

TECHNICAL APPENDIX 9.1: HYDROLOGY METHOD OF ASSESSMENT

9.1 Introduction

9.1.1 The assessment methodology, including criteria for assessing sensitivity of receptors, magnitude of change and cumulative effects, as well as overall significance criteria, is detailed below.

Criteria for Assessing the Sensitivity of Receptors

9.1.2 Effects on water resources are described as beneficial, neutral or adverse and are considered with reference to the value or sensitivity of the receptor, as described in **Table 9.1.1**.

Table 9.1.1: Sensitivity of Environmental Receptor		
Sensitivity of Receptor	Definition	Typical Criteria
High	International or national level importance. Receptor with a high quality and rarity, regional or national scale and limited potential for substitution/ replacement.	<ul style="list-style-type: none"> High likelihood of fluvial/ tidal flooding in the sub catchment – defined as 1:10 probability in a year. European Commission (EC) Designated Salmonid / Cyprinid fishery. Surface Water Framework Directive (WFD) class 'High'. Scottish Government Drinking Water Protected Areas. Aquifer providing regionally important resource such as abstraction for public water supply, abstraction for private water supply. Supporting a site protected under EC or UK habitat legislation/ species protected by EC legislation. Protected Bathing Water Area. Active floodplain. Highly GWDTEs. Average peat depth >1 m within the sub-catchment. NatureScot Class 1 or 2 peat soils.
Medium	Regional, county and district level importance. Receptor with a medium quality and rarity, regional scale and limited potential for substitution/ replacement.	<ul style="list-style-type: none"> Medium likelihood of fluvial/ tidal flooding in the sub catchment – defined as a 1:200 probability in a year. Surface water WFD class 'Good' or 'Moderate'. Aquifer providing water for agricultural or industrial use. Local or regional ecological status/ locally important fishery. Contains some flood alleviation features. Average peat depth >0.5 m within the sub catchment. NatureScot Class 3 or 5 peat soils Moderately GWDTEs.
Low	Local importance Receptor is on-site or on a neighbouring site with a low quality and rarity, local scale. Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.	<ul style="list-style-type: none"> Surface water WFD class 'Poor'. Unproductive strata/ no abstractions for water supply. Sporadic fish present. No flood alleviation features. Sewer. Average peat depth <0.5 m within the sub catchment. Mineral soils

Criteria for Assessing the Magnitude of Change

9.1.3 The size or magnitude of each impact is determined as a predicted deviation from the baseline conditions during construction, operation and decommissioning of the Proposed Development, as described in Table 9.1.2.

Magnitude of Impact	Criteria
Large	Large alteration/ change in the quality or quantity of and/or to the physical or biological characteristics of environmental resource.
Medium	Medium alteration/ change in the quality or quantity of and/or to the physical or biological characteristics of environmental resource.
Small	Small alteration/ change in the quality or quantity of and/or to the physical or biological characteristics of environmental resource.
None	No alteration/ change detectable in the quality or quantity of and/or to the physical or biological characteristics of environmental resource.

Criteria for Assessing Cumulative Effects

9.1.4 The potential for cumulative effects to occur as a result of the Proposed Development is assessed based on:

- the potential hydrological connection of other similar developments, which are the subject of a valid planning application;
- the potential for concurrent phases of construction with other similar developments with the potential for hydrological connection to the Proposed Development; and
- applicable validated planning conditions with regards to the potential impact of other similar developments on the water environment.

Criteria for Assessing Significance

9.1.5 Table 9.1.3 illustrates how residual effects are determined by comparison of the sensitivity of receptors with the magnitude of impact (i.e. predicted change). For the purposes of this assessment significant effects are those classified as Major or Moderate.

		Magnitude of Impact			
		None	Small	Medium	Large
Sensitivity of Receptor	High	None	Minor	Major	Major
	Medium	None	Minor	Moderate	Moderate
	Low	None	Negligible	Minor	Minor

TECHNICAL APPENDIX 9.2: GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS ASSESSMENT

9.1 Introduction

9.1.1 This Technical Appendix provides a summary of Groundwater Terrestrial Ecosystems (GWDTEs) within the context of the Proposed Development and provides a description of geological and hydrogeological conditions underlying the Site. Characterisation of the Proposed Development area takes into account National Vegetation Classification (NVC) surveying carried out by Ramboll in July 2024. Hydrogeological assessment of the identified potential GWDTEs is provided with associated mapping.

9.1.2 This TA is supported by the following:

- Figure 9.2.1: BGS 1:625,000 Bedrock Geology
- Figure 9.2.2: BGS 1:625,000 Superficial Geology
- Figure 9.2.3: BGS 1:625,000 Hydrogeology
- Figure 9.2.4: Soils Map of Scotland
- Figure 9.2.5: Surface Water Accumulation and Topographic Wetness Index
- Figure 9.2.5: NVC GWDTE Classification
- Figure 9.2.6: Ramboll GWDTE Assessment

9.2 Baseline

Bedrock Geology

9.2.1 According to BGS 1:50,000 mapping (**Figure 9.2.1**) the majority of the Site is underlain by bedrock of the Lewisian Complex (Gneiss). The remainder of the Site, approximately 5% of the Site in the west is underlain by bedrock of the Outer Hebrides Thrust Zone Mylonites Complex (protocataclisite).

Superficial Geology

9.2.2 According to BGS 1:50,000 mapping (**Figure 9.2.2**) approximately 50% of the Site in the west is underlain by Peat. While BGS mapping states that superficial geology is unmapped in the east of the Site, a number of peat depth probes were used to characterise the peat deposits at the Site and these are detailed in **Technical Appendix 10.1 (EIAR Volume 4)**.

9.2.3 Peat depths of up to 3 m were recorded on the proposed substation and converter site (Arnish Moor), with the greatest depths of peat in the east and west. At the northern parcel of the Site, to the west of the A859 (Creed North), peat depths increase from the eastern area (at indicative depths of 1 m) to the west where peat depths of up to 3 m were recorded.

9.2.4 According to the Soils Map of Scotland (**Figure 9.2.4**) the whole site is underlain by Class 1 Peat.

Hydrogeology

9.2.5 According to BGS 1:625,000 mapping (**Figure 9.2.3**), the aquifer underlying the Site is classified as a Low productivity aquifer and Groundwater is only present in near surface weathered zone and secondary fractures.

9.3 Groundwater Dependent Terrestrial Ecosystems

Introduction

9.3.1 According to UK Technical Advisory Group guidance¹ GWDTE may be defined as habitats “directly dependent on the water level in or flow of water from a groundwater body (that is, in or from the saturated zone). Such an ecosystem may also be dependent on the concentrations of substances (and potential pollutants) within that groundwater body, but *there must be a direct hydraulic connection with the groundwater body.*”

9.3.2 Therefore, where GWDTE are found to be present there is the potential for direct impacts where habitat may be lost, as well as the potential for indirect impacts as a result of any alteration in the quality or quantity of groundwater supply. Excavation

¹ UK TAG Guidance on the identification and risk assessment of groundwater dependent terrestrial ecosystems. (21/01/04) Version 5. Available online: https://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Risk%20assessment%20of%20terrestrial%20ecosystems%20groundwater_Draft_210104.pdf [Last accessed January 2025]

of soil and bedrock during the construction phase of the Proposed Development may cause localised disruption and interruption to groundwater flow. Interruption of groundwater flow would potentially reduce the supply of groundwater water to GWDTEs thereby causing an alteration/ change in the quality or quantity of and/ or the physical or biological characteristics of the GWDTE. Contamination of groundwater may also cause physical or chemical contamination to the GWDTE.

- 9.3.3 Following identification of potential GWDTEs from NVC mapping data, the hydrological and hydrogeological desktop study information has been used to help qualitatively determine the potential sensitivity of each potential GWDTE.
- 9.3.4 Hydrogeological assessment should assess the potential for ground-surface water interactions, and therefore the potential for habitats to be reliant of water supplies from the underlying aquifer.
- 9.3.5 Further details with regard to each GWDTE identified are provided below. The sensitivity of each of the GWDTE receptors has been classed based upon classifications provided within SEPA's guidance document LUPS4².

National Vegetation Classification

- 9.3.6 Following ecological surveying of the Creed North site, it was confirmed that habitats on the western land parcel comprise rain-fed bog and are unlikely to be groundwater dependent.
- 9.3.7 Several areas of potentially Moderately or Highly GWDTE habitat areas were identified on the proposed Arnish Moor site during NVC surveys conducted by Ramboll in June 2024. Further details with regard to each GWDTE identified are provided below and illustrated in **Figure 9.2.5**.
- 9.3.8 The full area of the Arnish Moor site is underlain by a Low productivity aquifer, and there is therefore a low potential for the emergence of groundwater from the aquifer at the surface.
- 9.3.9 In order to further assess the extent to which NVC communities are likely to be reliant on groundwater (rather than being reliant on direct rainfall, surface water runoff or connection to surface water features), a review has been carried out of flow paths of surface water runoff (flow accumulation) across the Site and assessment of areas at which the accumulation of surface water is likely to be observed (according to the calculated Topographic Wetness Index across the site).
- 9.3.10 The majority of potential GWDTE vegetation communities (High and Moderate) are found to be located in connection to surface water runoff paths, drainage features or are situated on areas of surface water accumulation (underlain deeper peat and characterised by poor drainage).
- 9.3.11 The Site is not characterised by areas indicative of flush habitat and the distribution of habitats identified as potentially groundwater dependent through NVC surveying is strongly indicative of a connection between land use and potentially High GWDTE vegetation communities.
- 9.3.12 Following identification of habitats with potential to be GWDTEs from NVC mapping data, the hydrological and hydrogeological desktop study information has been used to help qualitatively determine the sensitivity of each potential GWDTE.
- 9.3.13 Where a mosaic of NVC classifications was observed, only the community occupying the largest proportion of the mosaic has been considered as representative of the potential for the mosaic to be a GWDTE. Ecological surveying has been carried out on-site, up to 250 m from the infrastructure for the Proposed Development.
- 9.3.14 The sensitivity of each GWDTE receptor has been classified in accordance with Scottish Environment Protection Agency (SEPA) guidance LUPS – GN31³. The SEPA classification is modified from the UKTAG (2008)⁴ list of NVC communities, which provides the full list for all communities. The relevant UKTAG classification is also provided.
- 9.3.15 Table 9.2.1 sets out the predominant NVC communities encountered across the Arnish Moor site and confirms those with the potential to be a GWDTE which have been assessed further (**Figure 9.2.6**). Only potential GWDTE vegetation communities identified in ecological surveying are included in Table 9.2.1. Table 9.2.2 assesses the likely degree of

² Scottish Environment Protection Agency, Land Use Planning System SEPA Guidance Note 4, Planning guidance on on-shore windfarm developments, Version 7, May 2014

³ Scottish Environment Protection Agency, 2017. Land Use Planning System SEPA Guidance Note 31, Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems

⁴ Guidance within GN31 is adapted from 'UK Technical Advisory Group list of NVC communities and associated groundwater dependency scores (2008)

dependency on the underlying groundwater body, according to site-specific ecological and hydrological conditions. For each area assessed within Table 9.2.2, justification of the assessment of potential groundwater dependency is provided.

9.3.16 Ramboll has assessed site-specific conditions in relation to potential GWDTEs considering hydrogeological assessment of groundwater dependency as presented in Table 9.2.2 and Figure 9.2.6. This assessment includes consideration of:

- The direct hydrological connectivity of a potential GWDTE to surface water sources;
- Underlying geological conditions including the productivity of bedrock and superficial geology, the presence of peat soils and permeability of upgradient geology;
- Topography and the presence of rills or runnels indicative of surface runoff;
- The presence of indicative 'flush' patterns of vegetation communities;
- Land use; and
- The relative proportion of NVC communities and the potential dominance of non-GWDTE communities within surveyed areas.

Table 9.2.1: NVC Communities Present and their Potential Groundwater Dependency, according to SEPA NVC Classification

GWDTE ID on Figure 9.2.5	UK Hab Classification	NVC Communities Present	Potential GWDTE Classification (SEPA GN 31)	Shape Area (m²)
1	f1a6 - Wetland - Blanket Bog - Degraded blanket bog	M15	Moderate	86,345
6	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	51,764
9	h1b5 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Dry heaths; lowland (H4030)	M15	Moderate	3,680
11	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	2,041
12	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	64,644
13	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	17,695
16	f1a6 - Wetland - Blanket Bog - Degraded blanket bog	M15	Moderate	1,304
26	g4 - Grassland - Modified grassland	M23	High	18,4348
28	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	40,060
32	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	23,3506
35	h1b6 - Heathland and shrub - Dwarf shrub heath - Upland Heathland - Wet heathland with cross-leaved heath; upland (H4010)	M15	Moderate	88,626

Table: 9.2.2: Groundwater Dependency, according to Site-specific Ecological Conditions

GWDTE ID on Figure 9.2.6	GWDTE Classification (SEPA GN 31)	Ramboll Groundwater Dependency Assessment	Justification	Shape Area (m²)
1	Moderate	Not GWDTE	Surface water flow paths and connection to surface water feature (northern watercourse, Creed North site) and high TWI Underlain by Low productivity aquifer	86,345
6	Moderate	Not GWDTE	Surface water flow paths and high TWI Underlain by Low productivity aquifer	51,764
9	Moderate	Not GWDTE	Surface water flow paths and connection minor unnamed tributary of southern watercourse and high TWI Underlain by Low productivity aquifer	3,680
11	Moderate	Not GWDTE	Surface water flow paths and high TWI Underlain by Low productivity aquifer	2,041
12	Moderate	Not GWDTE	Surface water flow paths and connection to surface water feature (southern watercourse) and high TWI Underlain by Low productivity aquifer	64,644
13	Moderate	Not GWDTE	Surface water flow paths and high TWI Underlain by Low productivity aquifer	17,695
16	Moderate	Not GWDTE	Surface water accumulation (offsite) Underlain by Low productivity aquifer	1,304
26	High	Not GWDTE	Area spanning drained land in agricultural use, habitat distribution not indicative of groundwater emergence and surface water accumulation demonstrated along drainage cuttings. Underlain by Low productivity aquifer	18,4348
28	Moderate	Not GWDTE	Surface water feature (northern watercourse) and high TWI Underlain by Low productivity aquifer	40,060
32	Moderate	Not GWDTE	Surface water flow paths and connection to surface water feature (southern watercourse) and high TWI Underlain by Low productivity aquifer	23,3506
35	Moderate	Not GWDTE	Areas of surface water accumulation (offsite), habitat distribution (to south of Arnish Road) not indicative of groundwater emergence Underlain by Low productivity aquifer	88,626

9.4 Groundwater Dependency

9.4.1 UKTAG guidance (2004)⁴ recognises that most "water dependent terrestrial ecosystems lie along a continuum between always only groundwater dependent and always only surface water dependent [...]. The source of water supply for some wetlands does not appear to be critical, therefore the task of identifying dependence upon groundwater is sometimes complex".

9.4.2 SNIFFER (2007) guidance⁵ states that the dependence of wetlands on groundwater bodies is a result of hydrological connectivity. The degree of dependency will vary depending on whether the wetland is underlain by a low productivity or high productivity aquifer and whether there is a hydrological linkage mechanism between groundwater and the surface wetland. Likelihood of dependency is based upon the following:

- High Likelihood: characterised by intergranular, high productivity drift aquifer and dominantly intergranular, highly productive aquifer;
- Moderate Likelihood: characterised by intergranular, moderate productivity drift aquifer and fractured, very low productivity aquifer; and
- Low Likelihood: characterised by intergranular, very low productivity drift aquifer and fractured, very low productivity aquifer.

5 SNIFFER (2007) WFD66 – Wetland Hydrogeomorphic Classification for Scotland. Edinburgh: SNIFFER.

- 9.4.3 The underlying bedrock aquifer is assessed by the BGS to be of Low productivity, with limited groundwater in the near surface weathered zone and secondary fractures. Where superficial deposits of peat are present within the Site, while these soils may have a relatively high moisture content, peat generally has low hydraulic conductivities⁶. Therefore, it is assumed that there is low likelihood of groundwater dependency for all the GWDTEs within the Site (Table 9.2.3), based on assessment of underlying hydrogeology.
- 9.4.4 The UKTAG (2004) guidance provides criteria for identification and inclusion of GWDTEs in the risk assessment process, based on complementary ecological and hydrogeological assessments. These criteria have been used to produce the following matrix (Table 9.2.3), which provides an identification of sensitive and potentially sensitive GWDTEs that require a qualitative assessment to ascertain the significance of the risks the Proposed Development poses to them.

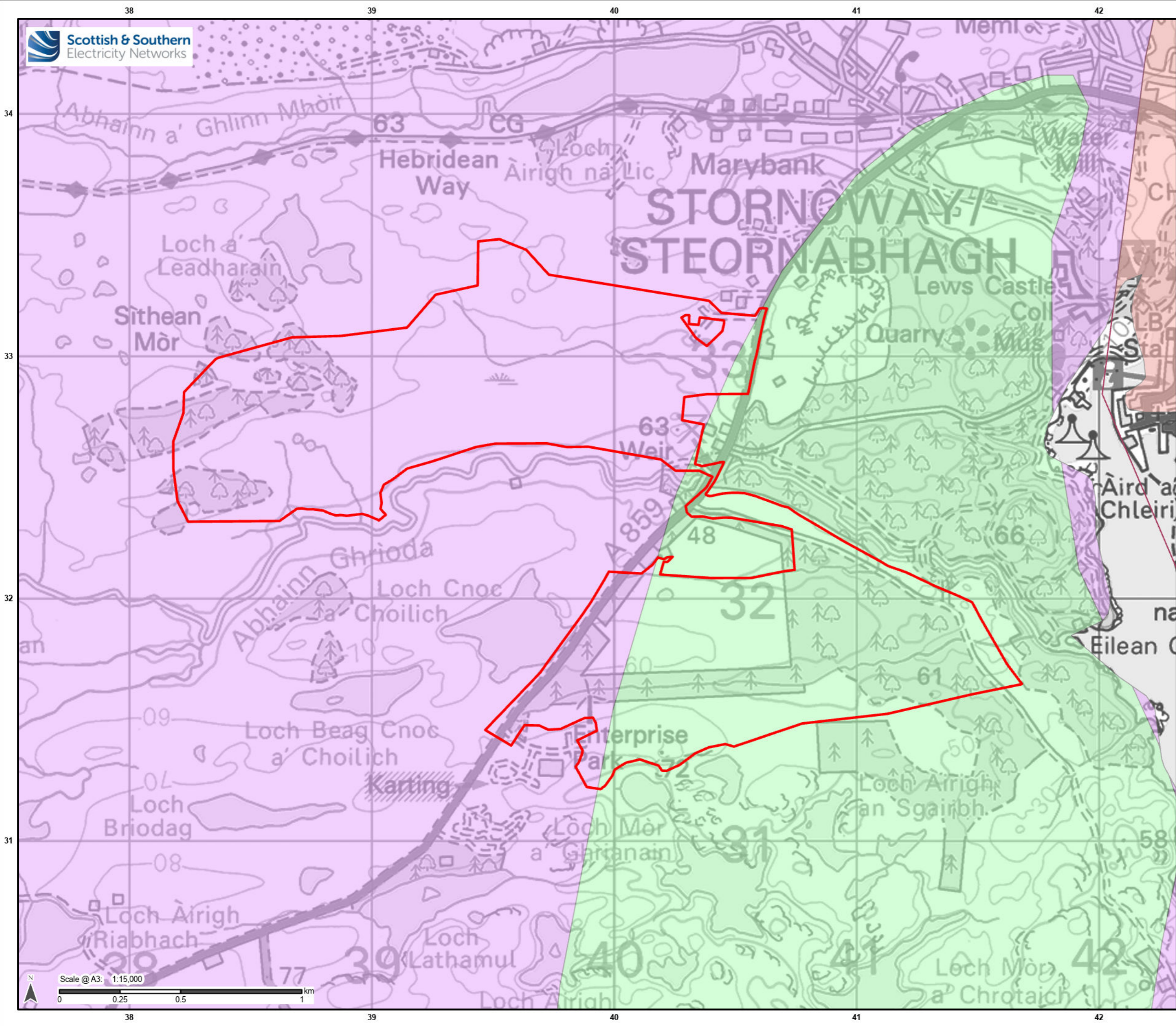
		Hydrogeological Assessment Groundwater Dependency Level		
		High Likelihood	Moderate Likelihood	Low Likelihood
Ecological Assessment of NVC Communities	Highly groundwater dependent	Sensitive GWDTE	Potentially sensitive GWDTE	Potentially sensitive GWDTE
	Moderately groundwater dependent	Potentially sensitive GWDTE	Potentially sensitive GWDTE	Not sensitive
	Not groundwater dependent	Potentially sensitive GWDTE	Not sensitive	Not sensitive

- 9.4.5 Since the likelihood of groundwater dependency is considered to be Low for all of the potential GWDTEs across the Site, in line with underlying hydrogeological conditions (as specified in SNIFFER (2007) guidance⁵), where potential GWDTE areas are identified in the site-specific assessment of NVC communities as being not groundwater dependent or of Moderate groundwater dependency, habitats are considered not sensitive (Table 9.2.1) and have therefore been excluded from further assessment.

9.5 Mitigation and Further Assessment

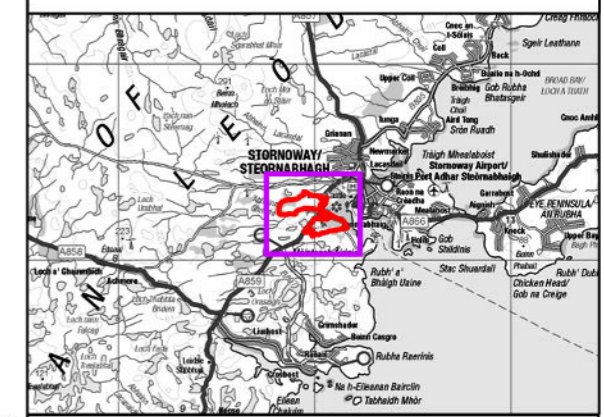
- 9.5.1 Hydrological and hydrogeological assessment shows that habitats identified through NVC surveying are situated on areas assessed not to be GWDTE. As such, specific mitigation with respect to groundwater supplies are not considered to be applicable.
- 9.5.2 It is considered that the maintenance of quality and quantity in surface water distribution across habitats will be important, particularly on areas of bog and peatland habitats. Suitable drainage and surface water measures would be used to maintain hydrological connectivity in peatland and wetland habitats and prevent deleterious impacts on surface water distribution, which would be addressed in a CEMP for the Site to be developed by the contractor. Mitigation measures would include the following:
- Avoidance of direct impacts by construction activity in such areas;
 - Implementation of Sustainable Drainage System (SuDS) measures to maintain quality of water supply;
 - Maintenance of flow paths/ redistribution of water where diverted; and
 - Implementation of pollution control measures.

⁶ Labadz Et. al (2010) Peatland Hydrology, Draft Scientific Review.



Legend

- Site Boundary
- Bedrock Geology
- Geologic Groups**
- FAULT ZONE ROCKS, UNASSIGNED - MYLONITIC-ROCK AND FAULT-BRECCIA
- LEWISIAN COMPLEX - GNEISS
- NEW RED SANDSTONE SUPERGROUP - SANDSTONE, BRECCIA AND CONGLOMERATE
- Bedrock Geology Faultlines



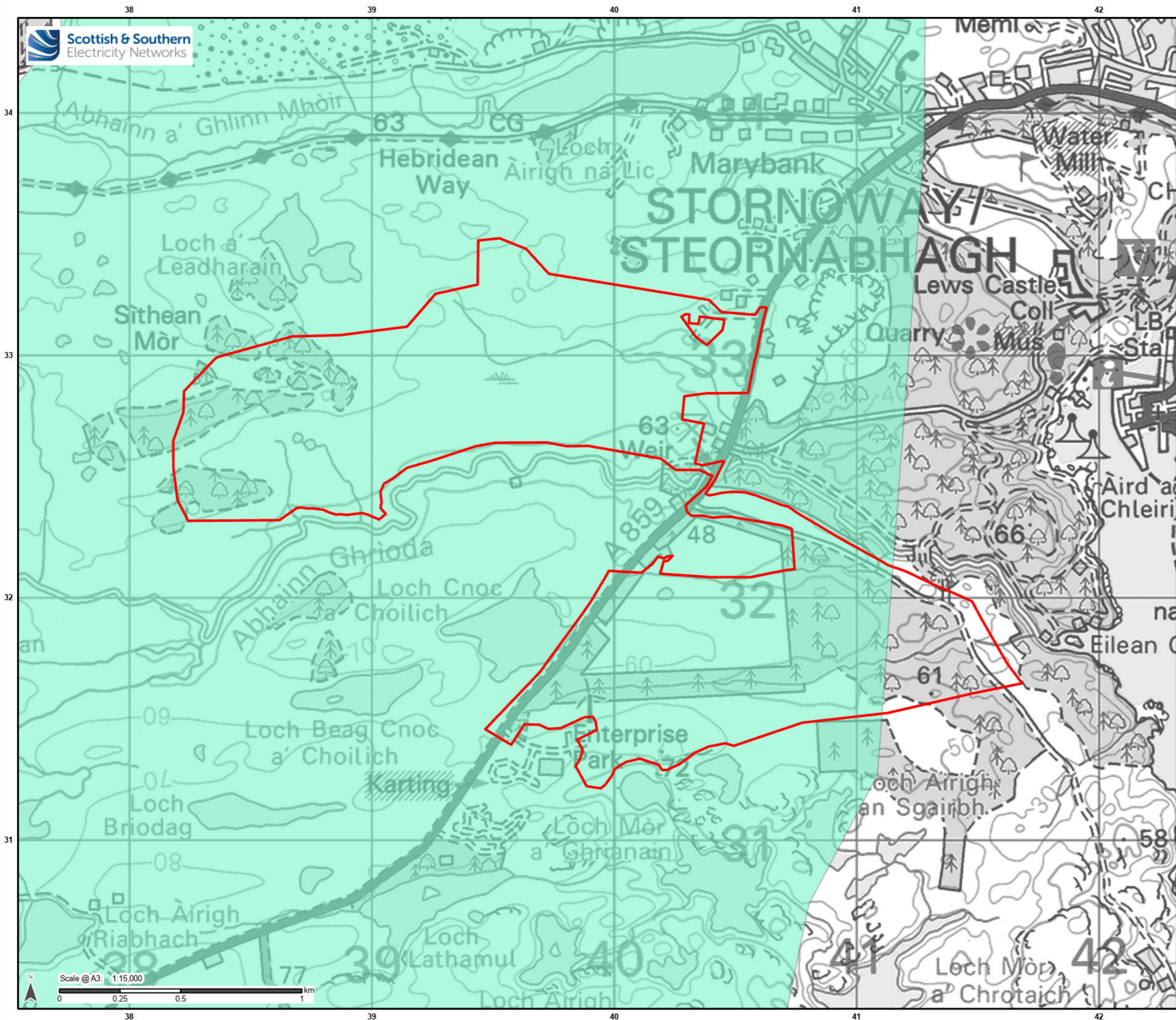
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Project No: LT000014
Project: Lewis Hub (AC Substation and HVDC Converter Station)

Title:
Figure 9.2.1: BGS
1-625,000 Bedrock Geology

Drawn by: JZ Date: 1/29/2025

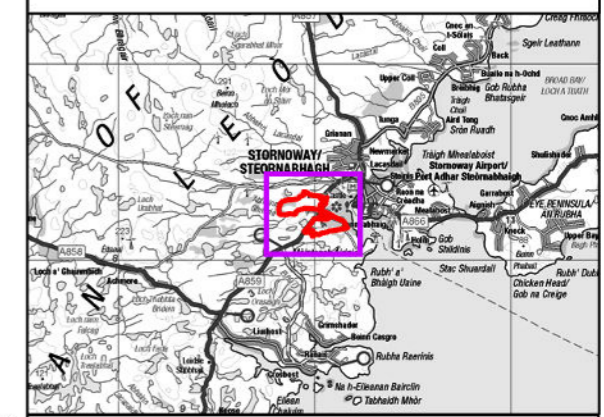
Drawing: 1620015322-RAM-MA-IA-0000X_Fig9.2.1BGS 1-625,000 Bedrock Geology



Legend

- Site Boundary
- Superficial Geology
- Geologic Groups**
- PEAT

Note - BGS Mapping States that superficial geology is unmapped in the east of the site. Details of peat depth mapping across the full extent of the site are provided in Technical Appendix 10.2 Outline Peat Management Plan.



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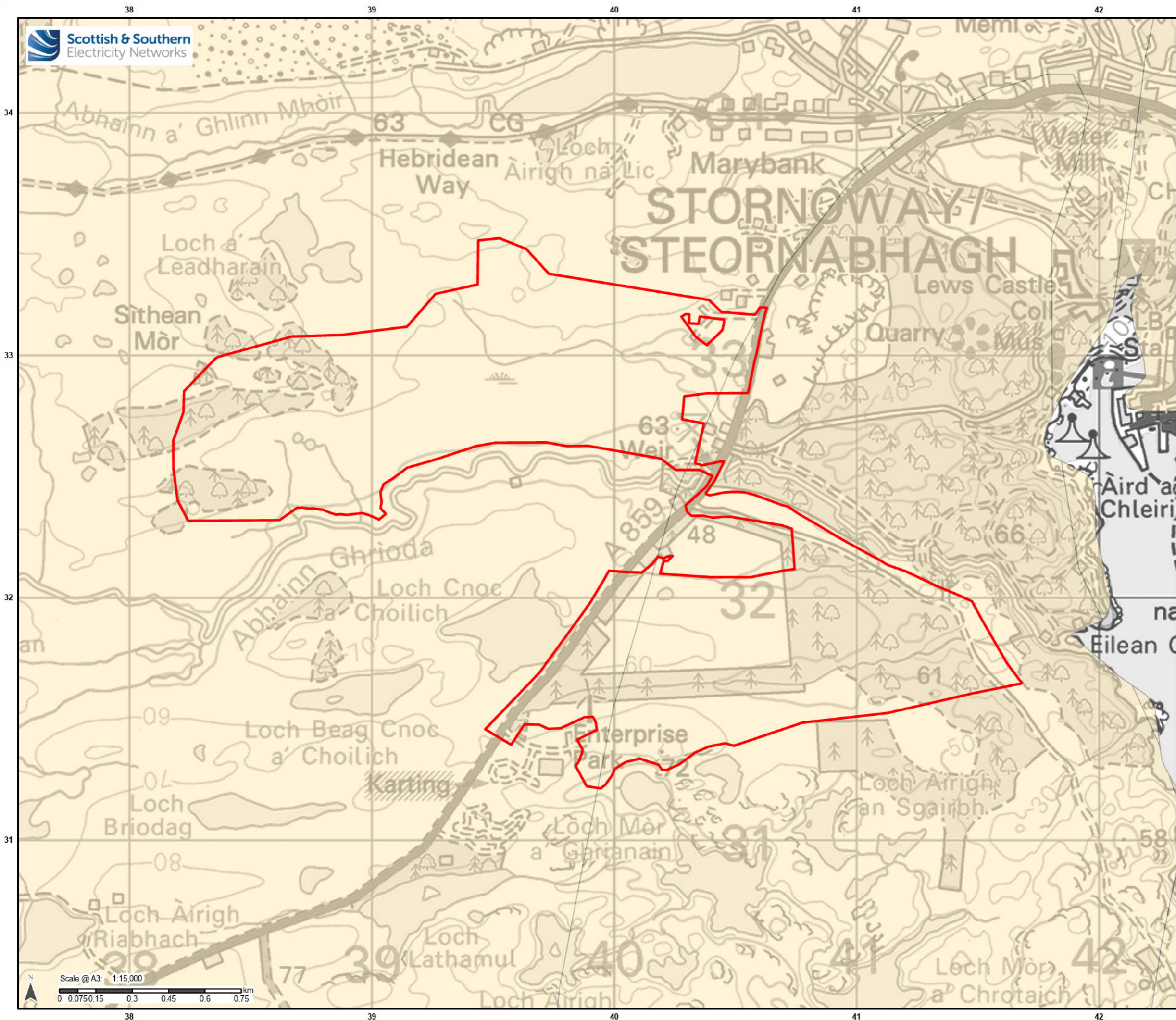
Project No: LT000014
Project: Lewis Hub (AC Substation and HVDC Converter Station)

Title:
Figure 9.2.2: BGS 1-625,000 Superficial Geology

Drawn by: JZ Date: 1/29/2025

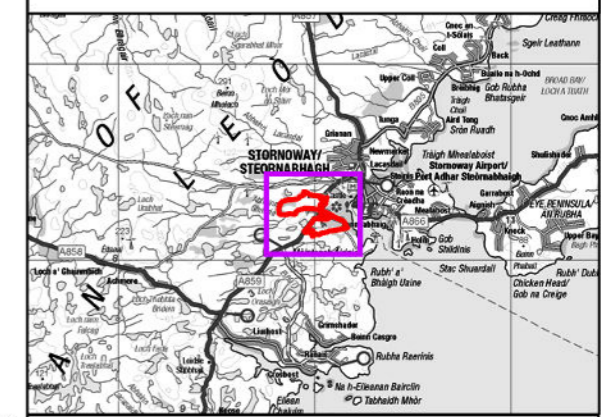
Drawing: 1620015322-RAM-MA-IA-0000X_Fig9.2.2BGS 1-625,000 Superficial Geology





Legend

- Site Boundary
- Hydrogeology
- CHARACTER**
- Low Productivity Aquifer



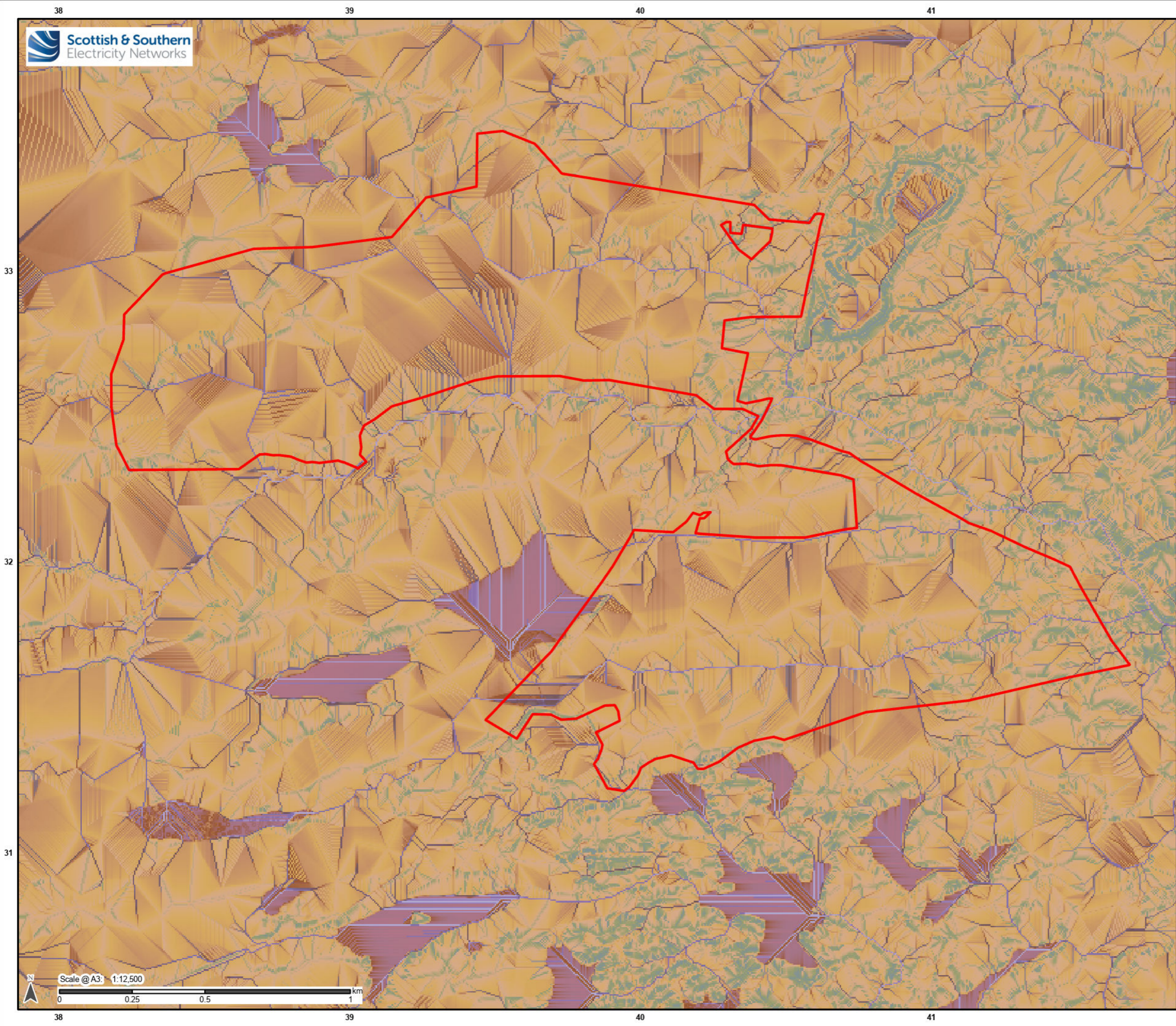
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Title:
Figure 9.2.3: BGS
1-625,000 Hydrogeology

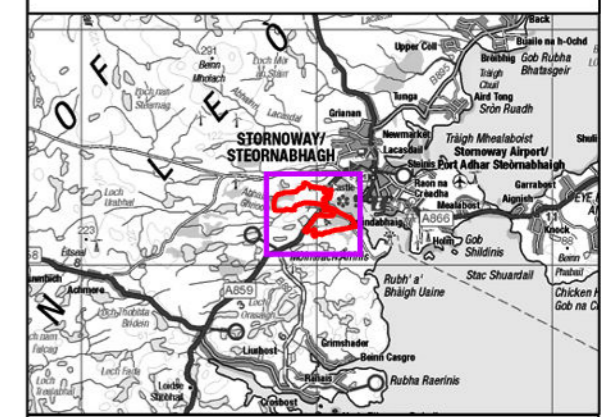
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Drawing: 1620015322-RAM-MA-IA-0000X_Fig9.2.3BGS 1-625,000 Hydrogeology



Legend

- Site Boundary
- Flow Accumulation Pathways
- Cumulative Flow**
- <500 m²
- >500 m²
- Topographic Wetness Index
- Wetness**
- 25.67
- 3.4



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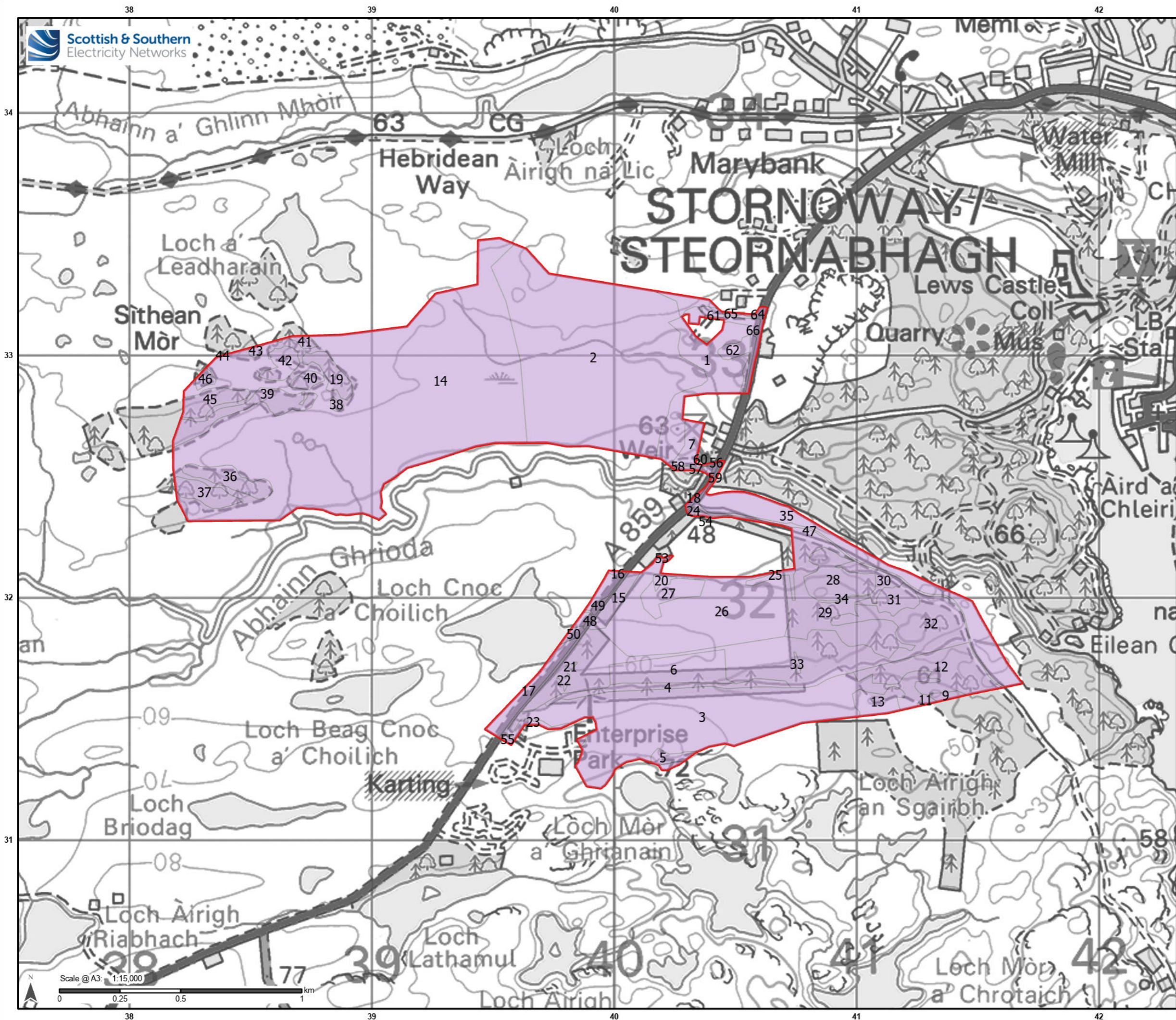
Project No: LT000014
Project: Lewis Hub (AC Substation and HVDC Converter Station)

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Figure 9.2.5:
Surface Water Accumulation and Topographic Wetness Index

Drawn by: JZ Date: 1/27/2025

Drawing: 1620015322-RAM-IA-0000X_Fig9.2.5SWAccumulationTopoWetnessIndex

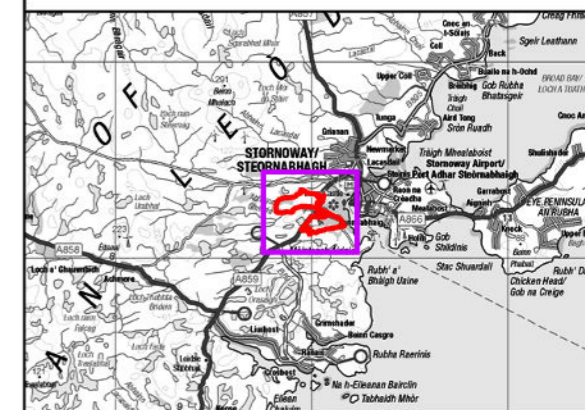




Legend

- Site Boundary
- Ramboll GWDTE Designations
- Not GWDTE

Note - Polygon Reference Number refers to assessment provided in Tables 9.2.1 and 9.2.2.



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Title:
Figure 9.2.7:
Ramboll GWDTE Assessment

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Drawing: 1620015322-RAM-MA-IA-0000X_Fig9.2.7Ramboll GWDTE Assessment

