of composite poles), which will be examined at the next step of the project.

Table 4-2: MCA Summary for Option 1

		Technical	Economic	Environmental	Deliverability	Socio-economic
Option 1	*1*					
	2					
	3					
	4					
	5					
	6					
	7					
Risk rating						

The main criteria and sub criteria used are listed below:

- **Technical performance criteria**: (1) *Safety Standard Compliance;* (2) *Expansion or Extendibility*; (3) *Technical Operational Risk; (4) Security & Planning Standard compliance, (5) Reliability performance, (6) Headroom, (7) Repeatability*.
- **Economic performance criteria**: (1) *Implementation Costs*.
- **Environmental criteria**: (1) *Biodiversity (flora & fauna, ornithology)*; (2) *Soil and Water*; (3) *Planning Policy and Land Use*; (4) *Landscape & Visual*; (5) *Climatic Factors*; (6) *Archaeology and Cultural Heritage*; (7) *Noise and Air*.
- **Deliverability criteria**: (1) *Implementation Timelines*; (2) *Project Plan Flexibility*; (3) *Dependence on Other Projects*; (4) *Risk of Untried Construction Technology*; (5) *Constructability*; (6) *Supply Chain Constraints*; (7) *Permits & Wayleaves*.
- **Socio-economic criteria**: (1) *Settlements & Communities*; (2) *Recreation & Tourism*; (3) *Humans and Human Health*; (4) *Traffic and Transport*; (5) *Telecommunication & Aviation*; (6) *Utilities*.

5. Option 2A – Upgrade existing 110 kV OHL to 220 kV and install 110 kV UGC

5.1. Description of Option 2A

Option 2A involves upgrading one existing Clogher - Cathaleen's Fall and one existing Cathaleen's Fall – Srananagh 110 kV OHL circuit to 220 kV and installing a replacement Clogher – Cathaleen's Fall and Cathaleen's Fall – Srananagh 110 kV underground cable circuit.

In addition, a new 220 kV substation at Clogher is to be built with two new 220/110 kV 250 MVA transformers. Power Flow Control devices are required to be installed on the new underground circuit to ensure that the flow of power is able to balance with the remaining OHLs.

Figure 5 below shows the study area and indicates the location of the three substations to be connected.

Figure 5: Location of the Substations within the study area to be connected in Option 2

5.1.1. Upgrading 110 kV Overhead Line to 220 kV

A new Clogher – Srananagh 220 kV circuit is to be created by voltage upgrading one of the existing Clogher - Cathaleen's Fall and Cathaleen's Fall – Srananagh 110 kV OHL circuit alignments. The existing 110 kV circuit will be removed prior to construction of the new 220 kV OHL, following the existing corridor.

The new 220 kV OHL will use the existing wayleave as much as possible, seeking to minimise the number of new landowner discussions, except for the connections to cable sections and final connections to substations. However, maintaining the existing alignment is not guaranteed and will require further studies and geotechnical investigations (GI). The structural options under consideration are traditional steel lattice structures and composite pole sets. These alternatives differ in both height and the number of structures required, and will depend on the technical feasibility, environmental constraints and consideration of visual impacts along the route.

The existing OHL connection from Clogher – Cathaleen's Fall – Srananagh consists of two OHL circuits operating in parallel, designated as circuit 1 or circuit 2. The voltage upgraded 220 kV OHL can use either circuit 1 or 2 and this determination would be made at the next stage of the project.

The design of the new 220 kV OHL could incorporate standard lattice galvanized metallic, single circuit, steel structures. Also, composite pole sets could be considered for the design if considered more effective in terms of cost, constructability or visual impact subject to the outcome of current ongoing trials.

Structures will have one or two ground wires, depending on the design, to protect against lightning strikes. This ground wire can have optical fibres to provide communication between substations. Conductor ratings were defined as a range from 600 mm^2 at 80°C ACSR conductor with summer rating of 434 MVA and winter rating of 513 MVA (1139A/1347A), to HTLS 586 mm^2 D-GZTACSR TRAONACH at 210°C with summer rating of 792 MVA and winter rating of 823 MVA (2081/216 A).

Foundations will be shallow concrete pads, with columns to connect to structure legs for metallic structures or the lower part of the structure is buried into the ground and secured with concrete, for poles. For areas with weak soil, there may be use of concrete piles.

5.1.2. New 110 kV Underground Cable

Before the existing Clogher - Cathaleen's Fall and Cathaleen's Fall - Srananagh 110 kV circuits can be worked on, a replacement 110 kV underground cable and associated infrastructure must be installed. The new cable could be routed under existing roads or off-roads, following EirGrid routing principles and standard specifications for trench cross-section and joint bay construction. In order to maximise power transfer, there would be a preference for flat formation ducted installation. A typical trench, at 110 kV, is 930 mm wide and 950 mm to the top of the power cable ducts. More information is available in Appendix A.

In addition to the new bay connections at each end of the new 110 kV cables, reactive compensation devices will also be required at Srananagh, Cathaleen's Fall and Clogher.

Whilst traditionally for this voltage, cables are delivered in 500 m drums, in order to reduce the number of joint bays, a bespoke design may allow for more cable length between joint bays and thus reduce the number of joint bays. This will need to be verified in future development work for the project.

The connection from Clogher to Srananagh is interrupted at Cathaleen's Fall, where the OHL loops into the substation. An initial challenge is presented by the River Erne near the Cathaleen's Fall substation, and then by the proximity to Ballyshannon and its topography. The proposed solution involves repurposing the existing 110 kV overhead line (OHL) towers to cross the river. The cable will then descend from cable sealing ends and proceed northward to Clogher.

The following sections present the assessment of Option 2A under each performance criteria and their sub criteria.

5.2. Technical Criteria

The sub criteria are listed below:

(1) Low risk to safety standard compliance, as this option uses a known technology and construction methodology that comply with the safety standards.

(2) Moderate to low risk to expansion or extendibility, as there is potential for 220 kV specification cable to be installed but operated at 110 kV. However, UGCs are significantly more challenging to expand compared to OHL, due to higher costs, greater physical constraints and more complex construction requirements.

(3) Moderate risk to technical operation risk, as OHLs are widely operated in Ireland, so operation and maintenance are well practiced. Cables introduce risks to the system, but still require minimal operation and maintenance inputs. The need for power flow control devices and reactive compensation into the new cable circuits also introduces technical operational risk.

(4) Low risk to security & planning standards compliance. The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operating Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The voltage upgrade and replacement 110 kV UGC option proposed would comply with the relevant system reliability and security standards above. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), the loss of either of the existing Cathaleen's Fall – Clogher 110 kV circuits, lead to major thermal overloads up to 155% on 110 kV circuits in county Donegal.

When the voltage upgrade and replacement 110 kV UGC option is added to the system model, the overall loading of the circuits under an intact network is reduced and importantly the post contingency thermal overloads are removed.

Underground cables by their nature introduce a number of additional technical aspects which have to be considered compared to overhead line solutions. UGCs are effectively a large capacitance and will store electrical energy. This will impact the grid in various ways that must be managed to guarantee a safe and secure grid. The cables would have to be compensated with shunt reactors (inductive) to avoid large increases in voltage during both normal operation and during switching of the cable.

The amount of compensation is dependent on the length of the cable and the voltage level to which it is connected. For the replacement 110 kV UGCs, four reactors would be required in total, i.e. one reactor at both ends of the two cables.

The cables may also require harmonic filters to mitigate against harmonic resonances which can occur. These resonances occur because the transmission network is made up mostly of overhead lines making it overall inductive while underground cables are capacitive. The combination of the inductive and capacitive elements can create resonances in the system which, if not mitigated, can damage transmission network and customer equipment.

The level (size and location) of filters required is dependent on available harmonic limit 'headroom' at the time of connection of the cable. Analysis indicates that harmonic filters may need to be installed in the North-West region for the voltage upgrade and replacement 110 kV UGC option.

No filters are associated at this stage of the development as these would have to be designed closer to the time of connection to achieve the best tuning.

Given the long 110 kV UGCs in this option, compared to Option 1, it has a higher risk of harmonic distortion. This option also needs reactive compensation which has a higher risk of operational challenges, such as zero-miss phenomenon. This option also has a higher risk of operational challenges such as when switching local transmission equipment such as transformers which can give rise to temporary over-voltages. All these specific technical challenges associated with UGCs are captured in the technical operational risk sub-criteria.

When the specific aspects of compliance with security and planning standards are considered, the voltage upgrade and replacement 110 kV UGCs option is considered to have a low impact or risk on compliance with standards.

(5) Moderate risk for reliability. This criterion is assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the solution. The reliability and outages of the station equipment associated with the solution are assumed to be the same for both options and are therefore not included in this analysis. Similarly, as both options propose the installation of a Clogher – Srananagh 220 kV OHL, the 220 kV OHL is also not included in this analysis. Therefore, the outcome is that this analysis compares the annual availability of 110 kV OHL technology as part of Option 1 with that of 110 kV UGC technology as part of Option 2.

The statistics for reliability are based on EirGrid's and international failure statistics, the mean time to repair and the availability in days per 100 km per year for OHL and UGC. It has been assumed that the 110 kV OHL and UGC circuits in Options 1 and 2 respectively would be approximately 80 km in length for the purpose of this assessment, i.e. straight-line distance between the existing Clogher and Cathaleen's Fall stations plus 25% and the straight-line distance between the existing Cathaleen's Fall and Srananagh stations plus 25%.

Unplanned Outages

As mentioned in Section 3.1.2, almost all faults on OHLs are of short duration as a result of transient faults. If an auto-reclose function is provided for the protection of the OHL, it will restore the circuit shortly after the fault. Auto-reclose is not available for faults on UGC and as such, faults are considered to be long-lasting and will not be re-energised until an investigation has been undertaken. Consequently, when a cable fault occurs, finding a fault location and resolving it can result in prolonged circuit outages. As such, cable circuits have a lower availability than OHLs because of the prolonged outage times in the event of a fault.

Taking the fault statistics of the approximately 331 km of 110 kV UGCs in Ireland (EirGrid, Analysis of Disturbance and Faults 2022 , March 2024), gives a projected fault rate of 0.4 unplanned outages/100km/year.

Table 5-1: Average Failure statistics for a 100 km 110 kV UGC

Parameter	Average statistics for 110 kV UGC
Reliability (Unplanned outages/100km/year)	0.4
Mean time to repair (days)	15 (Cigre, 2009)
Unavailability due to disturbance (days/100km/year)	6 days

Table 5-1 above shows the statistics for reliability, the mean time to repair faults, and the unavailability for 110 kV cables (based on Irish and international failure statistics for cables). These statistics, given that they apply to XLPE (cross linked polyethylene) cables, are taken to be applicable for this option.

Planned outages

Planned outages are normally associated with routine maintenance. The typical routine maintenance outage duration for 110 kV cables taken from our maintenance policies is 2-3 days per annum (dependent on the number of joint bays and cable sections). Each year an operational test is performed, and periodically an ordinary service. These maintenance outages equate to a total unavailability of 0.84%, or c.3 days per annum.

Combination of the planned and unplanned outages

The combination of the planned and unplanned outages for the 110 kV UGC as part of Option 2 and the total annual unavailability are set out in Table 5-2 and adjusted to reflect the length of the proposed option, i.e. approximately 80 km.

Table 5-2: Reliability performance of an 80 km 110 kV UGC

Summary of reliability performance of 110 kV OHL	110 kV OHL (80 km)
Reliability (Unplanned outages/100km/year)	0.4
Reliability (Unplanned outages/80km/year)	0.32
Mean time to repair (days)	15 (dependent on method of cable installation)
Unplanned Outages Unavailability due to disturbance (days/80km/year)	4.8 days/annum
Planned Outages	3 days
Total Annual Unavailability (days/80km/year) (rounded to nearest half day)	8 days/annum

The average failure rate and time to repair for the 110 kV UGC option is deemed to be high when compared to the 110 kV OHL option. The availability of the 110 kV UGC option as a result of outages is 97.8%, meaning its unavailability is twice that of the 110 kV OHL in Option 1. Based on this assessment, the reliability criterion for the 110 kV UGC option is considered to be at a moderate performance.

(6) Low risk to headroom. Both options provide the same transmission capacity and therefore accommodate the same amount of renewable generation in the North-West region. Hence, both options have been given a low impact in the assessment.

(7) Moderate to high risk to repeatability. Underground cable (UGC) technology for 110 kV voltage is already in use in the Irish transmission system, but on a smaller scale compared to OHL. Every time an UGC option is proposed as a solution, each cable option will have to be studied on its own merits. Bespoke network design would have to be considered for each option that would take account of harmonic distortion introduced by any cable or if voltage limiting equipment is required to accommodate the cable options into the transmission network. In terms of repeatability, it is therefore considered that there may be limitations in the network regarding accommodating cables. The impacts of the above points are usually greater, the higher the operating voltage of the cable used and the weaker the location of the transmission network under consideration. As such, it is considered that the UGC option has high to moderate risk of not meeting the repeatability criteria.

5.3. Economic Criteria

The sub criteria are listed below:

(1) Moderate to High risk to implementation costs due to the need to upgrade the voltage of the OHL, including dismantling of existing 110 kV structures, and construct the new 110 kV cable route. Wayleaves will be required for any changes in the 220 kV route and any offroad section of the underground cable, however maintaining the existing OHL alignment is not guaranteed and will require further studies and geotechnical investigations (GI). This option cannot be treated as a single scope of works, it must be approached in multiple stages, which adds complexity and cost.

5.4. Environment Criteria

The sub criteria are listed below:

(1) Moderate to high risk to biodiversity, as temporary habitat alterations during construction may pose challenges to protected species and conservation objectives in Special Areas of Conservation (SAC). Thorough surveys and mitigation measures are imperative to address potential biodiversity risks associated with underground cables.

(2) Moderate risk to soil and water, as the installation of the cables has the potential to disrupt surface water flows and provide a conduit to direct water to areas where flood risk may be increased. In addition, there is a requirement to cross several rivers and streams which may be susceptible to flooding, which could cause difficulties during the construction phase and increase the risk of both flooding to and from the works, in addition to increasing the likelihood of silty water runoff. The stockpiling of excavated material alongside the trench may also act as a 'bund' and cause either localised pooling of surface waters on land or a diversion into rivers and streams with insufficient capacity to receive it, causing localised flooding. It is not anticipated that there would be impacts on flood risk during operation. The crossing of rivers by 'cable bridge' technique could pose a flood risk, however it is assumed at this stage that the crossings would be trenchless. The construction of an OHL would depend on the placement of tower footings, with the localised removal of peat in some areas which would also have implications for the size of excavations required. In addition, peat removal will occur if the UGC cable goes through any areas of peat which is likely given the extent of peat in the study area.

(3) Moderate to high risks to climatic factors, as any new option would benefit by bringing renewable energy into the electricity supply network. The risks associated with the OHL are as per Option 1, however there will be an extended construction period (7 years and 9 months in comparison to 4 years and 3 months) and a larger amount of earth works and vehicle movements to build Option 2A.

(4) Low to moderate risks associated with planning policy and land use. While the provision of new electricity infrastructure and in particular the voltage upgrade from 110 kV to 220 kV is supported by the relevant development plan policies across the Project Study Area and there is a presumption in favour of the undergrounding of cables across the area, where this is practicable, there may be local policy compliance issues associated with the voltage upgrade of the existing OHL. Within the local planning context, Option 2A would broadly follow the route of existing infrastructure and has a 110kV undergrounding component which is cognisant of policy regarding electrical infrastructure. The need to accommodate the power flow control devices, reactive compensation devices, and potential harmonic filters due to the long lengths of 110 kV cable required in Option 2A increases the risk in terms of land use.

(5) Moderate risk to landscape and visual. The voltage upgrade of the existing 110 kV OHL to a 220 kV OHL is on a broadly similar route to the existing 110 kV OHL but there will be areas of minor divergence which create changes in the landscape and on existing views. Also, there may be some impacts on local landscapes as a result of the new towers (using traditional steel towers or composite pole sets) associated with the voltage upgraded 220 kV OHL (an increase in height and prominence compared with the existing 110 kV pole sets), making them more likely to have visual effects over longer distances. There would be some, but limited, impacts on landscape and views during construction of the UGC from temporary machinery and compounds; however, this is unlikely to be significant and would be largely screened by fencing. There may also have to be some landscape reinstatement for the areas of the UGC which are not adjacent to existing infrastructure. The UGC itself would have limited effects on landscape and views once reinstatement is completed; there would be joint boxes along the route which would affect both, but these effects are not expected to be significant. The power flow control devices, reactive compensation devices, and potential harmonic filters will also detract from the visual impact on the landscape.

(6) Moderate to high risk to archaeology and cultural heritage due to the potential for significant impacts on archaeological remains during construction of the UGC and on the setting of archaeological remains, architectural heritage, and cultural heritage assets during construction and operation of OHL towers or composite poles. Given the sensitivity and number of heritage assets identified within the study area, while it may be possible to reduce impact through optioneering, routing and design, it is unlikely that significant impacts on the setting of heritage assets can be completely avoided. While measures such as recording the setting of these assets may ameliorate impact, it is unlikely to wholly mitigate them.

(7) Low to moderate risk to noise and air. The construction of a new OHL and an UGC route would be likely to generate noise, vibration and dust impacts and while these impacts would be in the short to medium term (7 years and 9 months) it is expected they can be mitigated using standard mitigation procedures and these impacts would be temporary. There is likely to be a greater impact in the Study Area due to its prominent rural nature, however appropriate screening would be provided for construction works to avoid generating noise nuisance. During operation there is unlikely to be any impacts associated with air quality, but there may be operational impacts associated with noise. The power flow control, reactive compensation devices, and potential harmonic filters also contribute to a slight increase in the risk of noise pollution.

5.5. Deliverability Criteria

The sub criteria are listed below:

(1) High risk to implementation timelines. This is due to the fact the OHL construction can only commence once the UGC has been built, tested and put into service. A long construction period is required for such a lengthy cable route, with progress being limited by the allowable road closures. Due to the nature of the works, multiple crews can work at the same time at different locations along the route. An estimated 18 months is then required for OHL construction and lead time for conductor delivery. No major crossings over motorways and railways are anticipated, except for the crossing of The River Erne near Cathaleen's fall that could use existing structures to minimize the risk. The need to provide power flow control devices, reactive compensation devices, and potential harmonic filters will also extend the construction periods.

(2) Moderate to high risk in terms of project plan flexibility, as EirGrid's UGC routing principles allow for the use of public roads, where this is the 'optimal solution', and after consultation with the Roads Sector. North of Cathaleen's Fall there are very few regional roads and none that suit the routing of the cable. There is the N15 which is ideally suited to the cable route, however early engagement with the Road Authority/Transport Infrastructure Ireland (TII) is required in order to get their approval for the cable to be routed along this National Primary road. South of Cathaleen's Fall, the N15 continues to Sligo and there are several Regional and Local roads that are wide enough to accommodate the construction of at least one circuit, which will be based on a typical single 110 kV trench arrangement (i.e., the roads are wide enough to facilitate the cable circuit trench (~1 m wide), cable joint bay space requirements (~2.5 m wide) as well as space for construction plant and materials. However, this would be subject to further survey, assessment, and design, and consultation with the Road Authority and there being space in the road given that other utilities may already be laid in this road. The road network in the study area will provide some flexibility in the identification of the best performing route. The use of Horizontal Directional Drill (HDD) technology to cross existing rivers, rail and roads will provide flexibility to avoid crossing point constraints.

(3) Low risk due to dependence on other projects as this option does not depend on other projects.

(4) Moderate to high risk of untried technology, as the OHL and UGC technologies have been used by EirGrid and ESBN in abundance in the past, however, UGCs require additional equipment such as power flow control devices, reactive compensation devices, and potential harmonic filters, which adds further complexity.

(5) High risk to constructability. The laying of the new underground cables is a construction technique undertaken by a range of utility and other service providers. Duct and Joint Bay installation are the most construction-intensive elements of cable route installation as digging of a trench is required. For in-road cable laying, this phase will have the largest potential impact on traffic, including the potential need for rolling road closures and diversions. The OHL can be constructed predominantly offline and in rural areas/away from residential areas, in line with EirGrid's Routing Principles. The additional space requirements for the power flow control devices, reactive compensation devices, and potential harmonic filters will increase the risk in terms of constructability. Additionally, the need to build a new overhead line adjacent to the existing OHL, combined with the construction of a new UGC adds significant complexity to the construction process.

(6) High risk to supply chain constraints due to the need to procure and deliver significant lengths (approx. 90 km) of 110 kV UGC, along with power flow control devices, reactive compensation devices, potential harmonic filters and other associated large-scale equipment and testing apparatus. Further constraints associated with UGC include long lead times for cable manufacturing and delivery, which can impact project timelines. Risks can be mitigated with different suppliers across Europe/the world.

(7) Moderate to high risk associated with permits and wayleaves. TII consent is required to construct the cable trench within the road network, especially for the National roads. There is also the potential for the UGC circuits to be constructed in agricultural land, away from public roads to avoid these consenting issues however introducing potential new challenges in terms of landowner engagement and land use impacts. If statutory consent is required, it is likely to be the subject of an application directly to An Bord Pleanála (ABP) as Strategic Infrastructure Development (SID).

5.6. Socio-economic Criteria

The sub criteria are listed below:

(1) Moderate risk to settlements and communities, as local workers and industries may be negatively impacted during construction; however, this is in the short to medium term (7 years and 9 months). Beneficial effects for the local economy may be provided by the temporary project workforce and its associated spend. However, there may not be any long-term positive impacts in terms of employment for the local population due to the lack of specialist skills. The effects on culture and community are considered to be low risk because the Project is unlikely to impact community cohesion or influence cultural practices.

(2) Moderate to high risk to recreation and tourism during construction due to the level of disturbance caused. The construction phase is likely to involve significant roadworks, including trenching and heavy machinery operation, which will cause road closures and diversions. These disruptions can affect access to recreational areas, delay travel times and reduce overall tourism. Furthermore, during operation, the visual impact from the new OHL, may lead to negative impacts but these would be confined to areas which already has comparable visual disturbance from OHL.

(3) Moderate to high risk to humans and human health. This would be due to the short to medium term duration of effects (7 years and 9 months). The UGC portion involves intensive construction, including trenching and duct installation which can lead to prolonged disruption, noise, vibration and air quality issues. During operation, there will be negative impacts because of changes in the views around the proposed 220 kV OHL. In addition, the installation of the new 220 kV OHL infrastructure in close proximity to an existing live OHL introduces further risks. These include potentially increased safety considerations for construction workers

(4) Moderate to high risk to traffic and transport, the installation of a 110kV UGC will require disruption to the existing road network. In addition to disruption where cable laying is taking place there will also be an increase HGV numbers on rural roads because of the installation of the 220 kV OHL and this disruption has the potential to extend for 7 years and 9 months.

(5) Moderate risk to telecommunications and aviation due to the installation of the new, taller 220kV structures, as well as the installation of 110 kV UGCs, potentially in areas where existing underground services are present, resulting in further consultation and micro siting being required. Consultation required with relevant bodies.

(6) Moderate to high risk to utilities and major infrastructure. There is potential for effects on utilities and major infrastructure across the Technology Option 2A Study Area because where installation is taking place may directly conflict with existing utilities, such as water, gas and telecoms, increasing the likelihood of accidental strikes, service disruptions and safety hazards for construction workers. In addition to the impacts arising from UGC installation, there may also be a requirement to reroute minor services to facilitate the proposed OHL route. There may also be adverse impacts associated with connection into Cathaleen's Fall Substation relating to the reorientation of substation technologies and the distribution to surrounding community facilities.

5.7. Summary of Option 2A Assessment

Option 2A proposes upgrading an existing 110 kV OHL circuit between Clogher and Srananagh, passing through Cathaleen's Fall, to 220 kV and installing a replacement 110 kV underground cable circuit. The summary of the MCA can be seen in Table 5-3 below.

The overall **technical** performance of Option 2A carries a moderate risk, as the OHL technical performance aligns with established standards. Although the cables introduce system risks, they require minimal operation and maintenance. The existing OPGW on the 110 kV line could be undergrounded along with the cable, to avoid long fibre outages during new OHL construction. The power flow control, reactive compensation devices, and potential harmonic filters will introduce some operational challenges and increased maintenance requirements.

The overall **economic** performance of Option 2A carries a moderate - high risk. This is primarily due to the need to upgrade the existing 110 kV infrastructure to 220 kV, which involves dismantling the current overhead line structures and constructing new infrastructure, including a revised cable route and the installation of underground cables (UGCs). These activities are expected to result in significant capital expenditure, logistical challenges, and potential delays. These factors contribute to the elevated economic risk profile of this option.

The overall **environmental** performance of Option 2A carries a moderate - high risk. These are associated with archaeology and cultural heritage, as there is a significant risk of interacting with scenic routes and other such areas of visual prominence, as well as potential for physical impacts on known archaeology, architectural heritage and cultural heritage assets. There are also extensive environmental designations resulting from temporary habitat alterations during construction, which may pose challenges to protected species and conservation objectives in SACs. The impact of these biodiversity risks can be at least partly mitigated through routing.

The overall **deliverability** of Option 2A carries a high risk. Although the majority of construction is offline and located in rural areas, away from residential areas, the implementation timeline associated with this option carries a high risk due to the length of construction time required. This time scale is not including cable delivery lead time. It is also significant that the OHL construction can only commence once the new UGC is commissioned. The need for power flow control, reactive compensation devices, and potential harmonic filters within the system will pose deliverability challenges due to space restrictions at the substations.

The overall **socio-economic** performance of Option 2A carries a moderate to high risk. To meet the increased ground clearance requirements associated with upgrading the voltage from 110 kV to 220 kV, the height of the towers or poles along the route would need to increase, resulting in greater visual impacts. The structural options under consideration are traditional steel lattice structures and composite pole sets. These alternatives differ in both height and the number of structures required, and will depend on the technical feasibility, environmental constraints and visual impacts along the route. In addition to the technology changes required to build both parts of the Scheme in the study area, it is also anticipated that construction will take place over seven years which would resulting in short to medium term effects in the wider community. There may also be disruption to community facilities around Cathaleen's Fall Substation to facilitate connection of an UGC into the substation.

Table 5-3: MCA Summary for Option 2A

		Technical	Economic	Environmental	Deliverability	Socio-economic
Option 2A	*1*					
	2					
	3					
	4					
	5					
	6					
	7					
Risk rating						

The main criteria and sub criteria used are listed below:

- **Technical performance criteria**: (1) *Safety Standard Compliance;* (2) *Expansion or Extendibility*; (3) *Technical Operational Risk; (4) Security & Planning Standard compliance, (5) Reliability performance, (6) Headroom, (7) Repeatability*.
- **Economic performance criteria**: (1) *Implementation Costs*.
- **Environmental criteria**: (1) *Biodiversity (flora & fauna, ornithology)*; (2) *Soil and Water*; (3) *Planning Policy and Land Use*; (4) *Landscape & Visual*; (5) *Climatic Factors*; (6) *Archaeology and Cultural Heritage*; (7) *Noise and Air*.
- **Deliverability criteria**: (1) *Implementation Timelines*; (2) *Project Plan Flexibility*; (3) *Dependence on Other Projects*; (4) *Risk of Untried Construction Technology*; (5) *Constructability*; (6) *Supply Chain Constraints*; (7) *Permits & Wayleaves*.
- **Socio-economic criteria**: (1) *Settlements & Communities*; (2) *Recreation & Tourism*; (3) *Humans and Human Health*; (4) *Traffic and Transport*; (5) *Telecommunication & Aviation*; (6) *Utilities*.

6. Option 2B – Upgrade existing 110 kV OHL to 220 kV and install 110 kV UGC/Marine Cable

6.1. Description of Option 2B

Option 2B is as per Option 2A, however, it involves installing a submarine portion for a section of the replacement Clogher - Cathaleen's Fall and Cathaleen's Fall - Srananagh 110 kV circuit, in addition to underground land cables and associated infrastructure. The study area is as per Option 2A, shown in Figure 5. The text within Section 6 focuses on the additional marine section, however it should be noted that all criteria in Section 5 is still applicable.

The route will be comprised of several land sections and two distinct subsea, near shore, cable sections. These have been identified as the following:

1) Underground land cable from Clogher substation to land fall location along the Donegal Bay north coast.

2) Subsea (submarine) cable section from the Donegal Bay landfall location to a landing point on the coast, west of Ballyshannon.

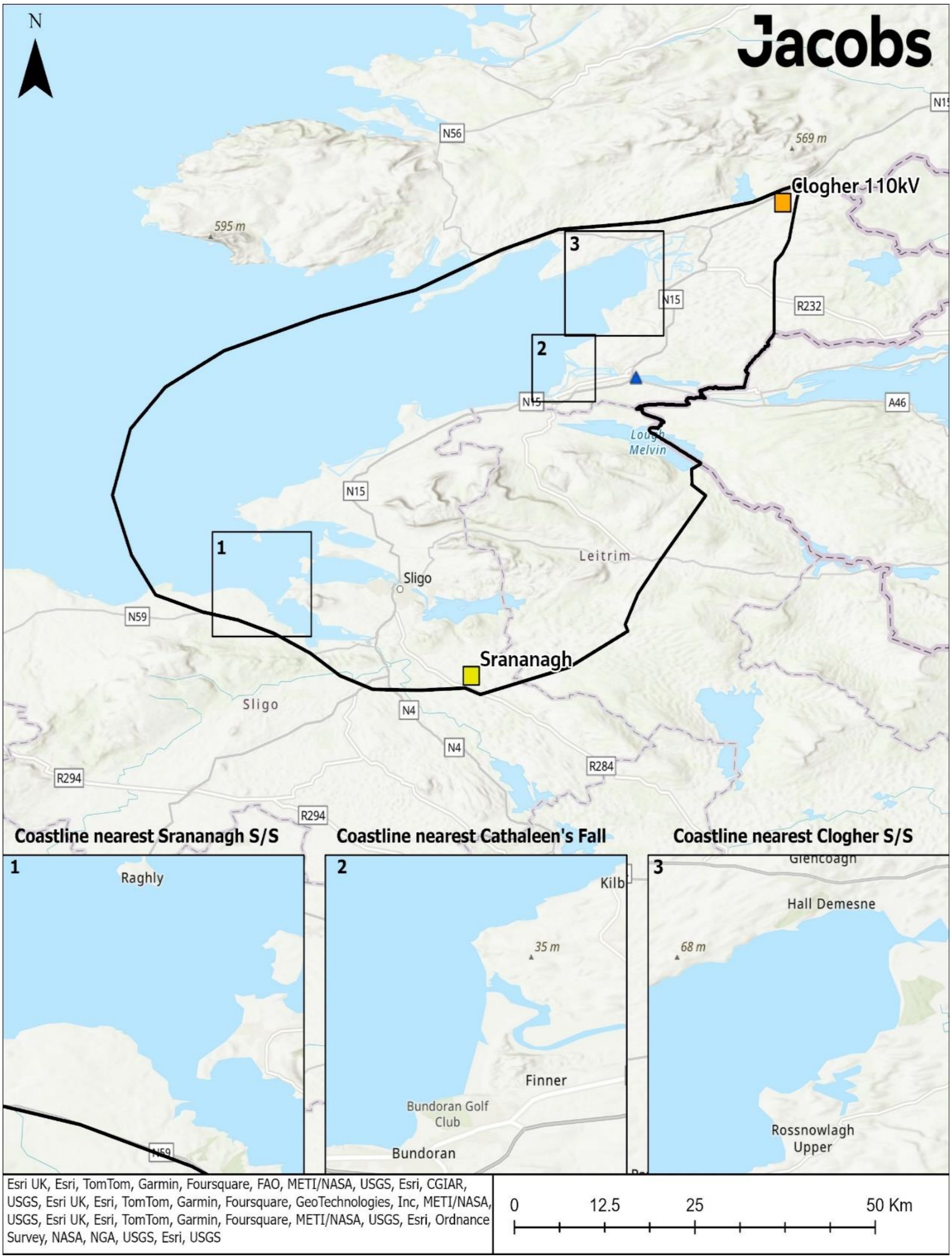
3) Out and return underground land cable from landfall point west of Ballyshannon to Cathaleen's Fall substation.

4) Subsea cable section from landing point at west of Ballyshannon to Ballysadare or Sligo Bay landing point.

5) Underground land cable from Ballysadare or Sligo Bay landing point to Srananagh substation.

The same general conditions apply to the land portion of the UGC as noted under Option 2A, but inserting a marine cable connection in the route of a traditional UGC connection requires the identification of landfall locations (areas of the coastline where the circuit transitions from traditional UGC to subsea specific cable) and transition joint bay locations. There are currently no specific locations for landfall identified, however an initial survey along the coasts has determined that there are many suitable areas, should this option be progressed. See Cathaleen's Fall denoted by blue triangle.

Figure 6 below. Landfall is feasible for each of the main marine-land connections listed above.



Cathaleen's Fall denoted by blue triangle.

Figure 6: Marine study area and coastlines near potential landfall sites.

Potential feasibility will need further refinement as the option progresses, but initial observations have been based on the following criteria:

- Suitable gradient for the cable to be routed on the seabed. Ensures fewer marine obstacles and facilitates cable connection to the landward section.
- Stable marine conditions. Dynamic environments, such as estuaries, can evolve through time with sediment being transported by the tides. This can lead to exposure of the cable in future and therefore a more stable beach location is required.
- Access for plant machinery to begin cable installation. Difficult terrain, such as sea cliffs, is an obstruction to cable connectivity, so it is important that appropriate plant machinery can access the site.
- Connectivity to land-based cable. As the substations are inland, the land-based link is vital. A location requires favourable conditions for the two cable sections to connect.

For the marine cable section, there is greater flexibility to adjust the route to avoid potential adverse conditions. Rock outcrops have been identified nearshore within the study area, particularly between the island of Inishmurray and Mullaghmore on the mainland. While it is possible to engineer solutions through rock outcrops, favourable substrate for cable laying is present in the west of the study area, providing a suitable alternative. Additionally, the presence of cultural assets, existing and future utilities, seabed dynamics and coastal activities have been assessed. Appropriate permits required for designated areas will also need consideration.

The following sections present the assessment of Option 2B under each performance criteria and their sub criteria.

6.2. Technical Criteria

The sub criteria are listed below:

(1) Low risk to safety standard compliance, as both the land and the subsea cable sections will comply with relevant European standards for the material supply, the safety of the installation and operation. The underground cable solution is a mature technology with established safety standards for both construction and maintenance. EirGrid has written proven specifications to verify compliance to their Standards. The marine cable technology is rapidly approaching its third decade and can be considered relatively mature when considering the voltage used (110 kV) and the type of shallow water installation that would be required for the connection.

(2) Moderate to high risk to expansion or extendibility, as there is potential for 220 kV specification cable to be installed for the UGC but operated at 110 kV. The marine cable corridor will be chosen to allow for an additional 220 kV submarine cable circuit to be placed alongside the 110 kV. The technical challenges associated with this are greater than those in Option 2A, due to the inclusion of the marine cable. This introduces additional complexities beyond those identified in Option 2A, particularly in relation to environmental constraints.

(3) Moderate to high risk to technical operation risk, as the marine cable introduces additional risk due to potential damage from anchor drops or dredging, as well as challenges associated with any required maintenance in a marine environment. OHLs are widely operated in Ireland, so operation and maintenance are well practiced. Cables introduce risks to the system, but still require minimal operation and maintenance inputs. The risks lie with the inherent complexity of having to manage multiple technologies over long connections: OHL, land and subsea cables. Not only does this increase the risk due to the direct failure of one of its components, but also increases the complexity

and duration of its repairs. The need for power flow control devices and reactive compensation into the new cable circuits also introduces technical operational risk.

(4) Low risk to Security & Planning standards compliance as per Option 2A. The security standards of the transmission network are defined:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operating Security Standards (OSS).

(5) Moderate to high risk for Reliability. Similar to option 2A, the three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit is to be considered. All factors discussed in section 5.2 are applicable, however it is important to note the added complexity in locating a cable fault with a marine cable.

(6) Low risk to headroom as per Option 2A.

(7) High risk to repeatability. Similar to option 2A, all factors discussed should be considered however it is important to note that subsea cables are not commonly used EirGrid projects.

6.3. Economic Criteria

The sub criteria are listed below:

(1) High risk to implementation costs due to the inclusion of a marine cable in addition to the upgrading of the OHL, dismantling of existing 110 kV structures, and construction the new 110 kV underground cable route. Same Wayleave issues as Option 1 for the new 220 kV route.

6.4. Environment Criteria

The sub criteria are listed below:

(1) Moderate to high risk to biodiversity. During the construction phase of the new 110 kV marine cable, there is potential to disturb fish, marine mammals and sea birds, thereby resulting in potential adverse impacts, though any impacts will be temporary and are not likely to be significant. The risks associated to the terrestrial portion of the route are as per Option 2A, but to a lesser extent due to the shorter UGC lengths.

(2) Low to moderate risk to soil and water, as the installation of a portion of marine cable is not expected to influence tides to the extent that it would increase tidal or local flooding. Other risks are largely as per Option 2A, however the risk to soil and geology (notably peat and rock) is low to moderate, noting that a significant portion of the UGC cable route will be marine.

(3) Moderate to high risks to climatic factors, as any new option would benefit by bringing renewable energy into the electricity supply network. However, like Option 2A, the differences in HGV traffic and duration of construction period (6 years and 4 months) may result in a larger carbon impact in comparison to Option 2A.

(4) Low to moderate risks associated with Planning Policy and Land Use. Obtaining a Maritime Area Consent (MAC) for the purpose of developing a marine cable route would be subject to EIA screening, AA screening and Natura Impact Statement due to the number of designated sites within the Donegal Bay area. However, with appropriate routing and choice of installation method, the location of the designations would not preclude consent. While the marine cable element of Option 2B would be supported by national and local policy, there would be policy conflicts for the OHL element which are already presented in Options 1 and 2A. A land use

constraint for the marine cable relates to Finner Camp, a military area between Ballyshannon and Bundoran. The adjacent beach, Tullan Strand, has been identified as a potential landfall location to connect the north and south sections to Cathaleen's Fall substation. The need to accommodate the power flow control devices, reactive compensation, and potential harmonic filters increases the risk in terms of land use.

(5) Moderate to landscape and visual, as the OHL risks are the same as Option 2A but there are also landscape effects and the cable transitions from the sea during construction. Plant machinery will be needed to facilitate the connections to the land-based UGC route, but this is limited once reinstatement is completed. Specialist vessels are also required to directly lay the cable and these will add to marine traffic and impact the coastal landscape during installation. The power flow control devices, reactive compensation devices and potential harmonic filters will also detract from the visual impact on the landscape.

(6) Moderate to high risk to archaeology, architectural heritage and cultural heritage. Construction of Technology Option 2B has the potential to have temporary impacts on the setting of underwater archaeological remains. It also has the potential to have an impact on the setting of terrestrial archaeological, architectural and cultural heritage assets, for example the introduction of towers and the voltage upgraded overhead line and visual and noise intrusion from construction traffic and activities. The continued presence of the marine cable could have an impact on the setting of underwater archaeological remains during operation. During operation there is also potential for impacts on the setting of terrestrial archaeological, architectural and cultural heritage assets, primarily from the presence of towers and overhead lines, potentially also from the landfall connections and substations.

(7) Low to moderate risk to noise and air, as impacts are not likely during the operational phase of the new 110 kV marine cable as the cables will be under the sea. There would be impacts to marine animals resulting from construction of the marine cable but these are expected to be temporary. The risks associated with the terrestrial portion of the route are as per Option 2A, but to a lesser extent due to the shorter UGC lengths. The power flow control, reactive compensation devices and potential harmonic filters also give rise to a slight increase in risk of noise pollution.

6.5. Deliverability Criteria

The sub criteria are listed below:

(1) High risk to implementation timelines. The marine cable and UGC can be constructed simultaneously and predominantly independently, and due to the nature of the works, multiple crews can work at the same time at different locations along the land-based routes. The marine portion of the route requires approximately 12 months for construction and cable delivery lead time. This includes construction of the required infrastructure for landfall connections. Adverse weather can delay construction times, but this can be avoided by scheduling for when weather is expected to be better (summer). The OHL construction can only commence once the cable route has been built, tested and put into service. Approximately 18 months are then required for OHL construction and lead time for line delivery. The need to provide power flow control devices, reactive compensation, and potential harmonic filters will extend construction periods as well.

(2) Moderate to High risk to project plan flexibility, although various routes are technically feasible for the marine cable, and the challenging terrain can be addressed through engineering solutions, these factors introduce significant uncertainty and potential delays. The route is split into two sections, connected at Cathaleen's Fall, so a partial marine cable is possible. Numerous landfall sites are available and considered. For the UGC portion and the voltage upgraded OHL, it is as per Option 2A.

(3) Low risk due to dependence on other projects as this option does not depend on other projects.

(4) High risk of untried technology, as the submarine technology is new to EirGrid. In general, marine cable technology at this voltage range is proven and tested, but novel techniques may be required to overcome topographic anomalies. The OHL and UGC technologies have been used by EirGrid and ESBN in abundance in the past. UGCs also require additional equipment such as power flow control devices, reactive compensation devices, and potential harmonic filters, which adds further complexity.

(5) High risk to constructability. For the submarine portion, there is favourable substrate for trenching of the cable west of Inishmurray. Various landfall points have been identified with gentle slopes onto land, also providing a favourable condition. There is a gentle slope for possible submarine alignments and the ability to avoid more difficult ground through routing, including rock outcrops and steep slope angles. The marine cable avoids crossing residential areas and can be laid much more quickly than terrestrial cables. The constructability of the UGC portion and upgrading the voltage OHL are as per Option 2A, however, the inclusion of the marine cable introduces additional constructability risks relating to installation, environmental constraints and limited flexibility in routing. The additional space requirements for the power flow control, reactive compensation devices, and potential harmonic filters will increase risk on constructability.

(6) High risk to supply chain constraints, as for the submarine cable, procurement is dependent on lead time and number of suppliers. A specialist cable laying vessel will be required so is dependent on availability of vessel and crew. Early contractor engagement for surveys and installation will reduce risk rating. For the UGC, procurement and delivery of approximately 53km of 110 kV UGC, the required reactors and other associated large-scale equipment and testing apparatus are required. Risks can be mitigated with different suppliers across Europe & possibly the world.

(7) High risk associated with permits and wayleaves, as the proposed submarine route crosses various conservation areas, requiring complex environmental assessments, regulatory approvals and licensing for construction will need to be granted. Consent from landowners may be required for onshore routes to the substations and possible consent may be needed from the Irish Military if construction or access is required within Finner camp. The risks associated to the UGC portion and upgrading the voltage OHL are as per Option 2A.

6.6. Socio-economics Criteria

The sub criteria are listed below:

(1) Moderate risk to settlements and communities as the extended construction period (6 years and 4 months in comparison to 4 years and 3 months for Option 1) will result in disruption to local communities in the short to medium term. Beneficial effects for the local economy may be provided by the temporary project workforce and its associated spend. However, there may not be any long-term positive impacts in terms of employment for the local population due to the lack of specialist skills. The effects on culture and community are considered to be low risk because the Project is unlikely to impact community cohesion or influence cultural practices.

(2) Moderate to high risk as there is potential for effects on Recreation and Tourism during construction (6 years and 4 months) due to the level of disturbance caused. During operation, the visual impact from the new OHL, may lead to negative impacts but these would be largely confined to areas which already have some visual disturbance from OHL.

(3) Moderate to high risk to humans and human health due to nuisance effects (changes in access, impacts to journey times) as a result of construction and operation however this would be for a short to medium term duration (6 years and 4 months). In addition to the risks associated with the UGC

outlined in Option 2A, the marine cable introduces further challenges, such as the use of heavy machinery equipment. During operation, there will be negative impacts because of changes in the views around the proposed 220 kV OHL.

(4) Moderate to high risk to traffic and transport, as there is some potential for adverse effects during construction of the voltage upgraded OHL but since installation will mainly take place offshore, limited driver delays and full access to amenities are to be expected. However, the inclusion of the marine cable introduces additional traffic and transport risks, such as boats and port operations.

(5) Moderate risk to telecommunications and aviation due to the installation of the UGC in existing roads with existing infrastructure, Further consultation would be required with Finner camp regarding whether they would be impacted by the installation of the marine cable. Where there is potential for effects on telecommunications and aviation across the Technology Option 2B Study Area, these may be mitigated using existing routeing guidance for both OHL routes means that conflicts should be avoidable and not impact the operation of the Project. In the context of the marine cable, there are no telecommunications cables in the Donegal Bay area and there should be no risk to aviation as a result of Technology Option 2B.

(6) Moderate to high risk to utilities and major infrastructure because where installation is taking potentially place directly conflict with existing utilities and major infrastructure. The risks associated to the UGC portion and upgrading the voltage OHL are as per Option 2A. This score would be dependent on routing taking place within the technological parameters of how cables and major infrastructure can coexist based on agreed buffers to reduce impacts. There may also be adverse impacts associated with connection into Cathaleen's Fall Substation relating to the reorientation of substation technologies and the distribution to surrounding community facilities.

6.7. Summary of Option 2B Assessment

Option 2B proposes upgrading an existing 110 kV OHL circuit between Clogher and Srananagh, passing through Cathaleen's Fall, to 220 kV and installing a replacement 110 kV cable circuit with both marine and underground cables. This option has socio-economic and environmental benefits, as well as good deliverability, however it is significantly more expensive, and the use of marine cables is unusual. The summary of the MCA can be seen in Table 6-1 below.

The overall **technical** performance of Option 2B carries a moderate to high risk, as the marine cable introduces some additional risk due to potential damage from anchor drops or dredging. There is also the inherent complexity of having to manage multiple technologies over long connections, which not only increases the risk due to the direct failure of one of its components, but also increases the complexity and duration of its repairs. The power flow control, reactive compensation devices and potential harmonic filters will introduce some operational challenges and increased maintenance requirements.

The overall **economic** performance of Option 2B carries a high risk. In addition to the costs associated with upgrading the existing 110 kV overhead lines, dismantling existing infrastructure, installing new 220 kV infrastructure, and constructing a UGC route, Option 2B introduces significant additional economic challenges due to the inclusion of a marine cable. Marine cable installation is inherently complex and capital intensive, which involves strict regulatory requirements and costly maintenance.

The overall **environmental** performance of Option 2B carries a moderate to high risk. In addition to the risks identified for Option 2A—such as potential impacts on archaeology, cultural heritage, and scenic landscapes—Option 2B presents additional environmental challenges due to the inclusion of a marine cable. Construction of the marine section has the potential to disturb fish, marine mammals, and seabirds, although these impacts are expected to be temporary and not significant with appropriate mitigation.

The overall **deliverability** of Option 2B carries a high risk mainly due to implementation timelines and supply chain constraints for the submarine cable, as procurement is dependent on lead time and number of suppliers. A specialist cable laying vessel will be required, so construction is dependent on availability of vessels and crew. For the UGC and OHL, the risks are as per Option 2A - the majority of the UGC construction is offline and located in rural areas, and the OHL construction can only commence once the UGC is commissioned. The need for power flow control, reactive compensation devices, and potential harmonic filters within the system will pose deliverability challenges due to space restrictions at the substations.

The overall **socio-economic** performance of Option 2B carries a moderate to high risk. While the installation of the marine cable will mainly take place offshore and there is reduced potential for driver delays, Option 2B would result in 65% more materials being moved over a longer period than Option 1, creating a larger impact. In addition to the issues around impacts around the installation of the marine cable and UGCs, the issues with OHL installation and operation would also be present. There is also a risk of encountering underground utilities when constructing the UGC, however to a lesser extent compared to Option 2A due to the shorter length.

Table 6-1: MCA Summary for Option 2B

		Technical	Economic	Environmental	Deliverability	Socio-economic
Option 2B	*1*					
	2					
	3					
	4					
	5					
	6					
	7					
Risk rating						

The main criteria and sub criteria used are listed below:

- **Technical performance criteria**: (1) *Safety Standard Compliance;* (2) *Expansion or Extendibility*; (3) *Technical Operational Risk; (4) Security & Planning Standard compliance, (5) Reliability performance, (6) Headroom, (7) Repeatability*.
- **Economic performance criteria**: (1) *Implementation Costs*.
- **Environmental criteria**: (1) *Biodiversity (flora & fauna, ornithology)*; (2) *Soil and Water*; (3) *Planning Policy and Land Use*; (4) *Landscape & Visual*; (5) *Climatic Factors*; (6) *Archaeology and Cultural Heritage*; (7) *Noise and Air*.
- **Deliverability criteria**: (1) *Implementation Timelines*; (2) *Project Plan Flexibility*; (3) *Dependence on Other Projects*; (4) *Risk of Untried Construction Technology*; (5) *Constructability*; (6) *Supply Chain Constraints*; (7) *Permits & Wayleaves*.
- **Socio-economic criteria**: (1) *Settlements & Communities*; (2) *Recreation & Tourism*; (3) *Humans and Human Health*; (4) *Traffic and Transport*; (5) *Telecommunication & Aviation*; (6) *Utilities*.

7. Conclusions

A new 220 kV connection is required to meet the need and objectives of the CP1233 project. The option of a 220 kV underground cable cannot be built as the grid cannot accommodate it – there would be significant issues with its operation, safety, and its reliability. Of the feasible options, Option1 was found to be the Emerging Best Performing Option. Table 7-1 below summarises the findings of the MCA for the five key criteria for each Option.

Option 1 has been selected because of the following reasons:

- **Economic and Deliverability -** Option 1 entails constructing a new 220 kV OHL, whereas for Option 2, an existing 110 kV line is to be upgraded to 220 kV, and in addition a new 110 kV underground cable and other additional equipment (power flow control devices, reactive compensation and potential harmonic filters) are to be installed. Option 2 therefore results in additional work and thus a longer construction programme (with associated increased costs):
    - approximately four years for Option 1;
    - approximately eight years for Option 2A; and
    - approximately six years for Option 2B.
- **Technical -** OHLs (like Option 1) are widely adopted in Ireland and therefore operation and maintenance are well practiced. The OHL line can also be upgraded in the future depending upon system ratings, e.g. increasing the thermal rating of the existing conductors. Options 2A and 2B would require additional equipment (like reactive compensation and power flow control) compared to Option 1 to resolve technical challenges.
- **Environment and Socio-Economics -** Option 1 may interact with scenic routes and other such areas of visual prominence, as well as potential for setting impacts on known archaeology, architectural heritage and cultural heritage assets. The adoption of the new composite pole technology could reduce the potential visual impact of the new OHL. There are also environmental designations with both geological and hydrogeological elements that could be affected by new OHL foundations, depending on their siting. Some of these risks will be greater for the underground cable element of Options 2A and 2B. Options 2A and 2B will have increased socio-economics effects due to the increased construction duration and additional construction traffic.

Option 2B competes closely with Option 2A. Option 2B has better environmental and socio-economic performance, as the majority of the route is marine based, thus resulting in less impact on archaeology, traffic and utilities. However, the submarine option has higher economic and technical risks due to the newer, more costly technology.

Summary Table of MCA for all Technology Options

To conclude, Option 1 is considered the Best Performing Option, with the new 220 kV OHL being taken through to Step 4. Option 1's reduced construction duration (approximately four years compared to approximately six to eight years) results in much less construction traffic, and a significantly lower cost. There are also less technical, environmental, and socio-economic impacts than the other possible options (Options 2A and 2B).

Table 7-1: Summary Table of MCA for all Technology Options

	Technical	Economic	Environmental	Deliverability	Socio-economic
Option 1					
Option 2A					
Option 2B					

Appendix A Cable Design

This appendix provides more details about the envisaged underground cable connection. Because this report does not consider route corridors at this stage, the information listed below is for initial guidance only. Works carried out at later stages, may indicate other solutions to be preferential.

A.1 EirGrid's reference performance specifications

The underground cable solution detailed below, has been completed with respect to the EirGrid standard CDS-GFS-00-001-R1: 110 kV, 220 kV and 400 kV Underground Cable Functional Specification

A.2 Typical trench cross-sections

A.2.1 220 kV Cable (Option 1)

For the 220 kV cable sections in Option 1, The basis of assessment is the EirGrid standard cross-sections in flat arrangement as per EirGrid drawing XDC-CBL-STND-F-008

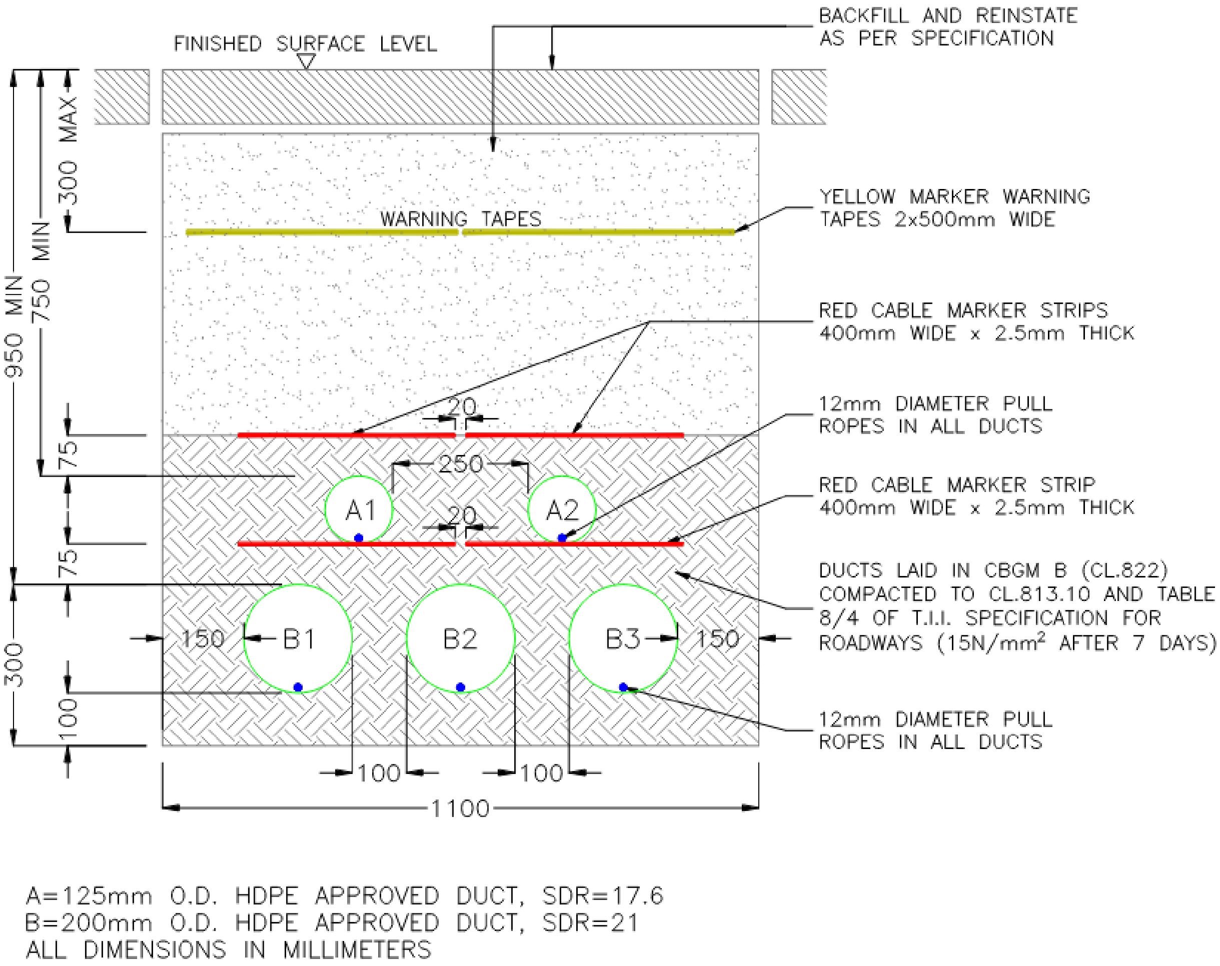


Figure A-1. 220 kV Cross-Section

A.2.2 110 kV (Option 2A and 2B)

For the UGC in options 2A and 2B, the basis of assessment is to use the typical EirGrid trench cross-section for 110 kV circuit. The flat arrangement below (rather than trefoil) is chosen to allow for greater power transfer. The cable cross section used is from drawing XDC-CBL-STND-H-008.

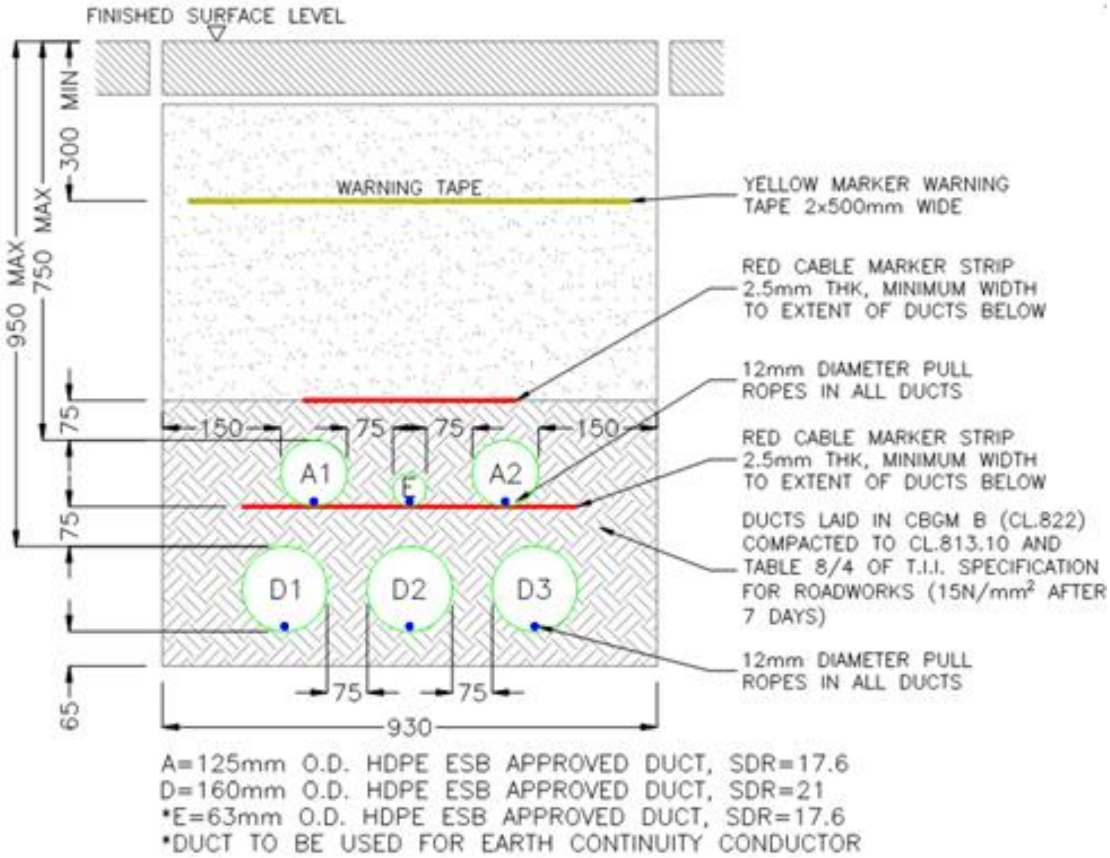


Figure A-2. 110 kV Cross-Section

In both options, these cable depths shall be maintained where reasonably possible. For crossings, route obstacles & marine sections, alternative cable installations shall be used on a case-by-case basis utilising methods such as horizontal directional drilling (HDD).

A.3 Cable ratings & Results

For the 110 kV and 220 kV options, required rating values are provided by EirGrid Policy Statement 11. Please see the values below:

Table A1: Circuit Ratings as per Policy Statement 11

	Winter		Summer	
	MVA	Amps	MVA	Amps
110 kV	210	1102	178	935
220 kV	606	1591	537	1410

A.4 220 kV (Option 1)

The cable used for the typical cross-section is the single core 2500 mm2 Copper (Cu). Where HDDs are required, it is expected that two cables per phase of 2500 mm^2 Cu will be required to achieve the ratings in Table A-1. As per the above cross-sections, standards and cable ratings, please see results below:

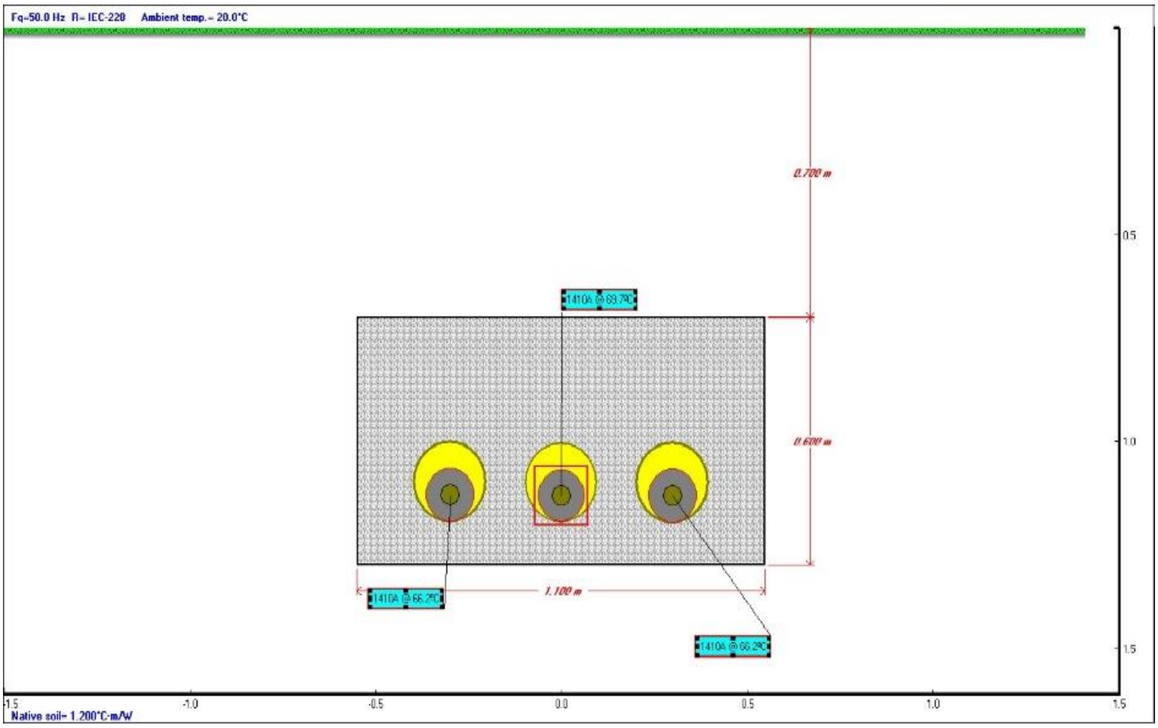


Figure A-3. Typical Summer result – 220 kV UGC

Required cable rating achieved with maximum conductor temperature at 70°C.

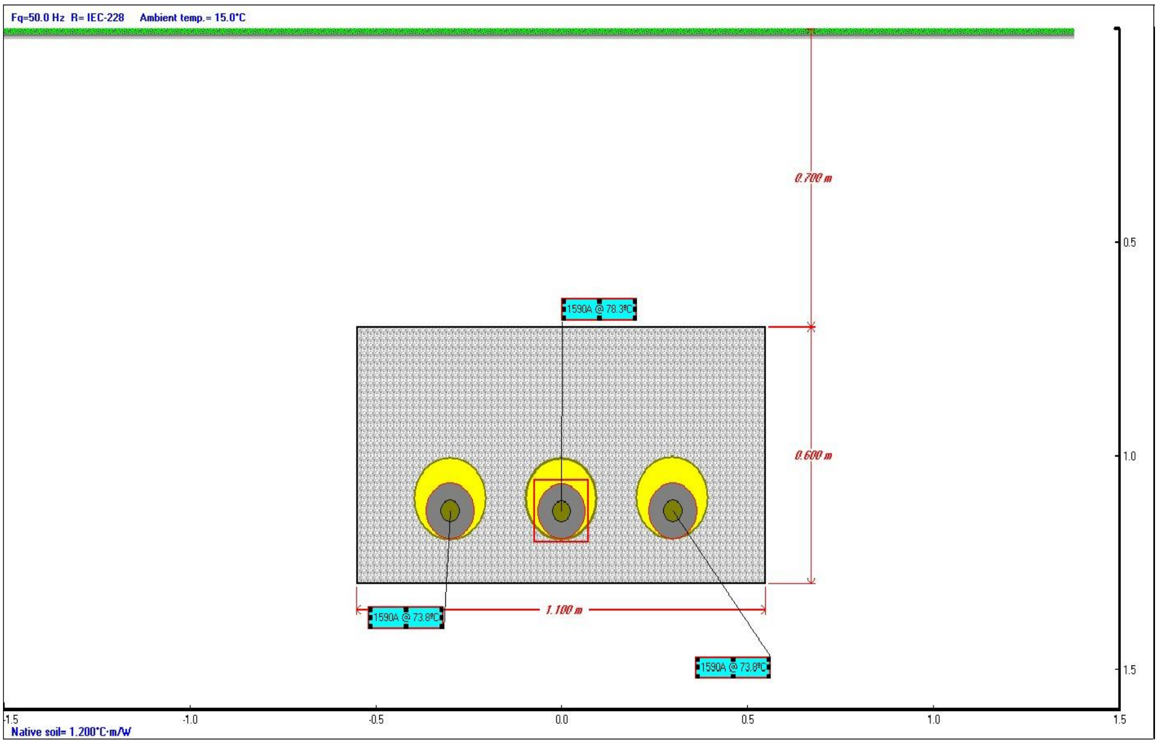


Figure A-4. Typical Winter result – 220 kV UGC

Required cable rating achieved with maximum conductor temperature at 78°C.

From the above results, for both the winter and summer conditions it can be seen that the cable ratings required at 220 kV are achievable in the typical cross-section along this route.

For areas that require deeper excavation to avoid obstacles, the cables shall be installed via a horizontal directional drill (HDD). Typically, each cable shall require a dedicated bore and duct with a spacing of 5-6m between each bore. Calculations have been based on two cables per phase of 2500 mm^2 Cu, in 250mm ducts at depth 10m to achieve the above ratings. These calculations will need to be revisited and progressed at a later design stage.

A.5 110 kV (Option 2A2A and 2B2B)

At 110 kV, the typical cable used to deliver the above-mentioned power is the single core 1600 mm^2 Al conductor. This is the proposed solution for the majority of the land section of the route.

For the marine sections it is proposed to use three core 110 kV 1200 mm^2 /1600 mm^2 Cu.

As per the above cross-sections, standards and cable ratings, please see results below:

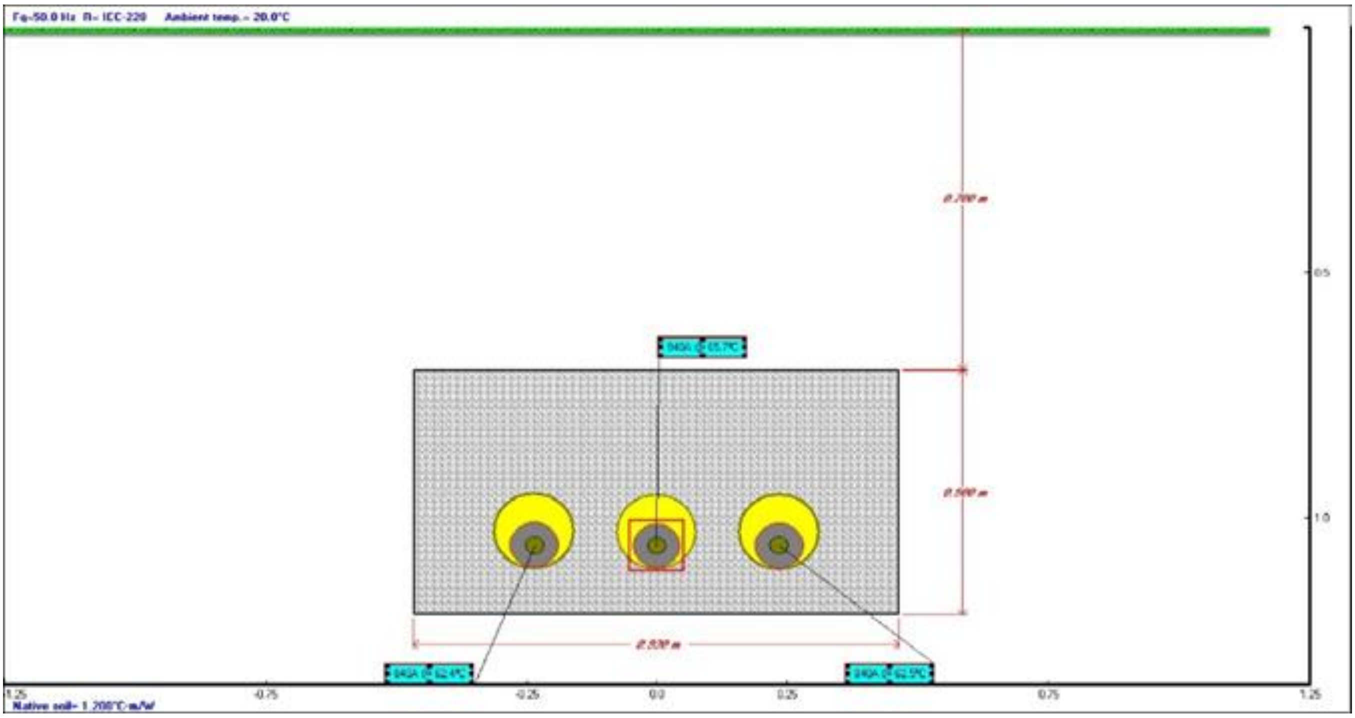


Figure A-5. Typical Summer Results – 110 kV UGC

Required cable rating achieved with maximum conductor temperature 66^{o}C.

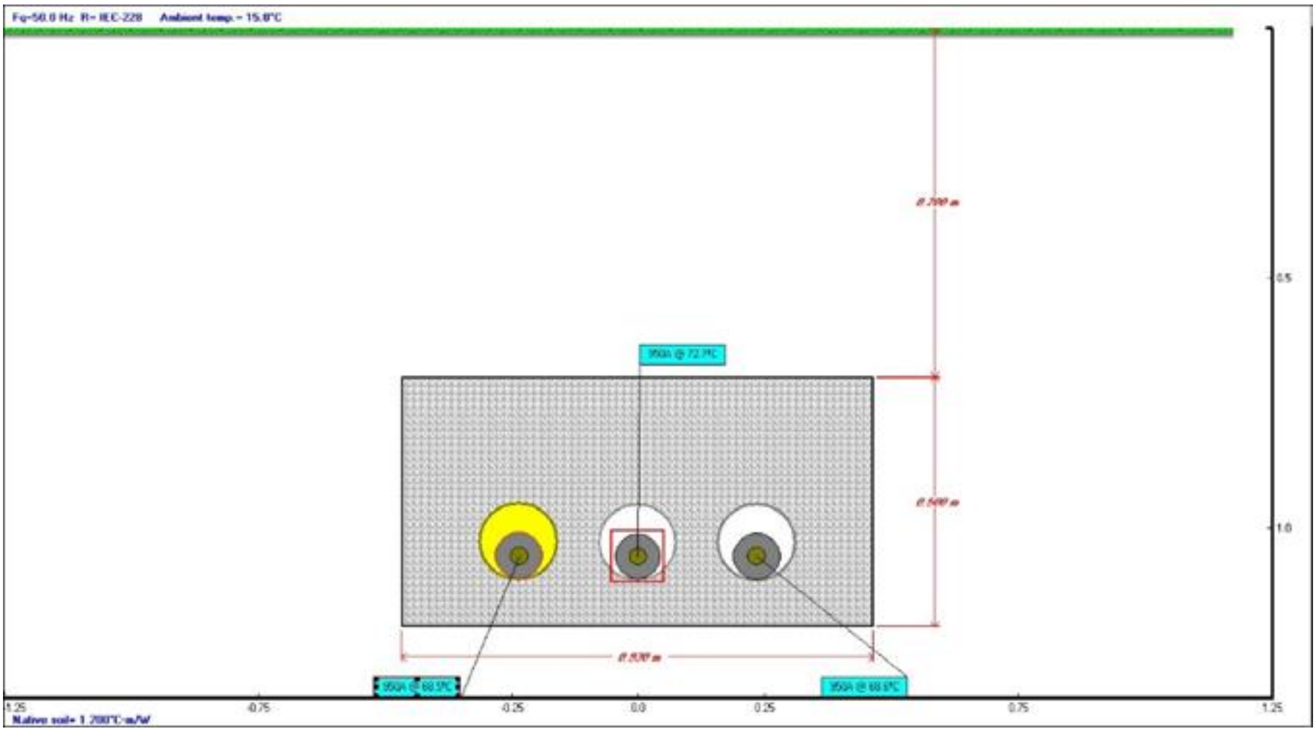


Figure A-6. Typical Winter Results – 110 kV UGC

Required cable rating achieved with maximum conductor temperature at 73^{o}C.

From the above results, for both the winter and summer conditions it can be seen that the cable ratings required at 110 kV are achievable in the typical cross-section along this route.

For areas that require deeper excavation to avoid obstacles, the cables shall be installed via a horizontal directional drill (HDD). Typically, each cable shall require a dedicated bore and duct with a spacing of 5-6m between each bore. Calculations have been based on one cable per phase of 1600 mm^2 Cu, in 250mm ducts at depth 10m to achieve the above ratings. These calculations will need to be revisited and progressed at a later design stage.

A.6 Notes on Cable Calculations

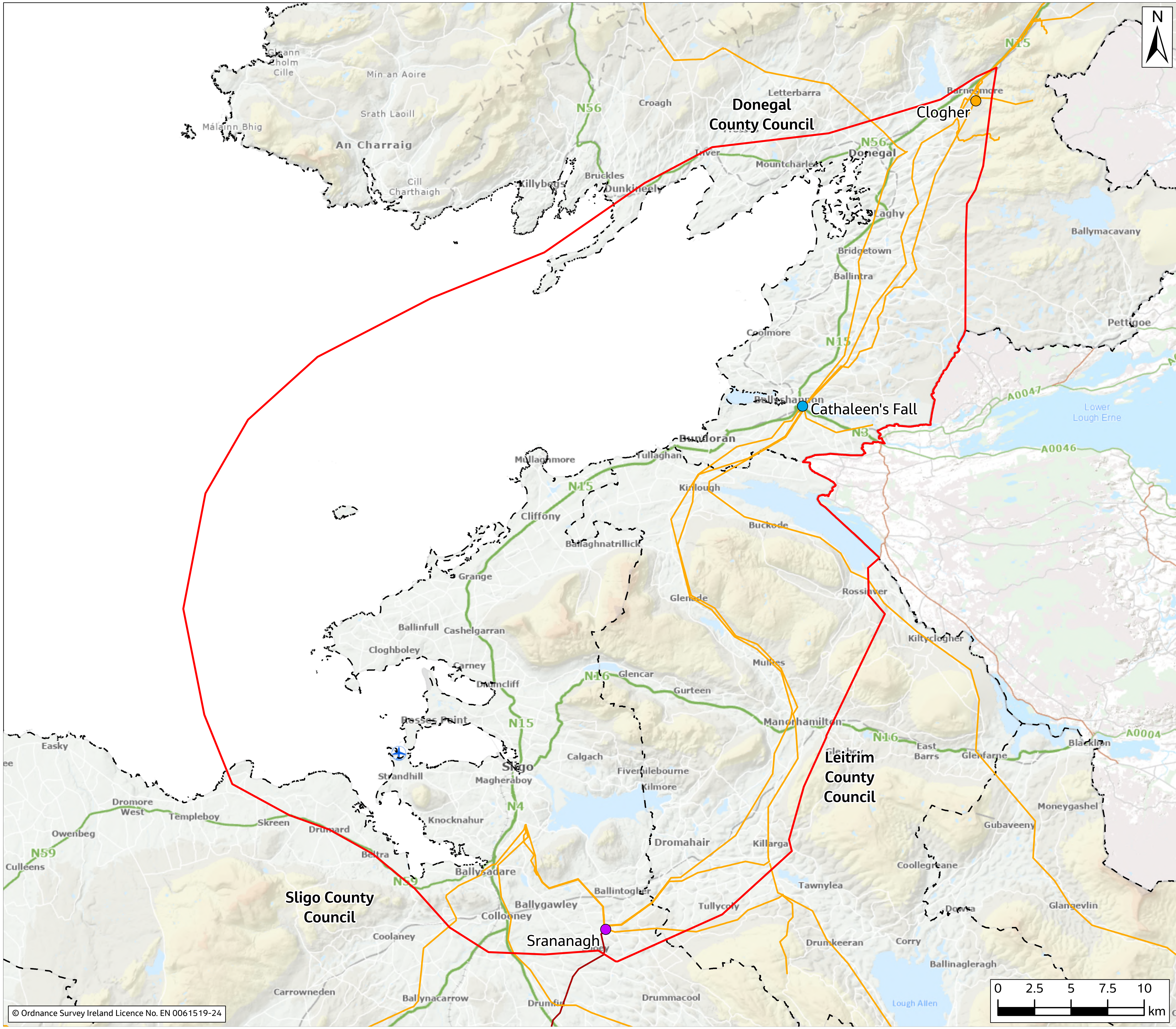
The calculations reported above are for information only.

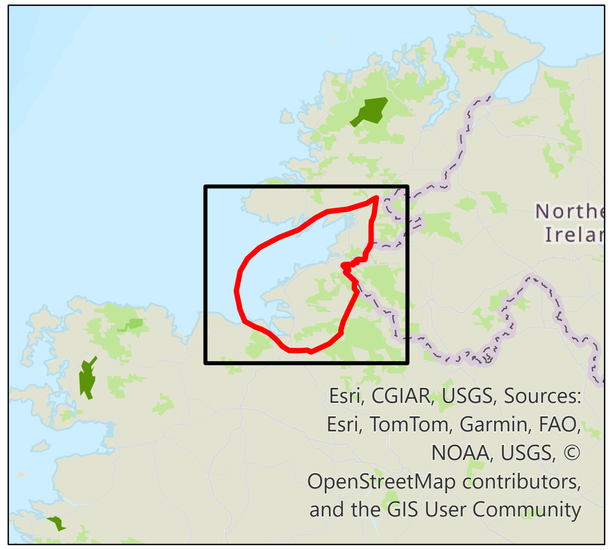
At this high level feasibility study, where the technology has not yet been chosen, the possible routes are undefined, the information provided are for initial assessment only. They are in no way conclusive, or representative of the final solution.

They have been performed with the following assumptions:

- A detailed pinch point analysis will need to be carried out to determine the thermal impacts of the cable cables near existing services, HDD and other obstacles.
- Thermal resistivity (TR) values and ground temperatures used in the calculations are from EirGrid document CDS-GFS-00-001-R1 “110 kV, 220 kV and 400 kV Underground Cable Functional Specification”.
- Ground investigation surveys will be required to determine accurate TR values for the calculations.
- No system derating due to joint bay separation unbalance has been considered.

Appendix B Constraints Mapping





Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
00	Aug 25	Initial Issue	AS	XX	XX	XX

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EirGrid

Project

CP1233 Donegal-Sranangagh Corridor

Drawing Title

Study Area

Drawing Status

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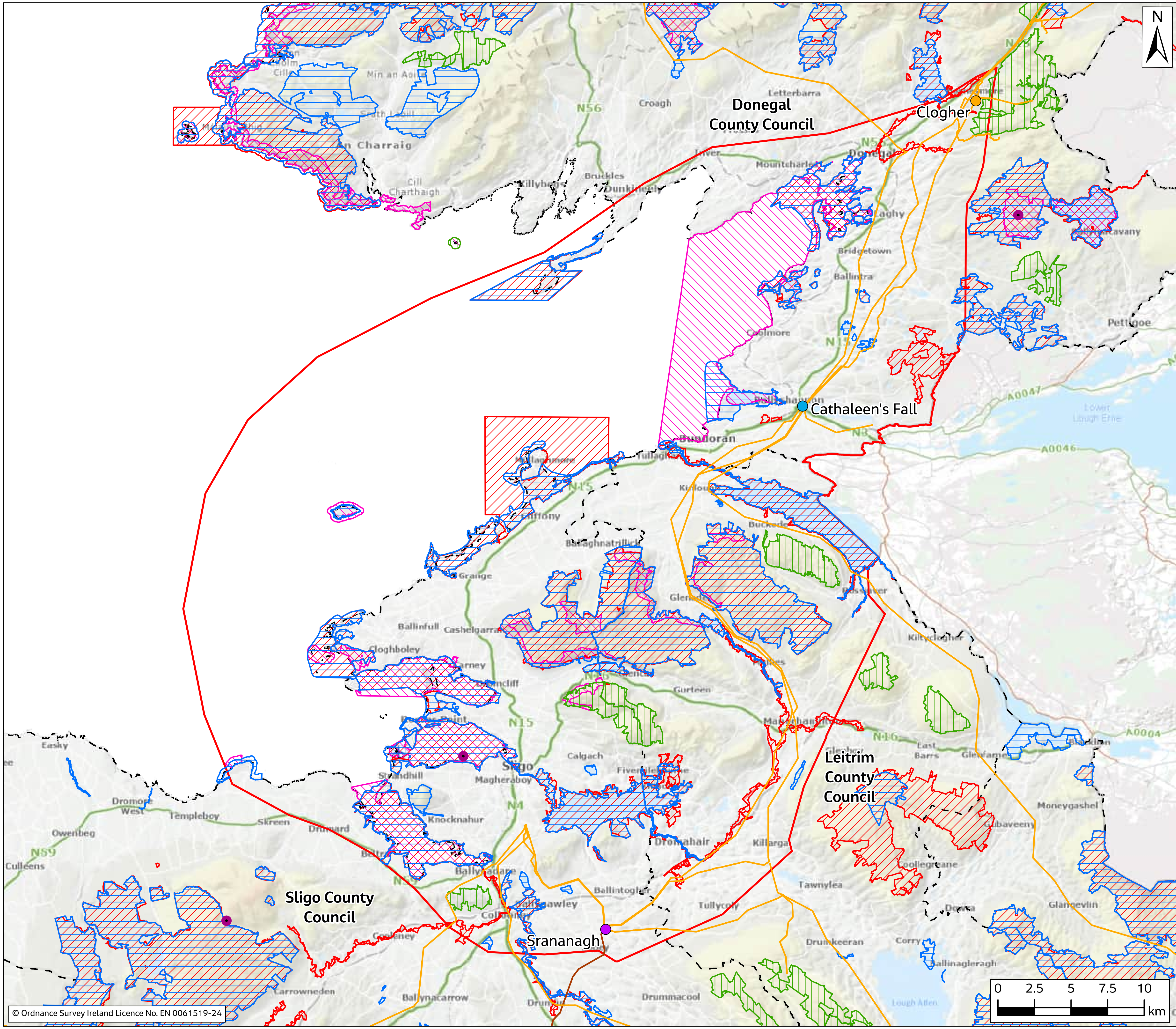
Jacobs No.	B321084AT	
Client No.	CP1233	

Drawing No.

B321084AT-JAC-ZZ-XX-DR-G-0005



Legend

- Project Study Area
- Local Authority Boundary

Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Sranangh 220kV

Overhead Line

- 110kV
- 220kV
- Ramsar Sites
- Natural Heritage Area (NHA)
- Proposed Natural Heritage Area (pNHA)
- Special Area of Conservation (SAC)
- Special Protection Areas (SPA)

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Drawing Title: Biodiversity Constraints

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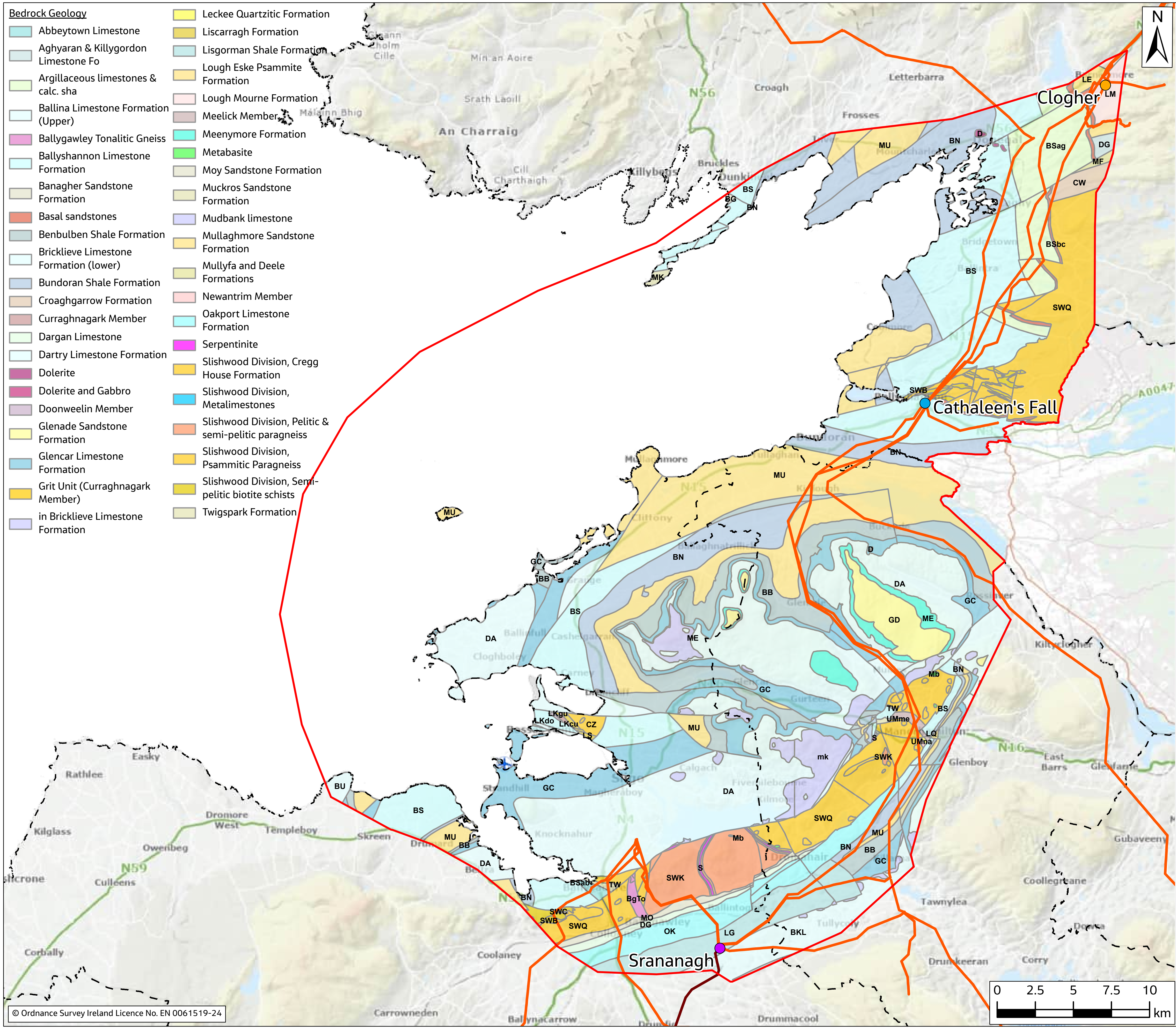


Legend

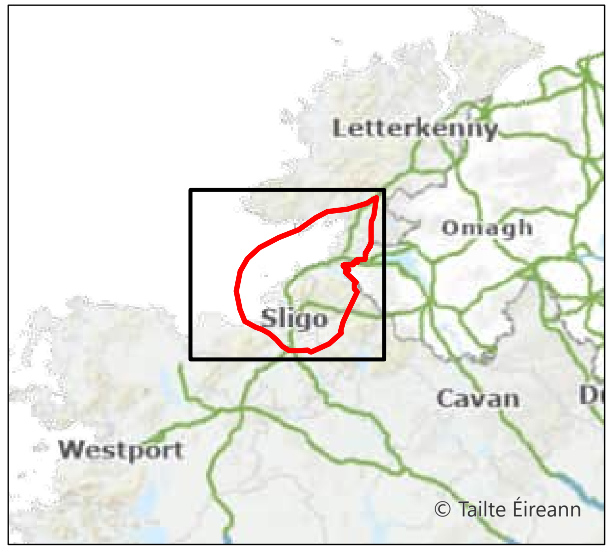
- Project Study Area
- Local Authority Boundary

Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Srananagh 220kV

Overhead Line

- 110kV
- 220kV



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Drawing Title

Geology Constraints

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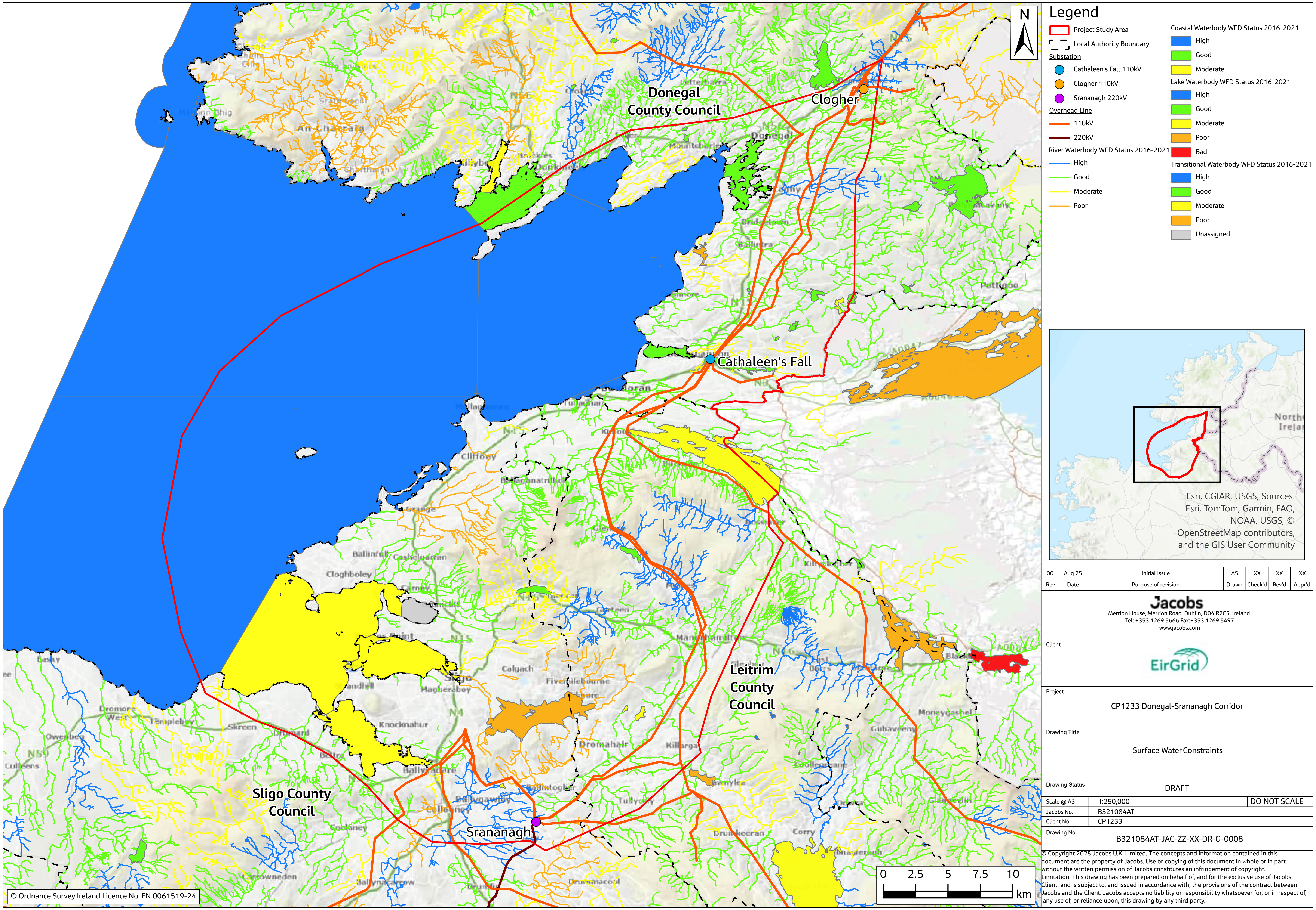
Client No.	CP1233	
Drawing No.	B321084AT-JAC-ZZ-XX-DR-G-0007	



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Project: CP1233 Donegal-Srananagh Corridor

Drawing Title: Surface Water Constraints

Drawing Status: DRAFT

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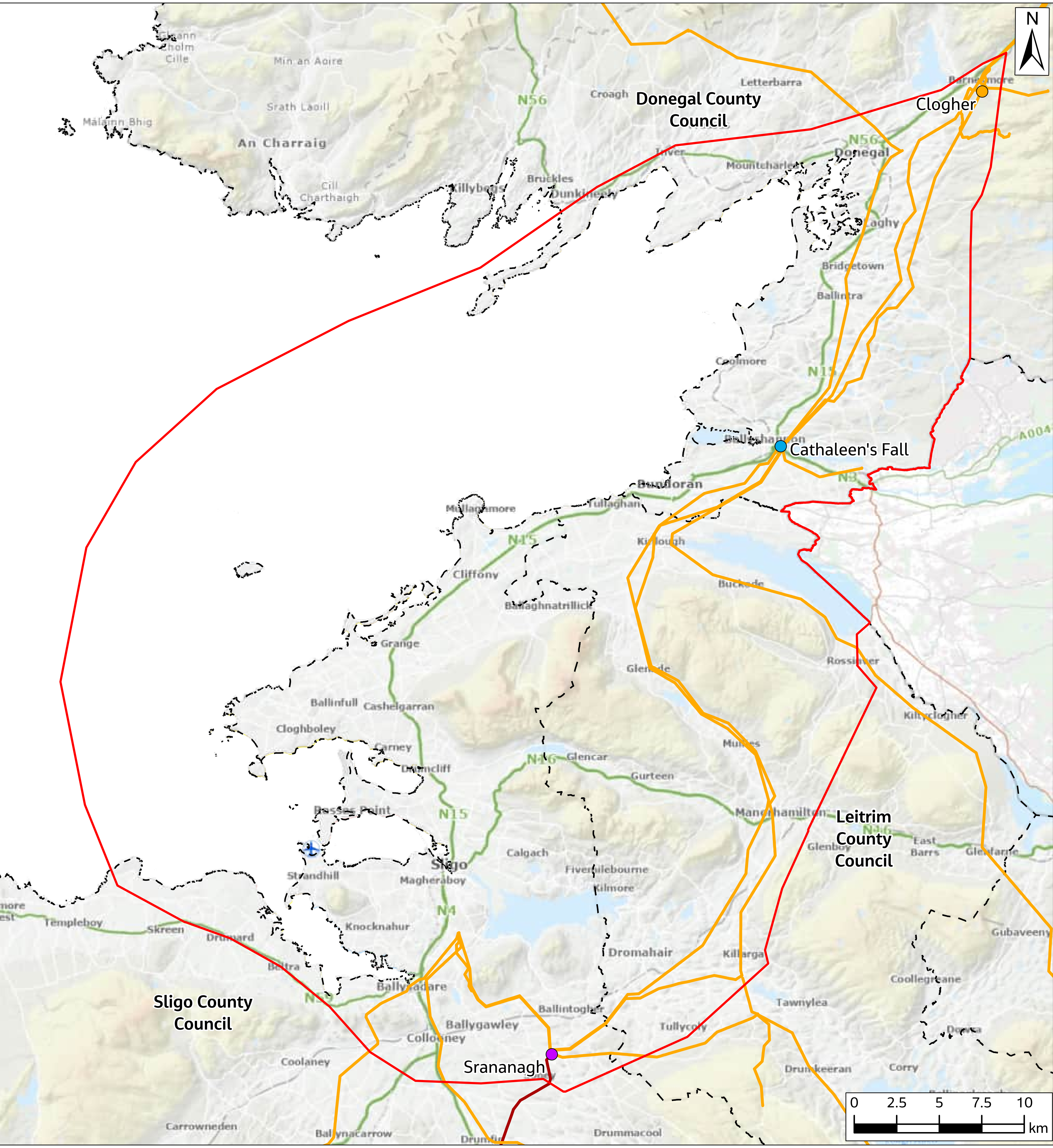
Drawing No.: B321084AT-JAC-ZZ-XX-DR-G-0008



Superficial Geology - Deposits

- A, Alluvium
- AcEsk, Eskers comprised of gravels of acidic reaction
- Ag, Alluvium (gravelly)
- Airfield/Airport
- BasEsk, Eskers comprised of gravels of basic reaction
- BktPt, Blanket Peat
- Causeway
- Crannog
- Cut, Cut over raised peat
- FenPt, Fen Peat
- Fill, Made ground
- GLs, Gravels derived from Limestones
- GMp, Gravels derived from Metamorphic rocks
- GNSSs, Gravels derived from Namurian sandstones and shales
- KaRck, Kartsified bedrock outcrop or subcrop
- L, Lacustrine sediments
- Mbs, Marine beach sands
- Mesc, Esturine silts and clays
- Pier
- Rck, Bedrock outcrop or subcrop
- Scree
- TCh, Till derived from cherts
- TDCSsS, Till derived from Devonian and Carboniferous sandstones and shales
- TdlMr, Tidal Marsh
- TLCSsS, Till derived from lower Carboniferous sandstones and shales
- TLs, Till derived from limestones
- TMp, Till derived from Metamorphic rocks
- TNCSSs, Till derived from Namurian and Carboniferous sandstones and shales
- TNSSs, Till derived from Namurian sandstones and shales
- Urban
- Water
- Ws, Windblown sands
- Wsd, Windblown sands and dunes

Legend

- Project Study Area
- Local Authority Boundary

Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Sranangagh 220kV

Overhead Line

- 110kV
- 220kV

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Project: CP1233 Donegal-Srananagh Corridor

Drawing Title: Subsoil Constraints

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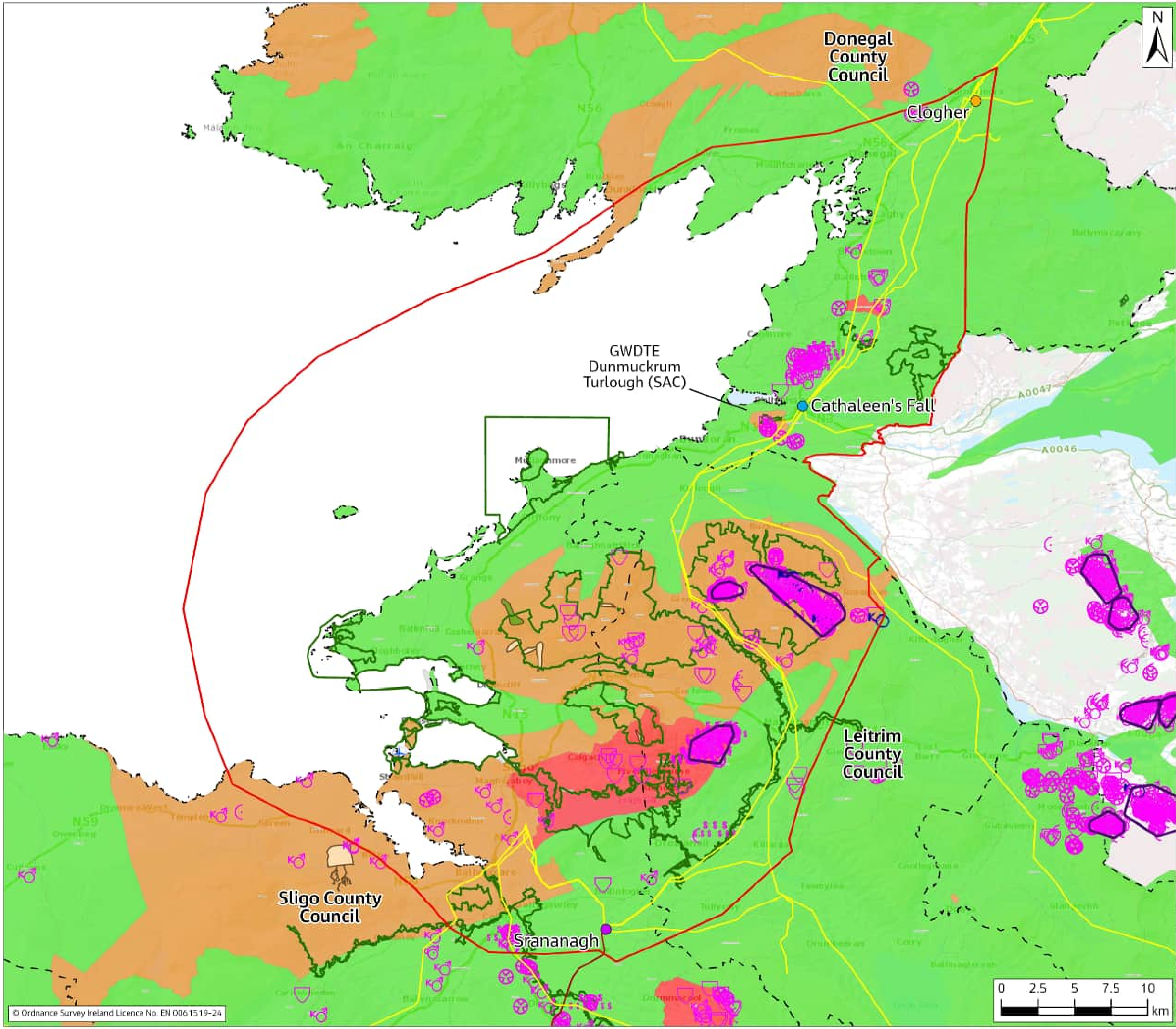
Client No.	CP1233	
Drawing No.	B321084AT-JAC-ZZ-XX-DR-G-0009	



Legend

- Project Study Area
- Local Authority Boundary

Substation
- Cathaleen's Fall 110kV
- Clogher 110kV
- Srananagh 220kV

Overhead Line
- 110kV
- 220kV

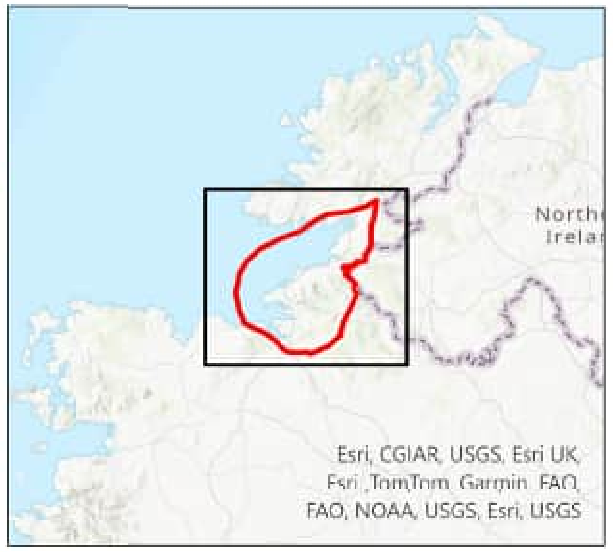
Karst Landform
- Borehole
- Cave
- Dry Valley
- Enclosed Depression
- Estavelle
- Spring
- Superficial Solution Feature
- Swallow Hole
- Turlough
- Unknown

- Karst Landform - High Density Area
- Designated Ecological Site with Groundwater Component
- Designated Ecological Site with Groundwater Component - Buffer 250m

Group Scheme and Public Supply Source Protection Areas

Public Supply Source Protection Areas
- SI-Inner Protection Area
- SO-Outer Protection Area
- Group Scheme Preliminary Source Protection Area

Ground Waterbodies Risk
- At Risk
- Not at Risk
- Review
- Unassigned



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Drawing Title

Environmental Constraints Report: Groundwater Constraints

Drawing Status

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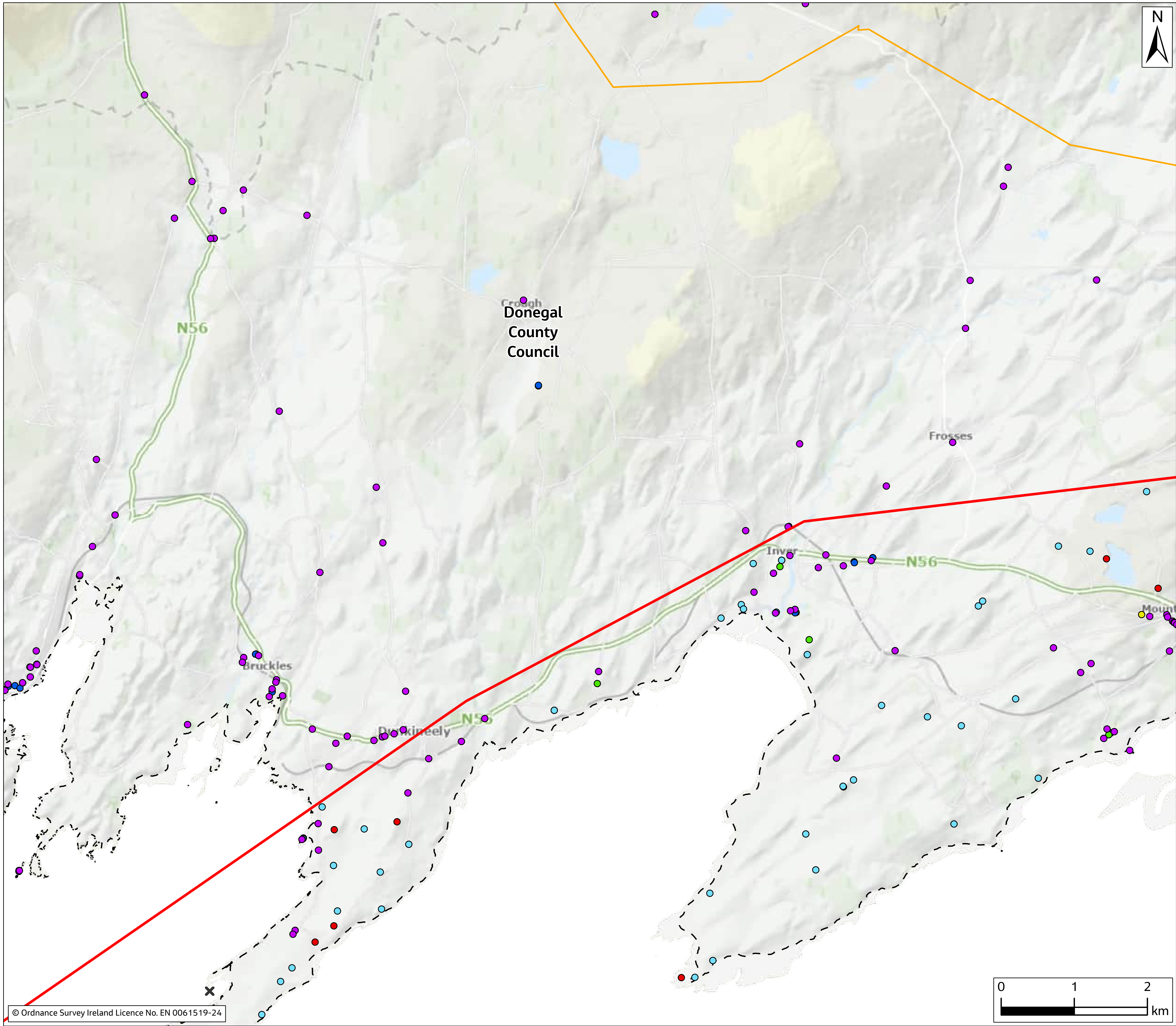
Jacobs No.	B321084AT	
Client No.	CP1233	

Drawing No.

B321084AT-JAC-ZZ-XX-DR-G-0010



Legend

- Project Study Area
- Local Authority Boundary

Existing Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Srananagh 220kV

Existing Overhead Line

- 110kV
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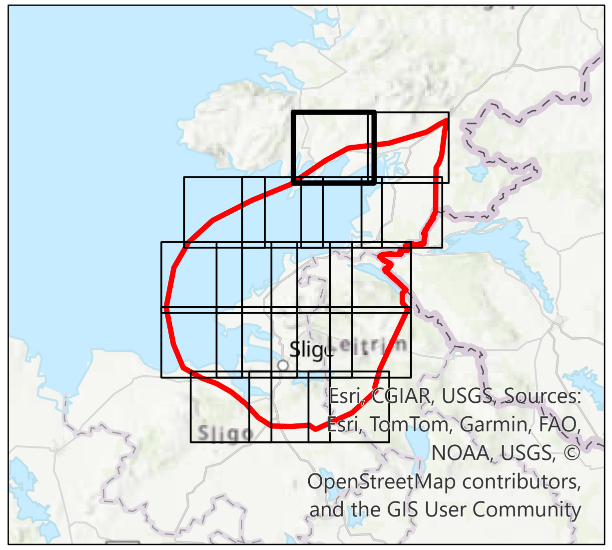
- Protected Structure
- Recorded Monument
- Sites and Monuments Record (SMR)
- Site with Preservation Order
- Wreck recorded on the Wreck Inventory of Ireland
- Protected Structure



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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www.jacobs.com

Client: EirGrid

Project: CP1233 Donegal-Srananagh Corridor

Drawing Title: Archaeological, Architectural Heritage and Cultural Heritage Constraints

Drawing Status: DRAFT

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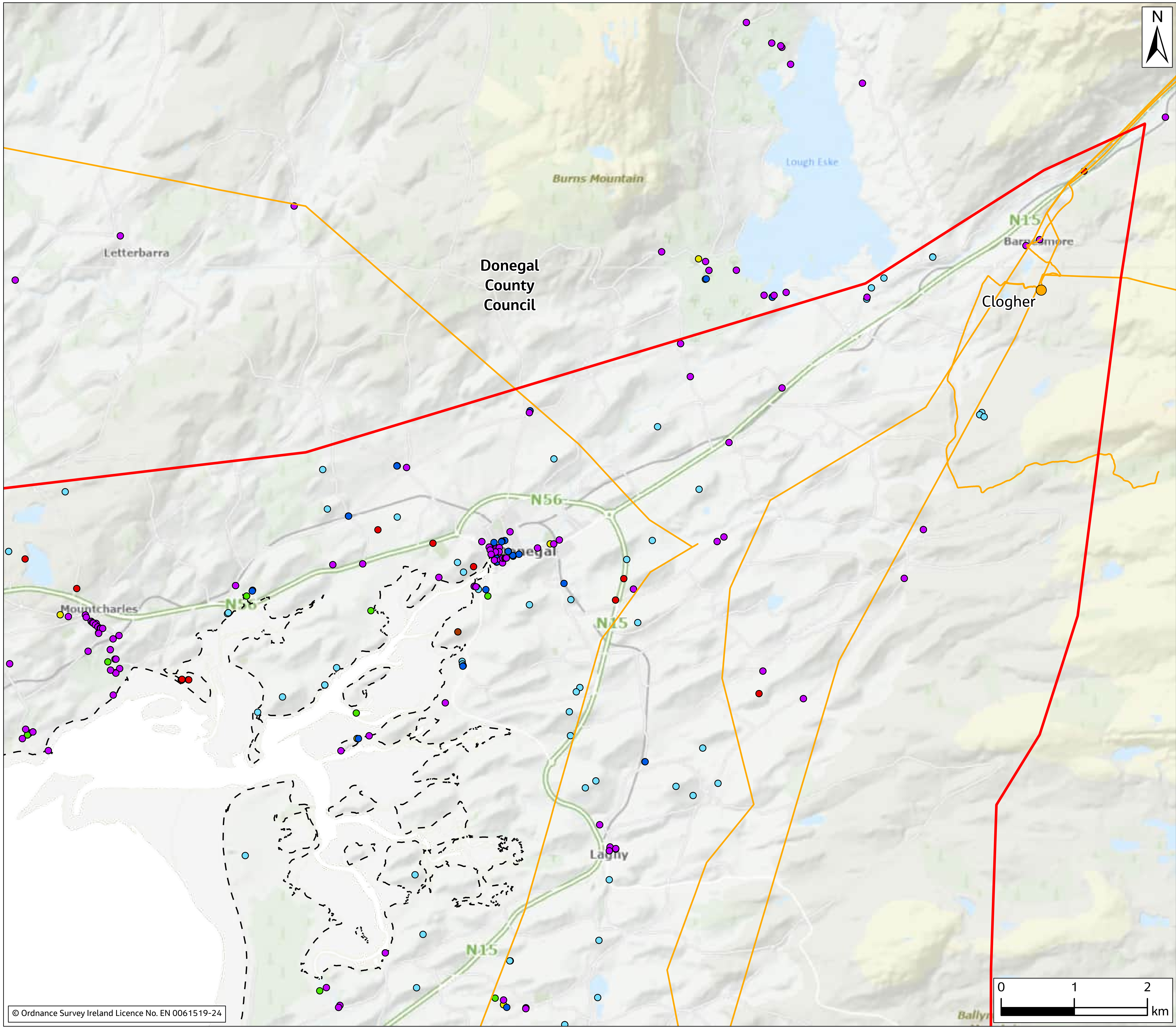
Client No.	CP1233	

Drawing No. B321084AT-JAC-ZZ-XX-DR-G-0014



Legend

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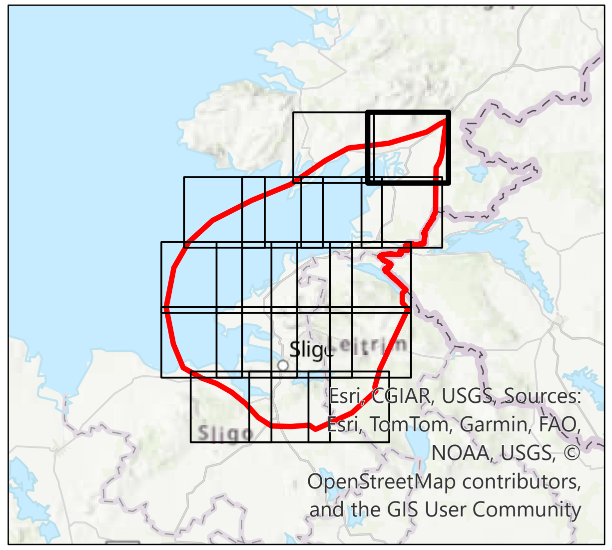

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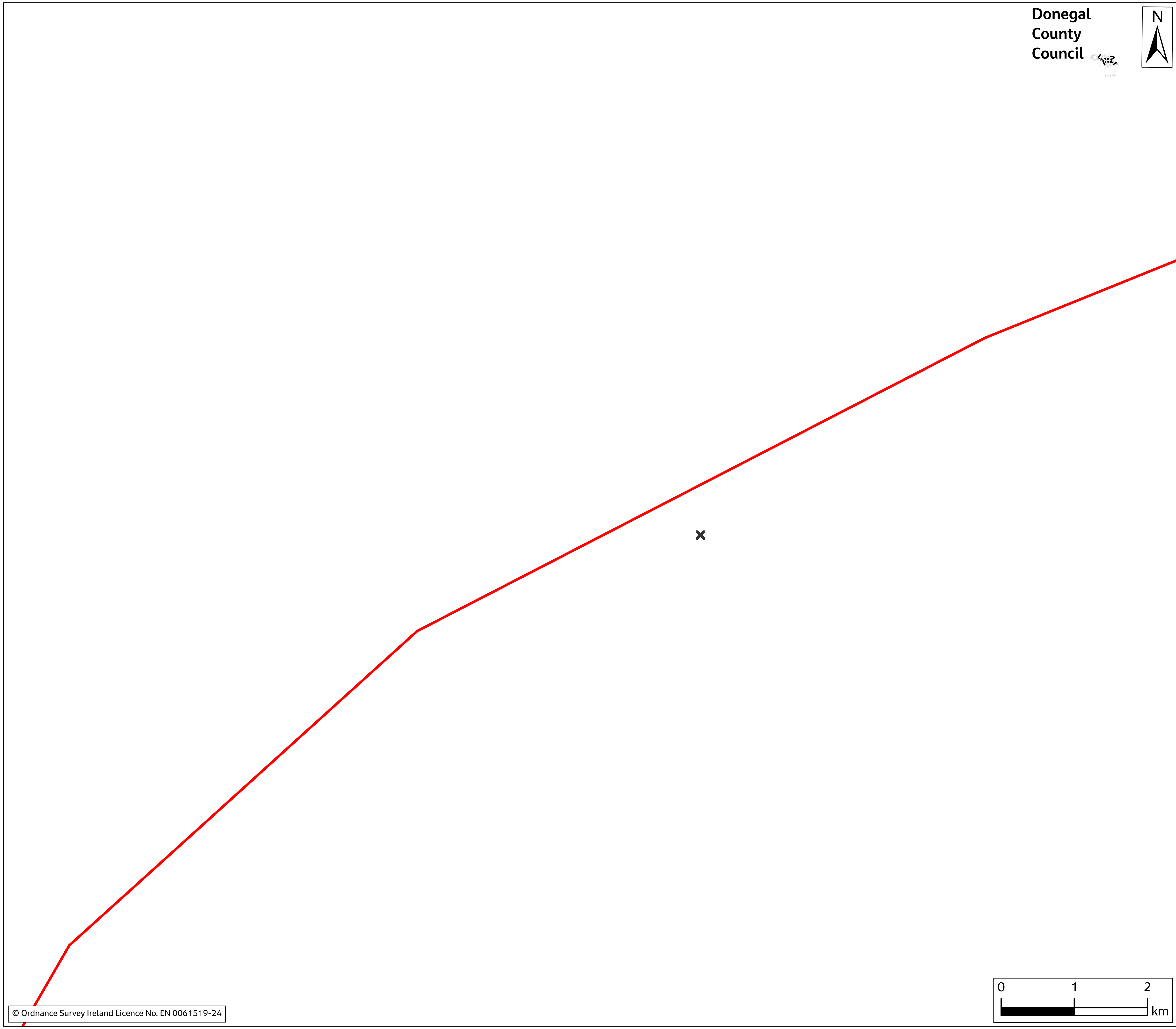

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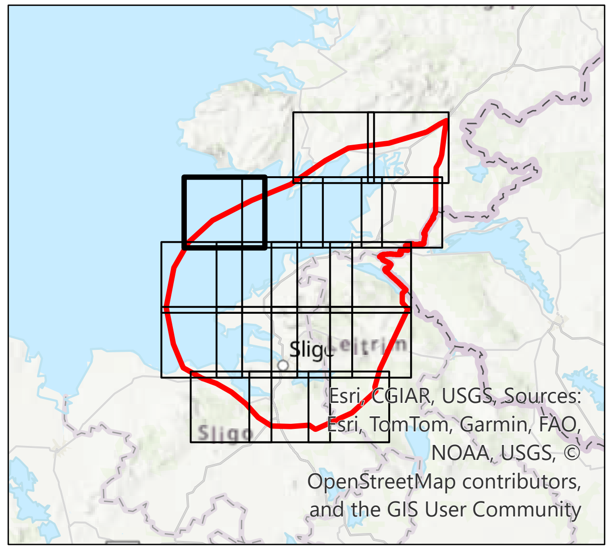

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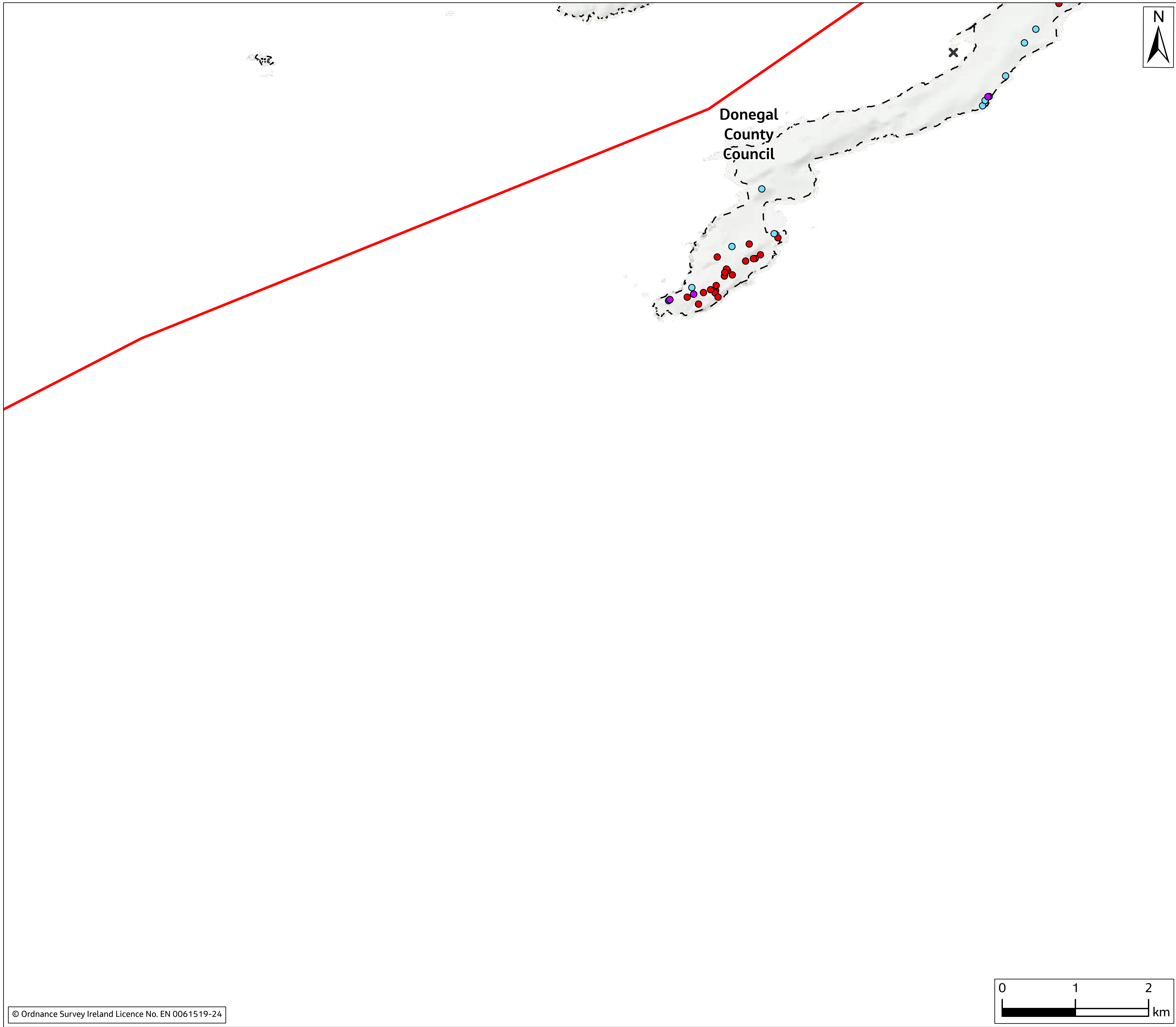

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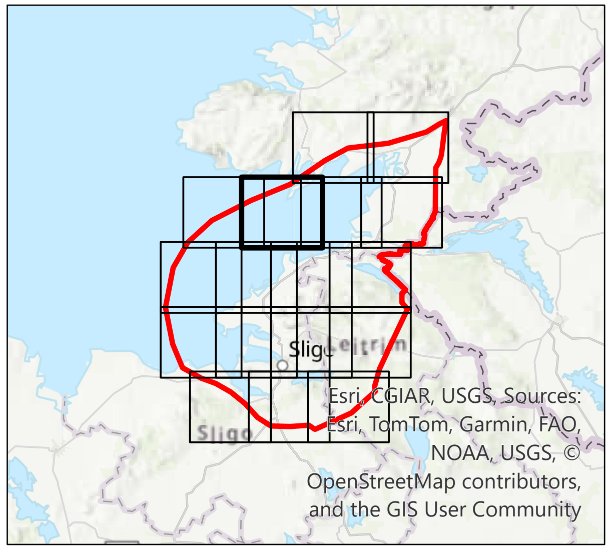

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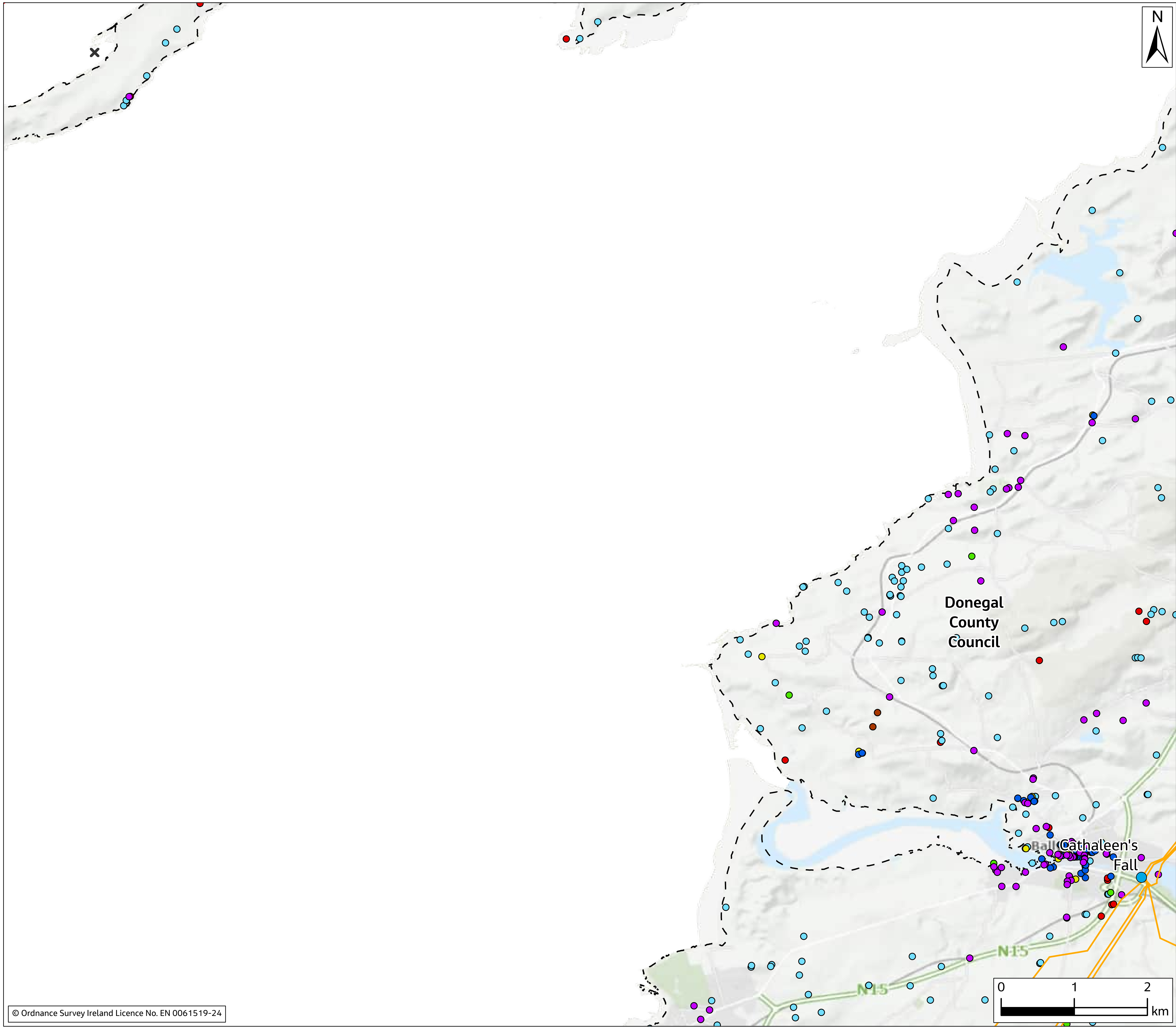

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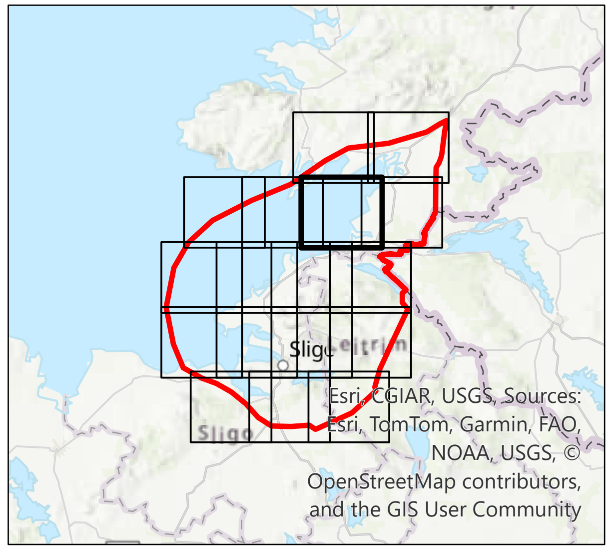

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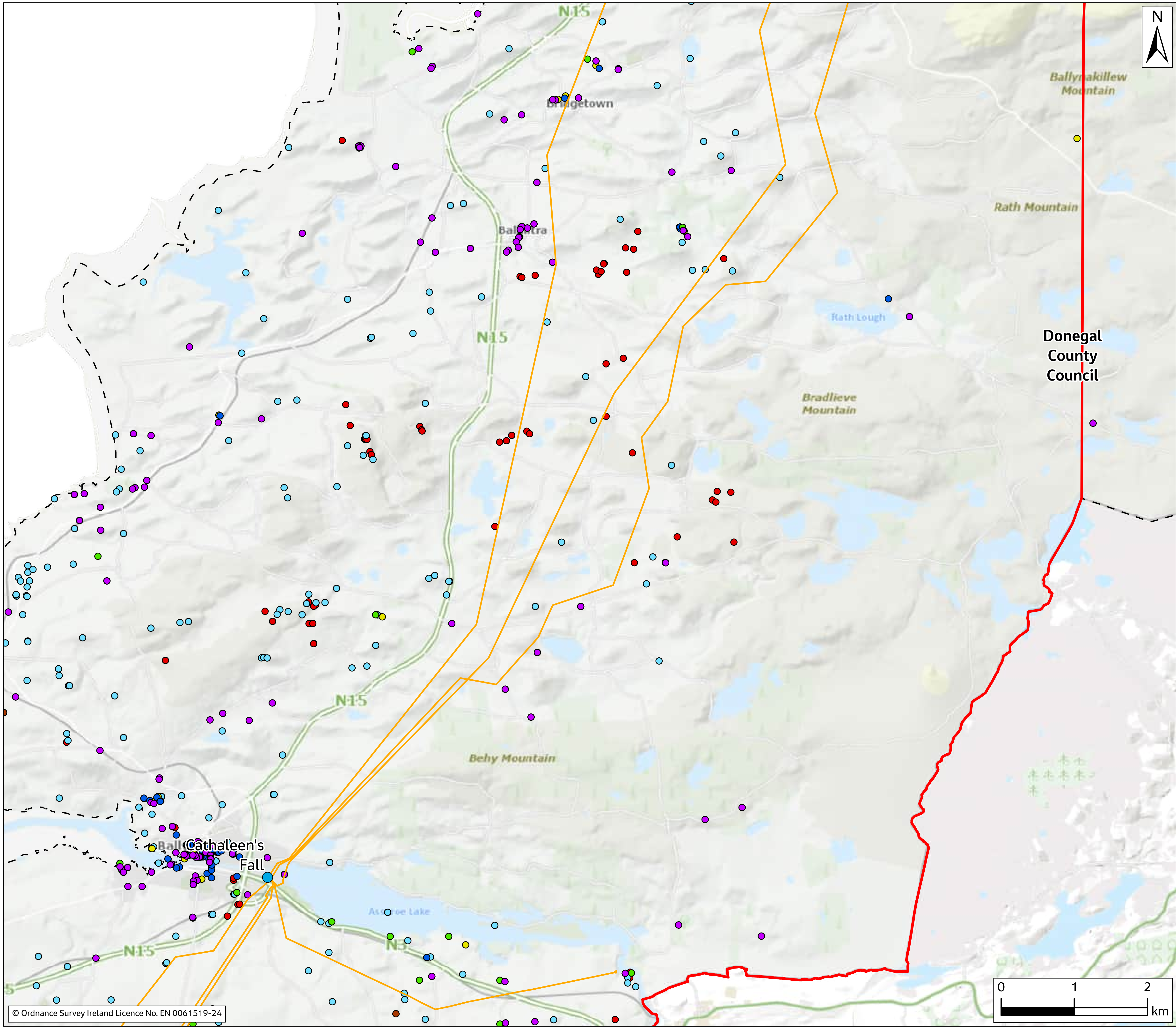

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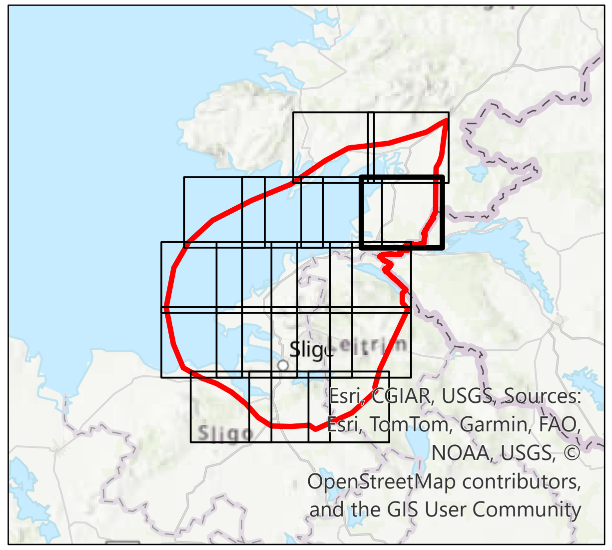

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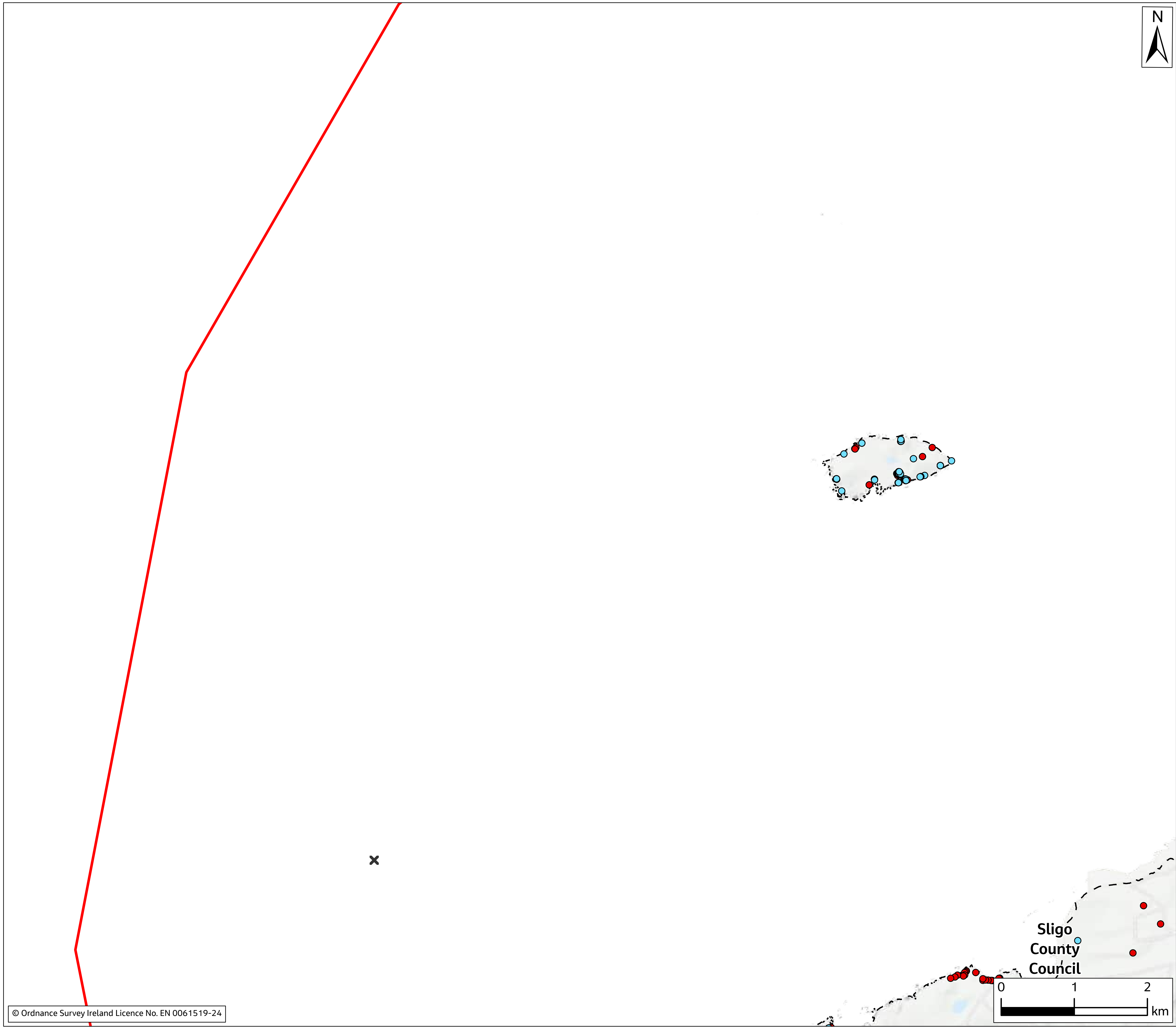

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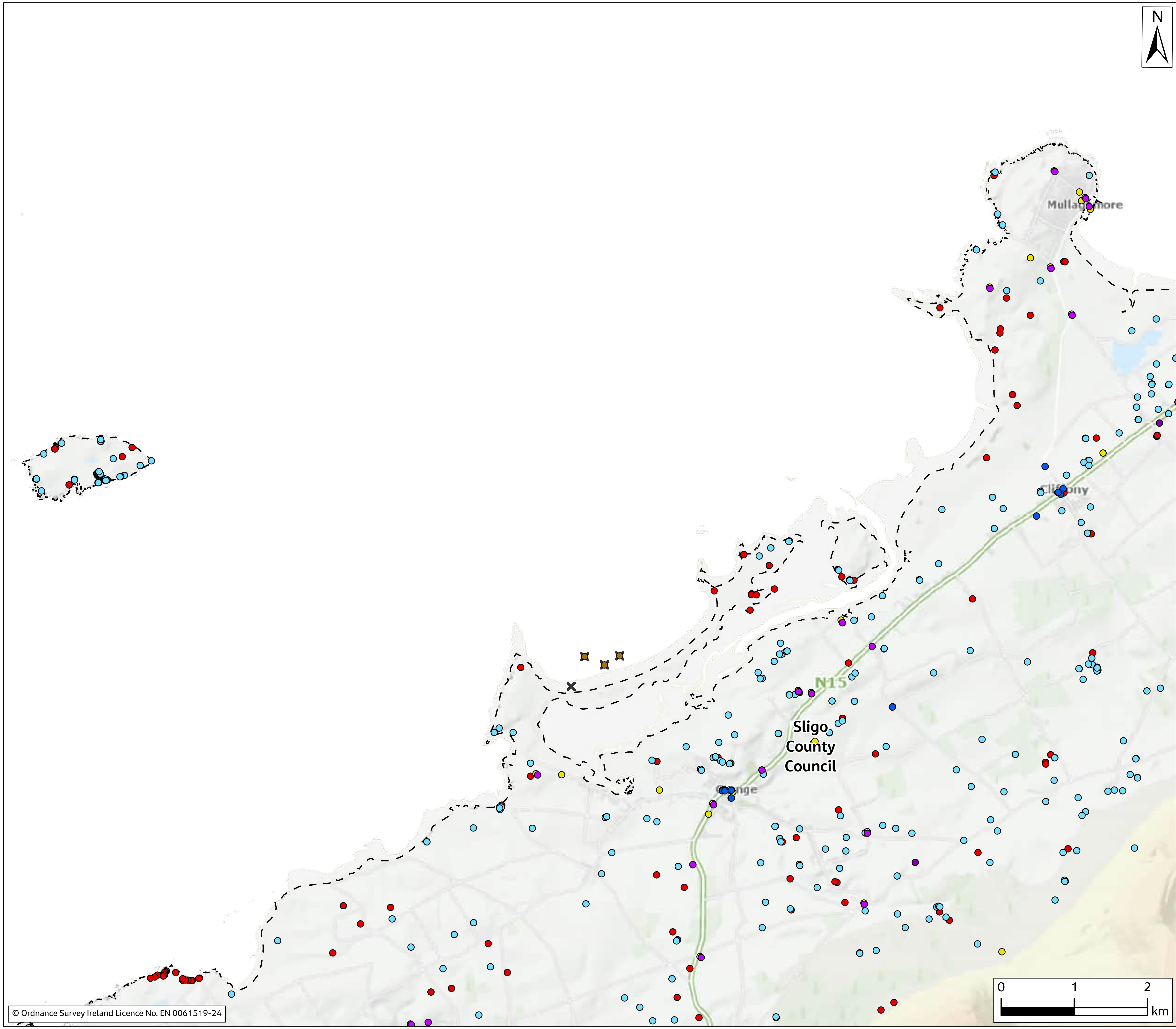

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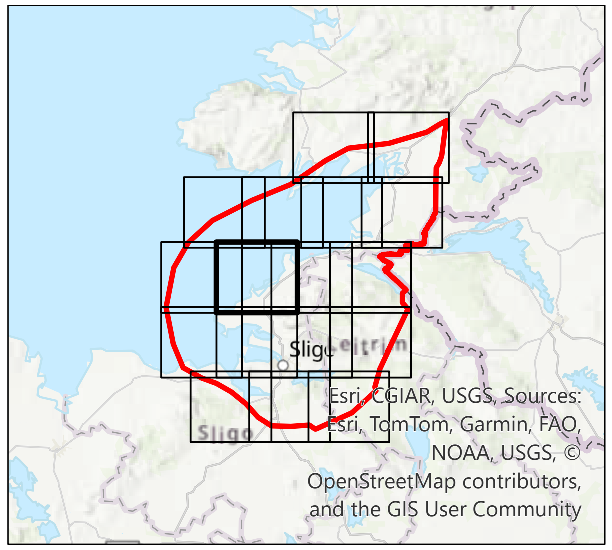

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Drawing Title

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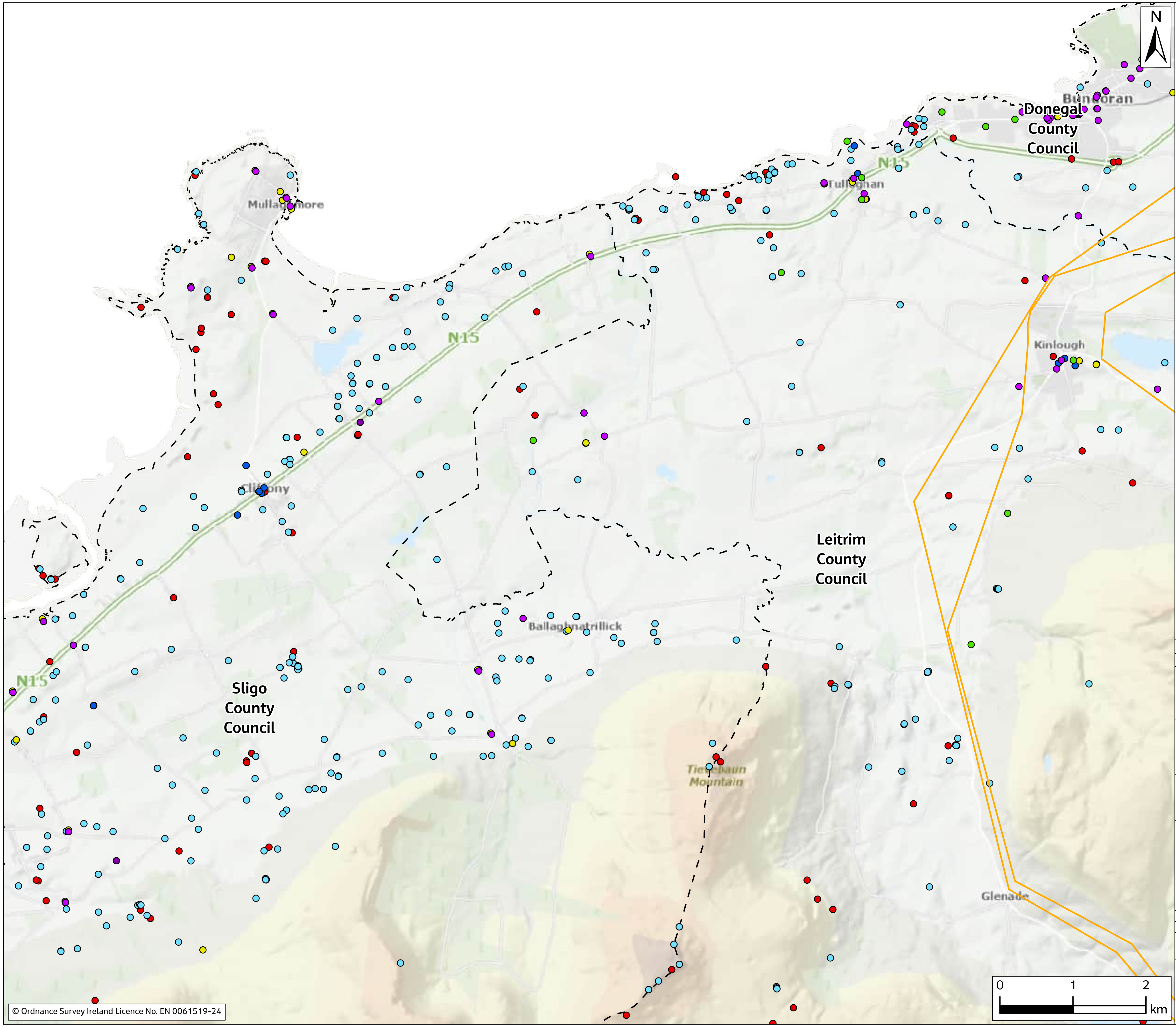

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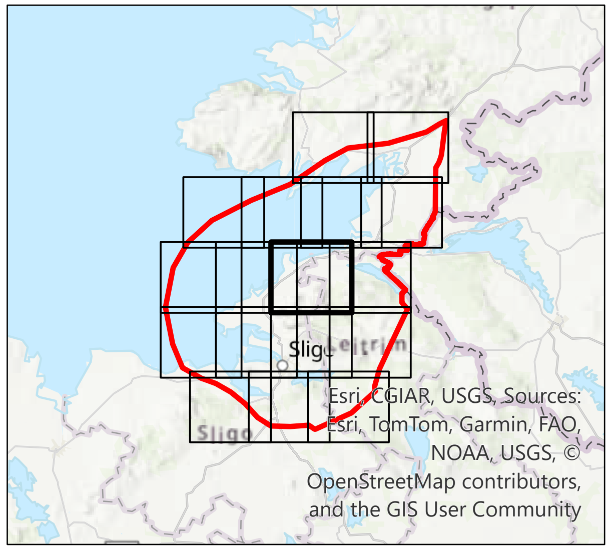

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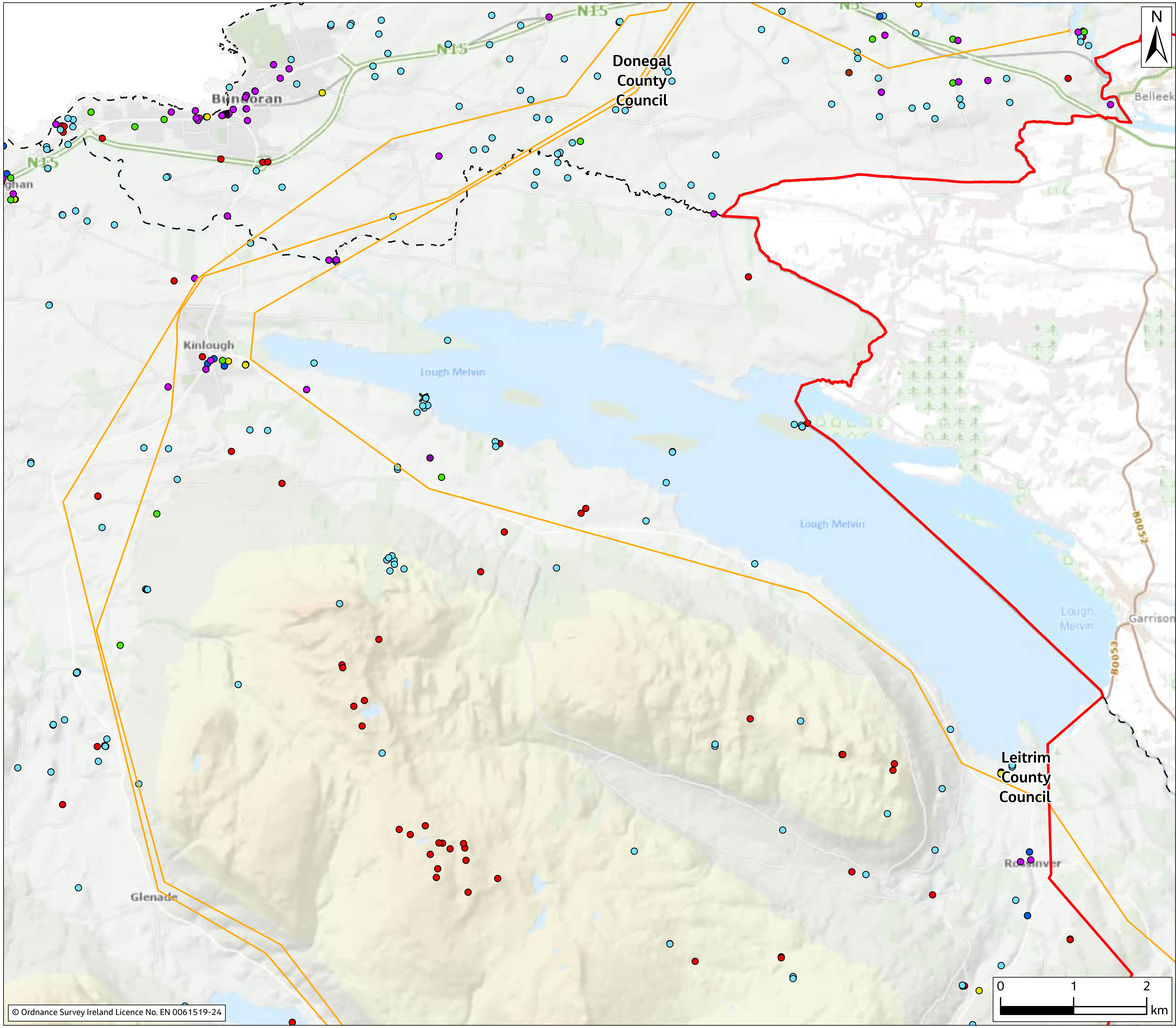

N

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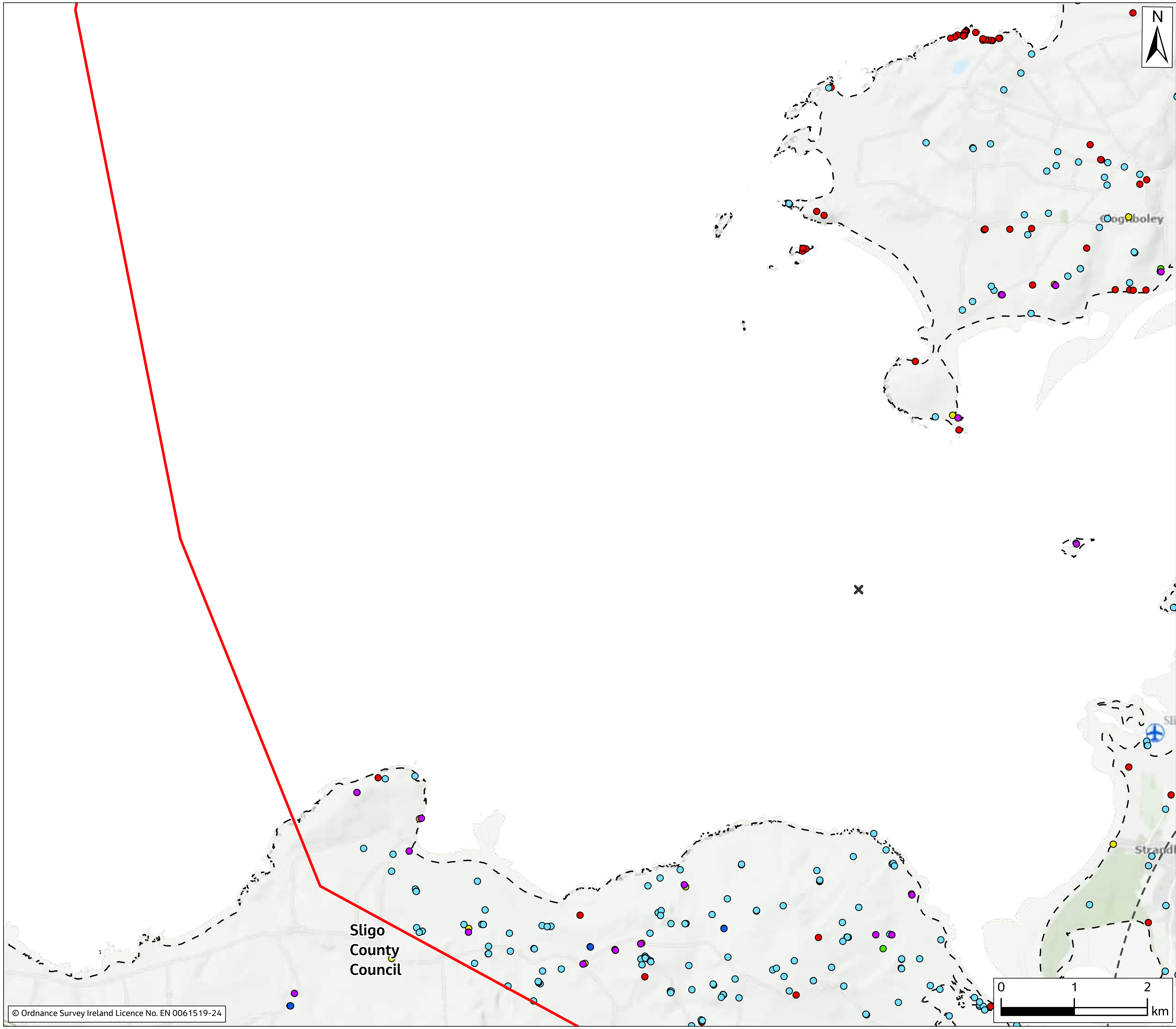

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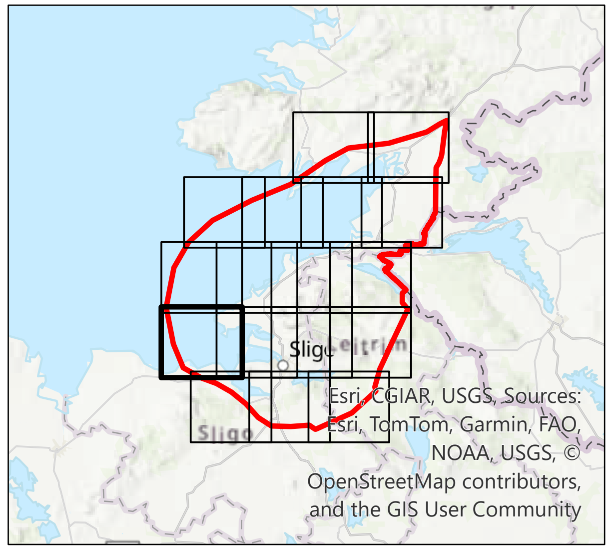

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Drawing Status: DRAFT

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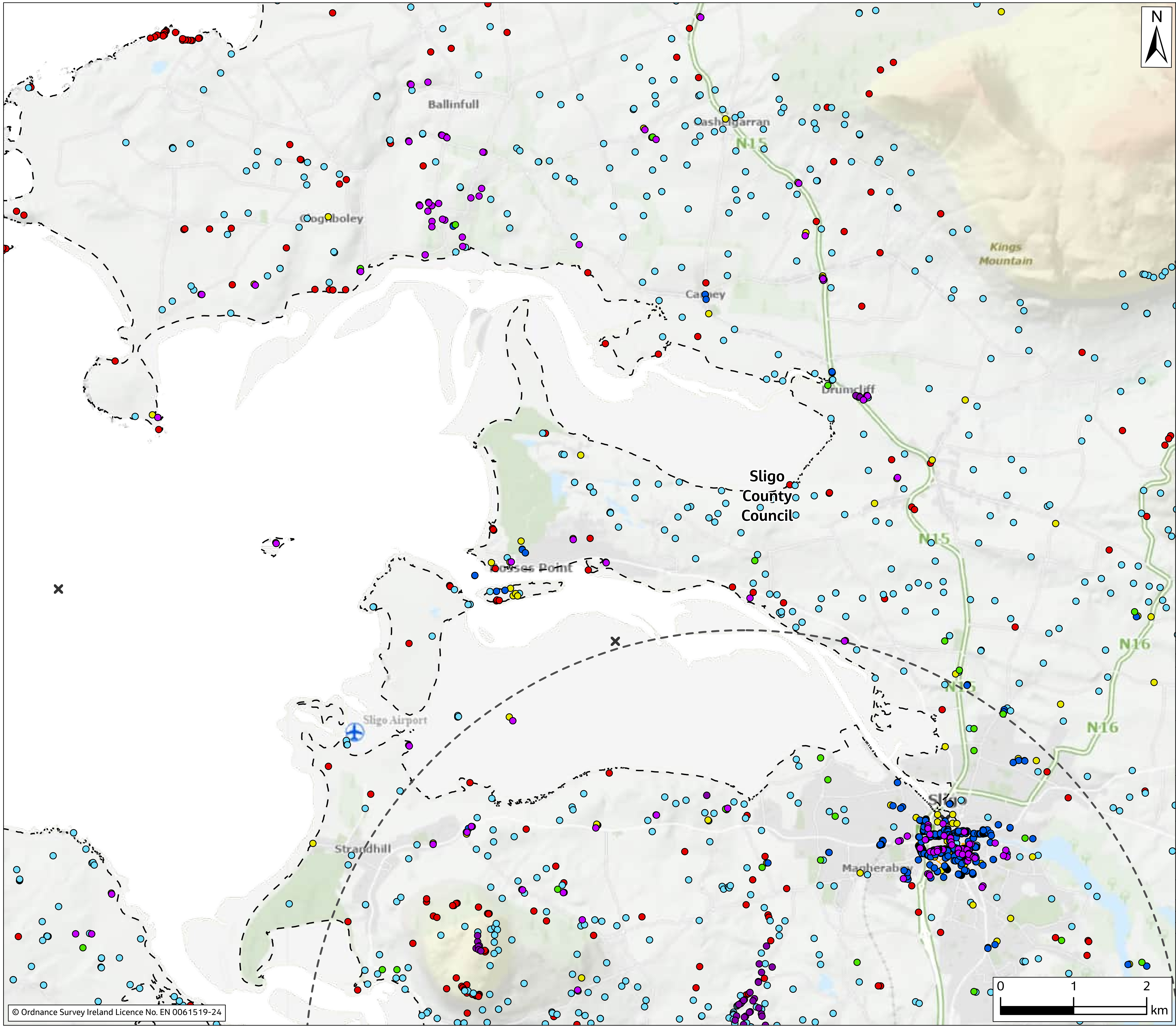

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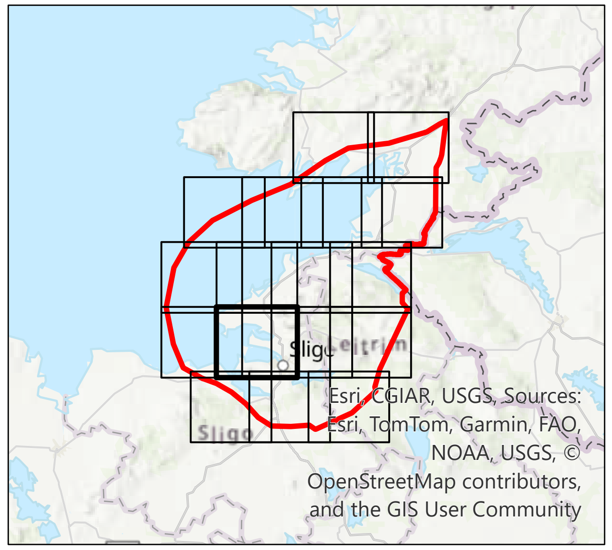

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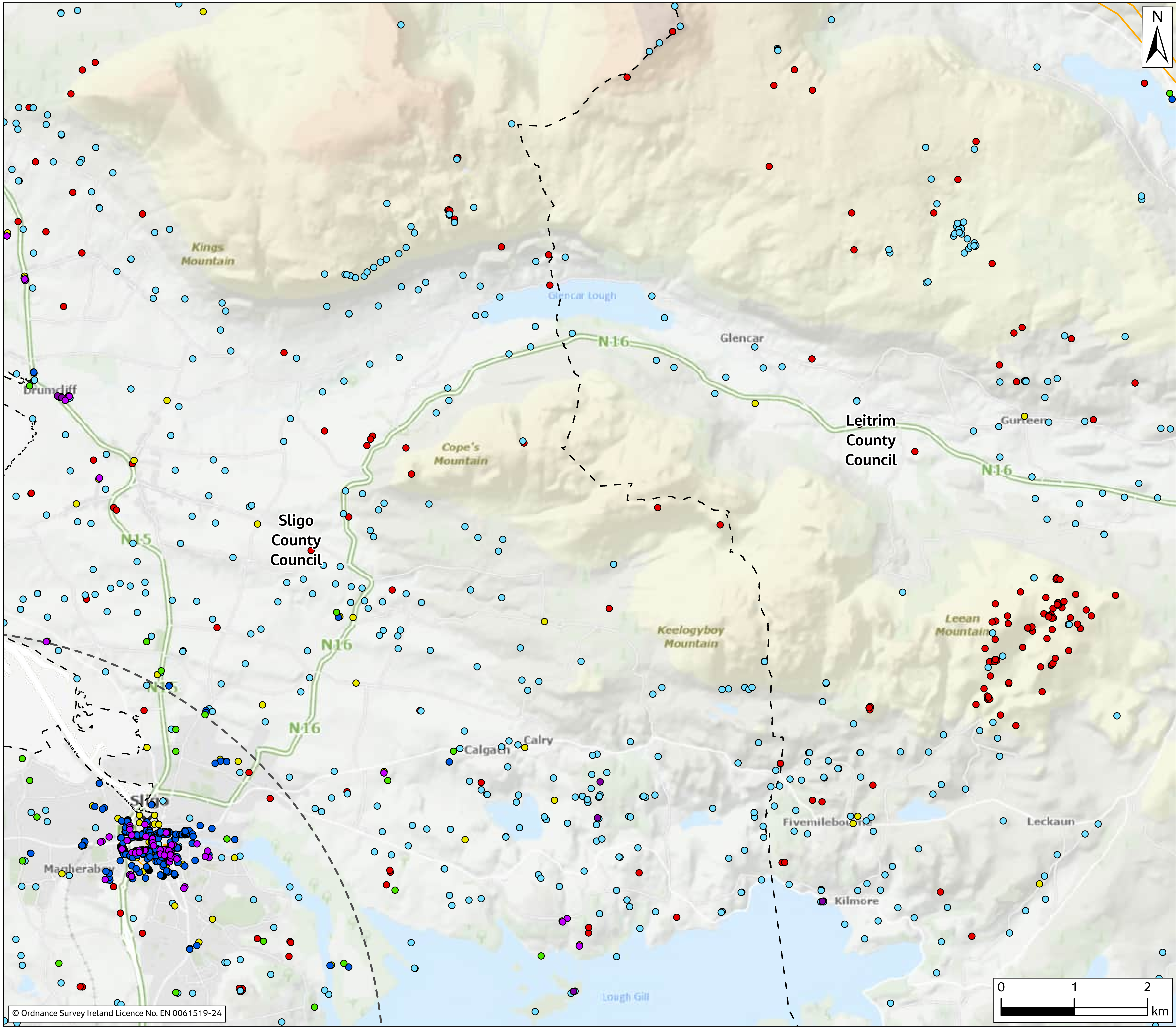

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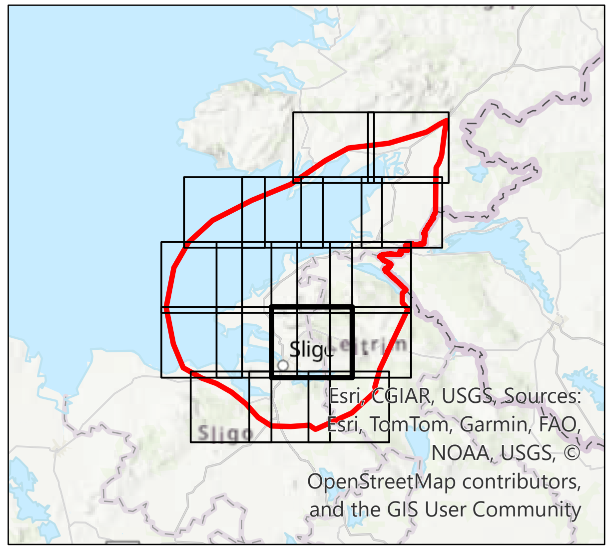

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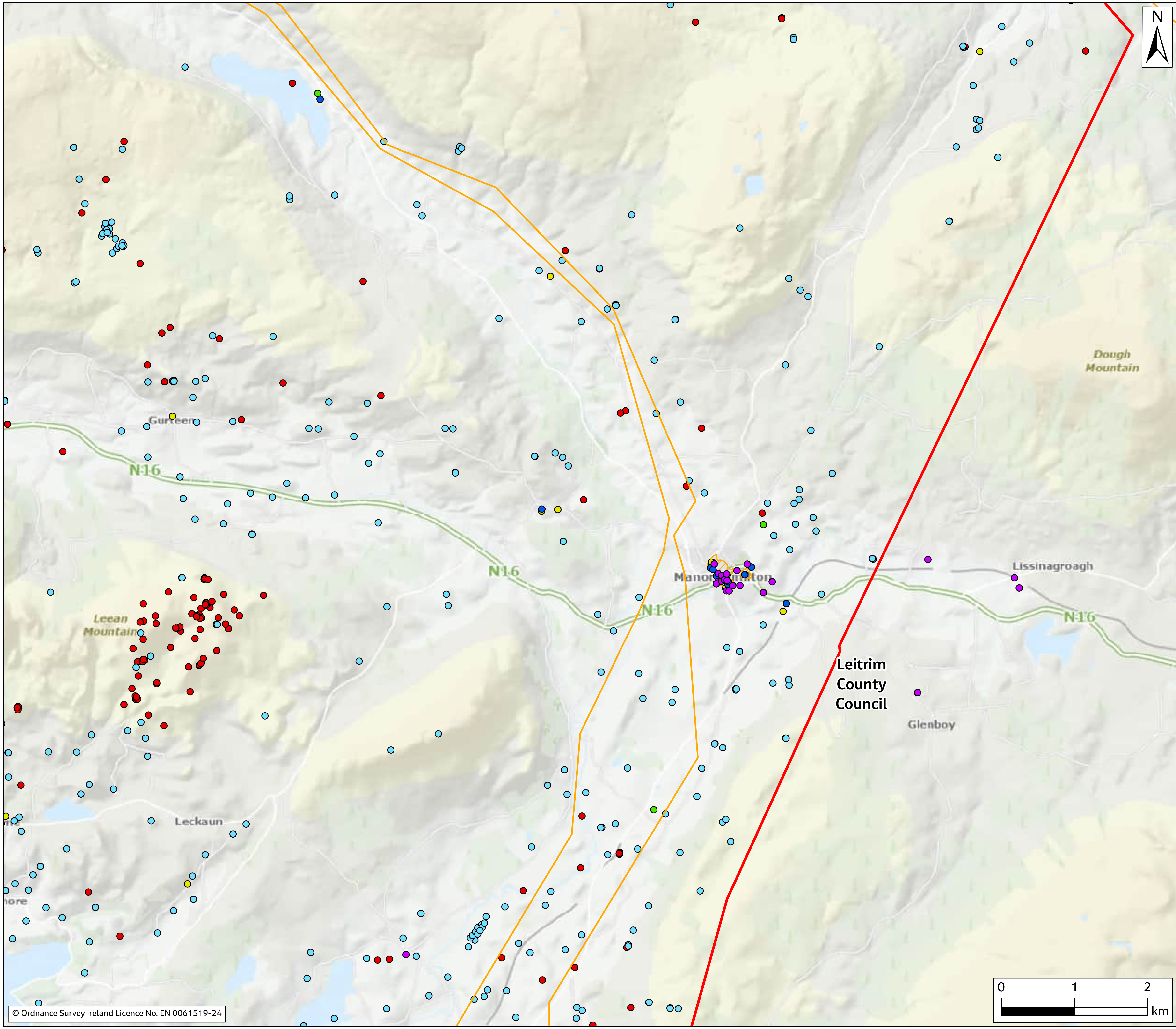

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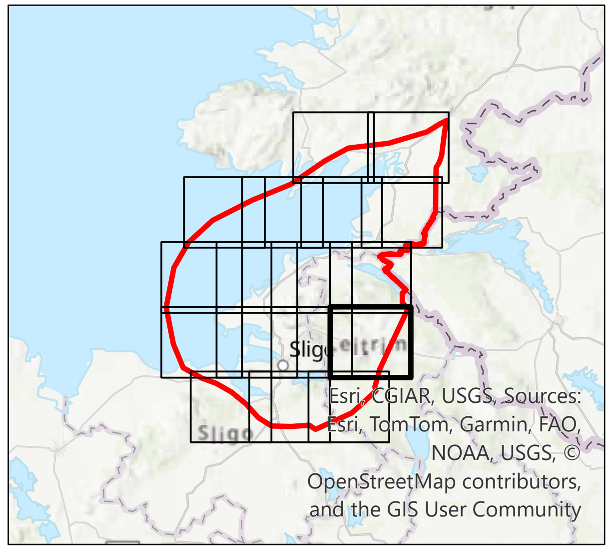

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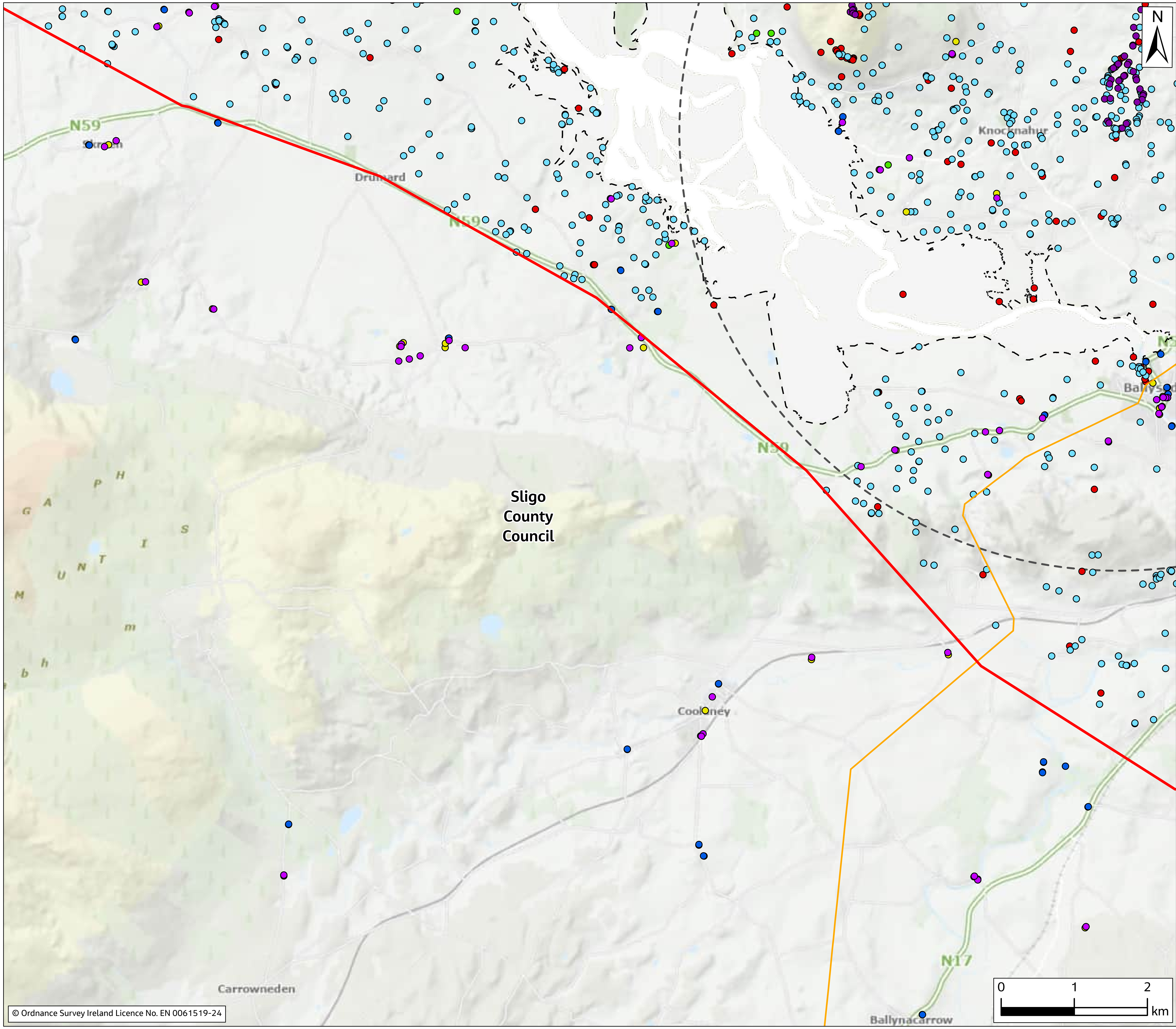

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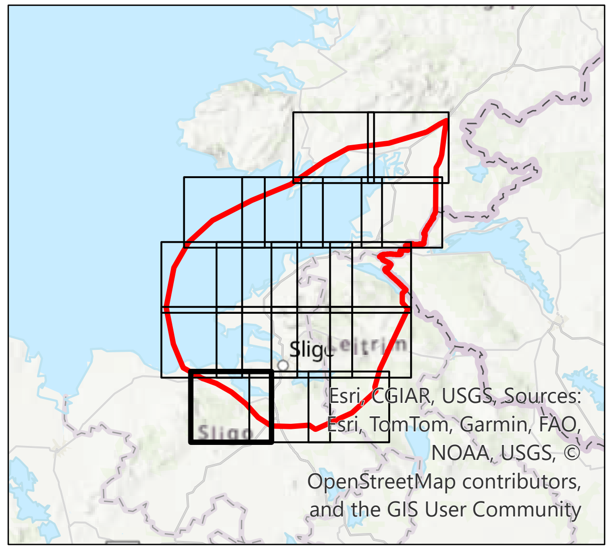

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
00	Aug 25	Initial Issue	AS	XX	XX	XX

Jacobs

Merrion House, Merrion Road, Dublin, D04 R2C5, Ireland.
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Client

EirGrid

Project

CP1233 Donegal-Srananagh Corridor

Drawing Title

Archaeological, Architectural Heritage and Cultural Heritage Constraints

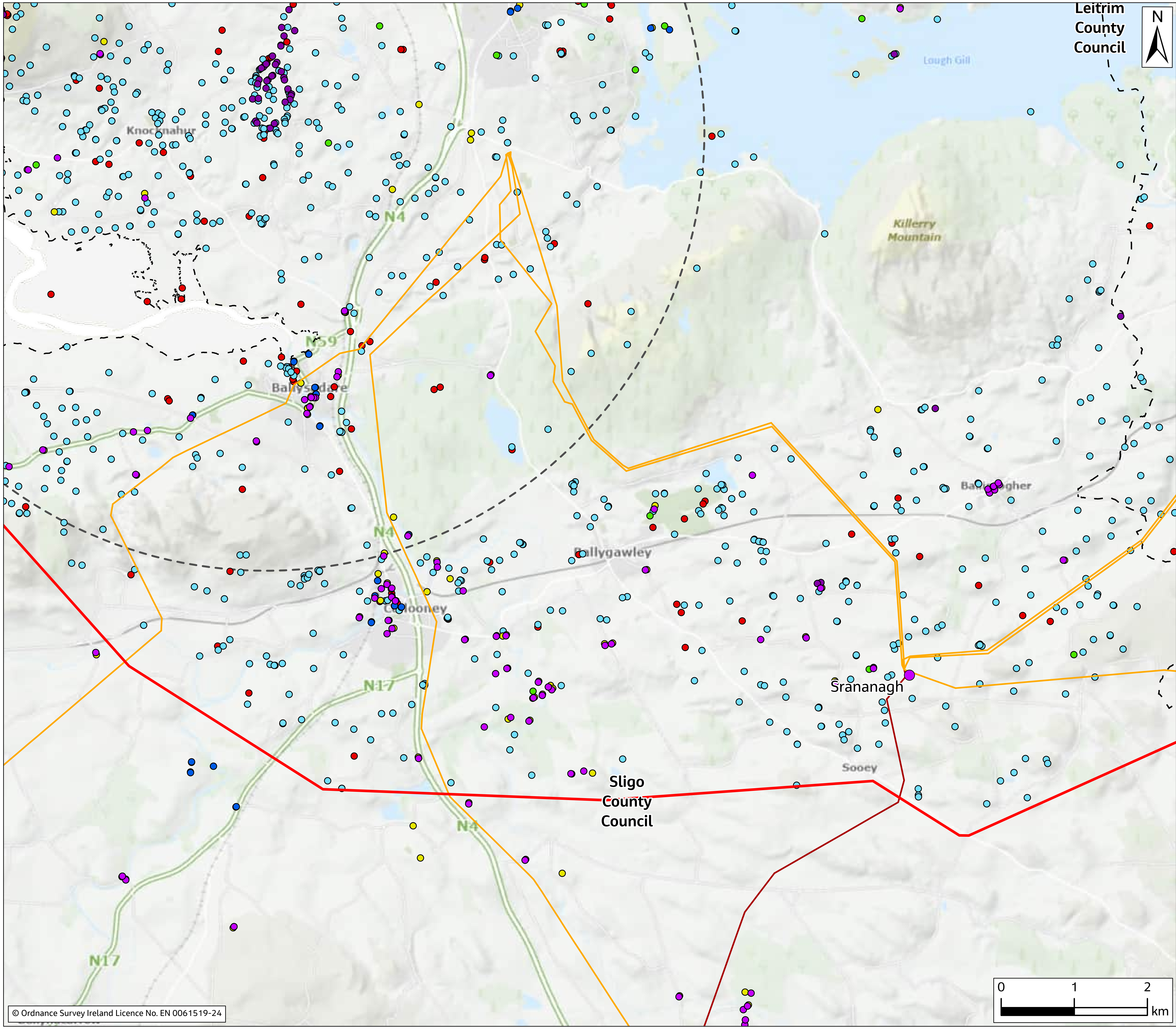
Drawing Status

DRAFT

Scale @ A3	1:50,000	DO NOT SCALE
Jacobs No.	B321084AT	
Client No.	CP1233	

Drawing No.

B321084AT-JAC-ZZ-XX-DR-G-0028



Legend

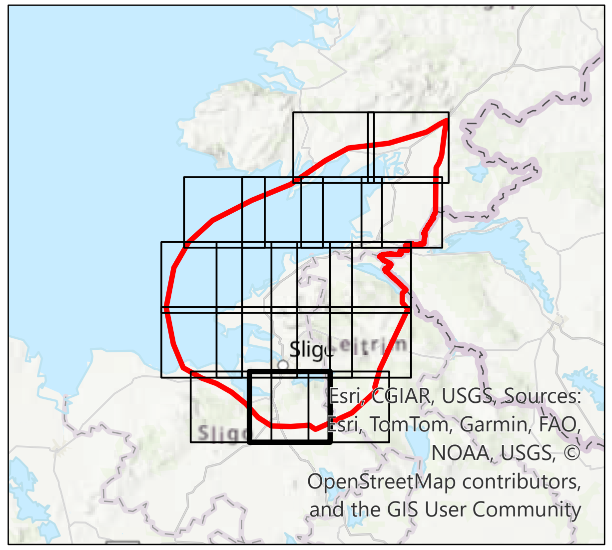
- Project Study Area
- Local Authority Boundary

Existing Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Srananagh 220kV

Existing Overhead Line

- 110kV
- 220kV
- Building of Architectural Heritage recorded by NIAH
- Garden and Designed Landscape
- National Inventory of Architectural Heritage (NIAH)
- National Monument
- Protected Structure
- Recorded Monument
- Sites and Monuments Record (SMR)
- Site with Preservation Order
- The Passage Tomb Landscape of County Sligo Tentative List Site (approximate location)



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Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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Client

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Project

CP1233 Donegal-Srananagh Corridor

Drawing Title

Archaeological, Architectural Heritage and Cultural Heritage Constraints

Drawing Status

DRAFT

Scale @ A3	1:50,000	DO NOT SCALE
Jacobs No.	B321084AT	
Client No.	CP1233	

Drawing No.

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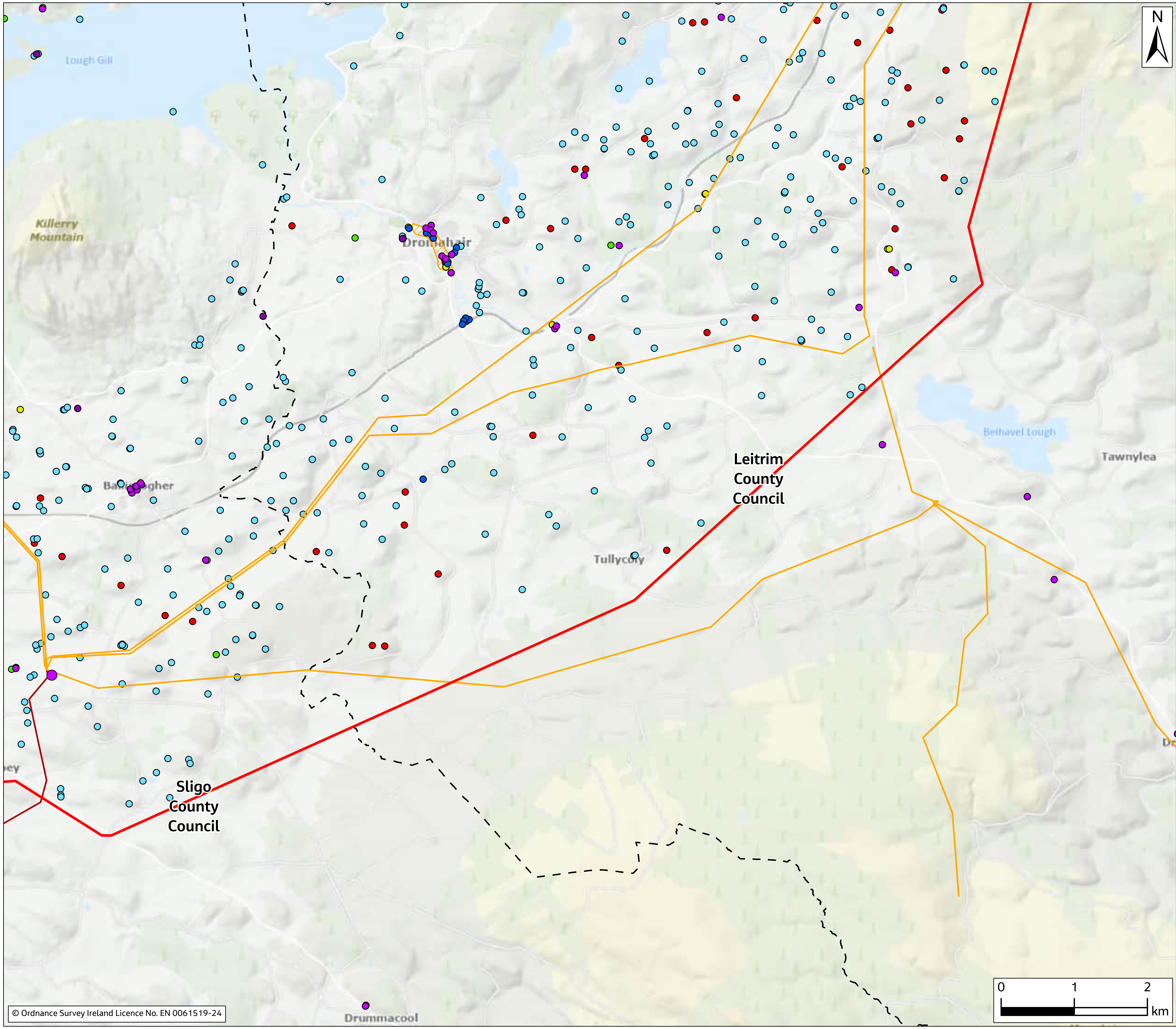


Legend

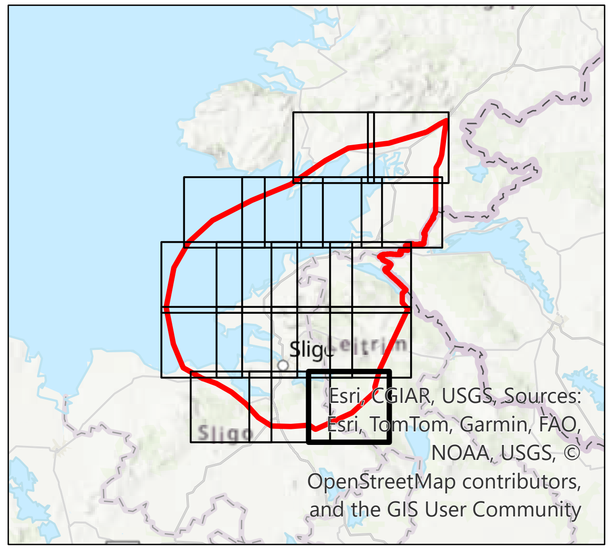
- Project Study Area
- Local Authority Boundary

Existing Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Srananagh 220kV

Existing Overhead Line

- 110kV
- 220kV
- Building of Architectural Heritage recorded by NIAH
- Garden and Designed Landscape
- National Inventory of Architectural Heritage (NIAH)
- National Monument
- Protected Structure
- Recorded Monument
- Sites and Monuments Record (SMR)
- Architectural Conservation Area (ACA)



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Client

EirGrid

Project

CP1233 Donegal-Srananagh Corridor

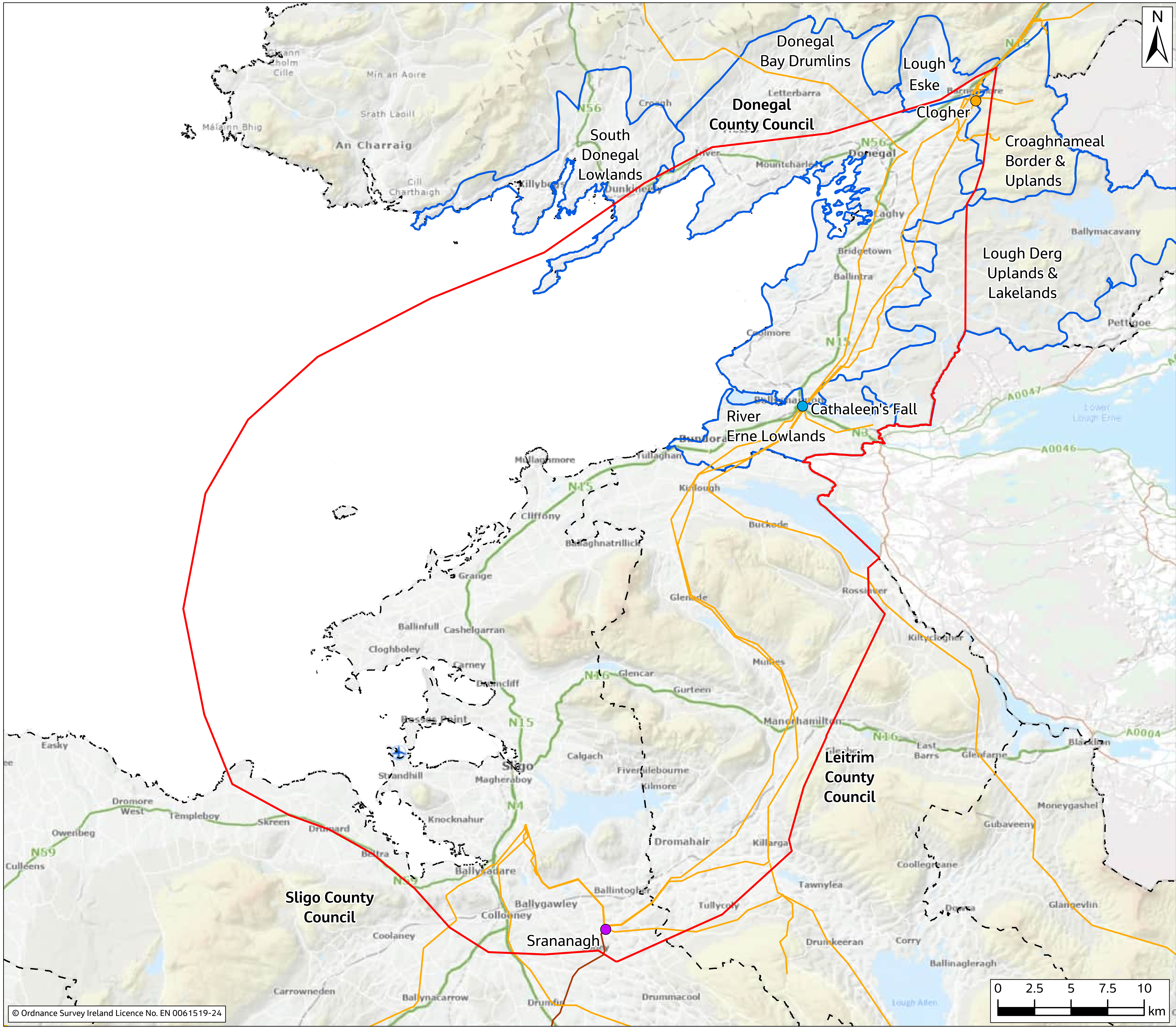
Drawing Title

Archaeological, Architectural Heritage and Cultural Heritage Constraints

Drawing Status

DRAFT

Scale @ A3	1:50,000	DO NOT SCALE
Jacobs No.	B321084AT	
Client No.	CP1233	
Drawing No.	B321084AT-JAC-ZZ-XX-DR-G-0030	



N

Legend

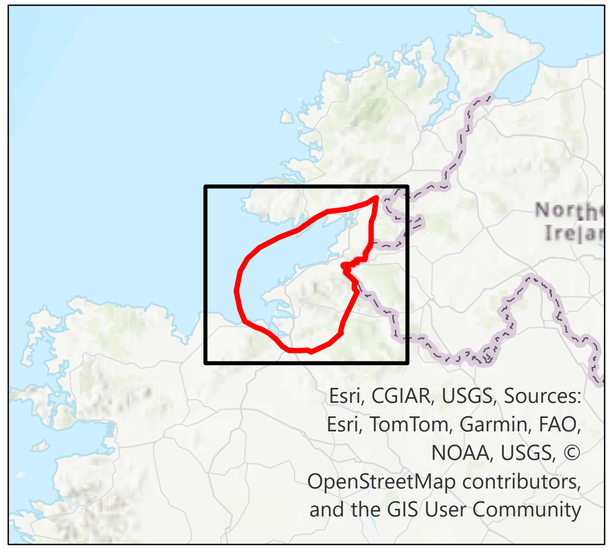
- Project Study Area
- Local Authority Boundary

Substation

- Cathaleen's Fall 110kV
- Clogher 110kV
- Sranangagh 220kV

Overhead Line

- 110kV
- 220kV
- Landscape Character Area - Donegal



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Project

CP1233 Donegal-Sranangagh Corridor

Drawing Title

Landscape and Visual Constraints

Drawing Status	DRAFT	
Scale @ A3	1:250,000	DO NOT SCALE
Jacobs No.	B321084AT	
Client No.	CP1233	
Drawing No.	B321084AT-JAC-ZZ-XX-DR-G-0012	