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Technical Appendix 10.6: Groundwater Dependent Terrestrial Ecosystems (GWDTE) Assessment

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Making Sustainability Happen

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1.0 Introduction

SLR Consulting Ltd (SLR) was commissioned by Windburn Wind Farm Limited to conduct an assessment of potential areas of Groundwater Dependent Terrestrial Ecosystems (GWDTE) to inform the design of the proposed development.

A National Vegetation Classification (NVC) habitat mapping exercise has been conducted as part of the ecology baseline assessment, and this has been used to identify potential areas of GWDTE within the site. The methodology and results of the NVC habitat mapping exercise are discussed in detail within **Chapter 8: Ecology** of the EIA Report.

Areas of potential GWDTE are shown on Figure 10.8.

This Technical Appendix should be read in conjunction with **Chapter 10** of the EIA Report which contains a detailed description of the local hydrology and hydrogeology, flow mechanisms and hydraulic properties of the soils and geology, the embedded mitigation incorporated in the development design, and an assessment of impacts on groundwater and surface water flows and quality.

1.1 Assessment Methodology and Report Structure

As required by Scottish Environment Protection Agency (SEPA) GWDTE guidance¹ the assessment has been undertaken by suitably qualified and experienced specialists.

The assessment is cognisant of SEPA's expectations for the assessment of impact of developments on GWDTE as detailed in their guidance which applies to all developments requiring an Environmental Impact Assessment (EIA) provided any temporary or permanent dewatering abstractions are unlikely to exceed 10 m³/day.

SEPA recommends adopting a phased approach to the assessment of risks to GWDTE, with greater detail being required for higher risk sites or activities, and identify the steps given in **Table 1-1**.

Step	Description
1	Identify any GWDTE features
	The relevant buffer zones for GWDTE for all proposed infrastructure (provided expected dewatering rates do not exceed 10m ³ /day) are:
	a) 10m radius of all activities;
	b) 100m radius of all subsurface activities less than 1m in depth;
	c) 250m of all subsurface activities deeper than 1m.
	Habitat survey screening for potential GWDTE:
	Ecological survey(s) are required to identify whether any GWDTE are present within the above buffer zones.
	A Phase 1 habitat survey should be provided unless the developer is already aware that GWDTE are likely to be present. The guidance 'SNIFFER (2009) WFD95 – A Functional Wetland Typology for Scotland' may be used to identify wetland types, both within and outwith the site boundary, within the relevant buffer zones as a minimum (for the purpose of micro-siting a wider expanse may be surveyed).

Table	1-1:	SEPA	Methodology	– GWDTE	Assessment	Steps
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¹ SEPA (2024) Guidance on Assessing the Impacts of Developments on Groundwater Dependent Terrestrial Ecosystems

Step	Description
	If Phase 1 habitat survey results indicate that there may be relevant habitats present, a National Vegetation Classification (NVC) survey should be provided. A list of NVC communities that may be dependent on groundwater is included in Appendix B of SEPA's guidance. Wetlands containing these communities should be considered to be GWDTE unless further information can be provided to demonstrate this is not the case.
	Developers can choose to undertake the NVC survey without a Phase 1 habitat survey should they consider it likely that GWDTE are present within the buffer zones.
	Assessing groundwater dependency:
	Assessment is required to determine whether the potential GWDTE features identified are likely to be dependent on groundwater, either year around or seasonally.
	The interpretation should consider both ecology and hydrogeology. Groundwater dependency should be assessed on a site-specific basis for each potential GWDTE feature identified. Relevant factors include botanical communities present, local ground conditions, topography, and surface drainage. The interpretation should include assessment of the likely rooting depths relative to the water table, including potential seasonal variations.
	Features that are indicative of groundwater dependency include:
	 habitats associated with springs;
	 where soils are persistently waterlogged on otherwise well drained steep to moderate slopes, in the absence of surface water sources;
	 upper edge of GWDTE is aligned with concave breaks in slope;
	 diffuse groundwater emergence is often focused along linear geological features (fractures, faults etc);
	 persistent flow even during dry weather;
	 limited variation in temperature; and
	may be base enriched.
	If no potential GWDTE features are present in the area of interest, no further risk assessment is required. Otherwise, proceed to Step 2.
2	Qualitative Impact Assessment
	A conceptual site model (CSM) should be provided as part of the Environmental Statement. This should include interpretation of the hydrogeological setting, including the groundwater flow regime, and the ecological features present. This may be supported, as appropriate, by intrusive ground investigation, groundwater monitoring, or groundwater modelling in addition to topography, properties of the emergent water and the soil, and underlying geology.
	Qualitative assessment of the potential impacts to any GWDTE features identified within the relevant buffer zones is required. This should consider the expected extent, magnitude, likelihood, and duration, frequency and reversibility of any potential impacts.
	The impact assessment should consider the impacts to each GWDTE feature individually, including any potential cumulative effects if the GWDTE feature is in close proximity to multiple parts of the proposed development.
	An iterative approach is recommended, using the impact assessment findings to inform the design process. Consider modifying the development proposals to avoid potential impacts as far as possible (i.e. by moving proposed activities outwith the relevant buffer zones).
	If the potential impacts to GWDTE are Low or Unimportant, then no further risk assessment is required. Otherwise, proceed to Step 3.
3	Detailed Quantitative Risk Assessment
-	This is expected to be supported by appropriate characterisation of the ground conditions at both the relevant infrastructure location(s) and the GWDTE(s), plus the pathway(s) in

Step	Description
	between if appropriate. This will require ground investigation, including groundwater level and quality monitoring.
	The hydrogeological assessment should quantify the potential change(s) in groundwater levels or flow regime, and/or groundwater quality. The modelling approach, input parameters and assumptions should be justified. The hydrogeological modelling predictions should inform the assessment of the ecological risks to the GWDTE.
	If the quantitative risk assessment confirms the potential impacts are Major or Medium, then provide details of the site-specific mitigation measures proposed to avoid or offset the potential impacts. The nature of the mitigation measures required will depend on both the development and the GWDTE. Consultation with SEPA, and other relevant stakeholders as appropriate (e.g. NatureScot), may be beneficial when developing site- specific mitigation measures.
	Then refine the quantitative risk assessment to confirm whether any residual impacts to GWDTE remain once the proposed mitigation measures are in place.
	If the assessment proceeded to Step 3, then monitoring is required to demonstrate the effectiveness of the proposed site-specific mitigation measures developed during Step 3.

The areas of potential GWDTE, as identified in the NVC survey, and an assessment on their potential groundwater dependency is presented in Section 2 of this report, in accordance with Step 1 of the SEPA guidance. Where potential GWDTE are considered to be groundwater dependent, a qualitative risk assessment has been completed and is presented within Section 3 of this report (Step 2 of the SEPA guidance).

2.0 Groundwater Dependent Terrestrial Ecosystem Assessment (Step 1)

2.1 Site Setting

The proposed development is situated within the Ochil Hills, approximately 2.9km north of Alva, Clackmannanshire. Ground elevations across the site range from approximately 142m Above Ordnance Survey (AOD) within the northern extent of the site, near the access from the A9, to approximately 677m AOD near the summit of Ben Buck within the south eastern extent of the site.

As discussed in **Chapter 10** of the EIA Report the following conceptual hydrological site model has been developed for the study area:

- the proposed development is in an area that receives frequent rainfall and has a high annual rainfall total;
- the superficial deposits within the site generally comprise of peat and glacial till, whereas to the northern extent of the site, the hill tops locally and some of slopes near watercourses are shown to be absent of any superficial deposits;
- the majority of the site, including the turbine area, is underlain by igneous rocks of the Ochil Volcanic Formation whilst the northern extent of the site, near the existing access from the A9, is underlain by sandstones of the Sherrifmuir Formation;
- several inferred faults are recorded by the British Geological Survey across the site;
- the aquifer productivity and groundwater vulnerability datasets (**Figure 10.7** of the EIA Report) confirms that the peat and glacial till superficial deposits at the site are not considered a significant aquifer;
- regional hydrogeological mapping and aquifer productivity mapping confirm that the igneous rocks beneath are classified as a low productivity aquifer which are generally without groundwater except in the near surface weathered zone and secondary fractures; and
- the Sherrifmuir Formation sandstones beneath the northern extent of the site and the igneous volcaniclastic sediments beneath part of the eastern extent of the site, near the River Devon, are classified as a moderately productivity aquifer which may yield moderate amounts of groundwater.

As a consequence of these characteristics groundwater recharge at and surrounding the site is limited by the following factors:

- steeper topographic gradients will result in rainfall forming surface water runoff; and
- the peat, glacial till and igneous deposits inhibit infiltration owing to their generally low bulk permeability.

SEPA do not maintain any groundwater level monitoring locations within the study area. In the absence of published information or data held by SEPA, it is anticipated that limited groundwater will be present as perched groundwater within the more permeable horizons of the glacial till deposits, in the upper weathered surface of the igneous rocks, and at a deeper depth within the sandstones of the Sherrifmuir sandstones. Secondary permeability may be evident where there are faults and fractures in the bedrock and which may exert local control on groundwater flow direction.

Groundwater flow regionally is expected to follow topography and in the north of the site be northwards toward the Allan Water, and in the south of the site southwards to the River Devon.

In the north of the site local variation of groundwater flow direction may occur where there are groundwater abstractions maintained by Highland Spring and given the common absence of superficial cover in watercourse corridors there is potential for hydraulic connectivity between surface water and groundwater.

2.2 NVC Mapping

The methodology used to undertake and results of the NVC habitat mapping exercise are discussed in detail within **Chapter 8** of the EIA Report.

The NVC survey was undertaken in accordance with industry standard methodologies and guidelines, during which NVC communities were mapped in the field by applying polygons around visible boundaries of homogeneous vegetation or mosaic and /or transitional communities. Where readily identifiable, stands were classified and mapped at sub-community level.

Target notes were taken to record habitats and any specific features too small to map.

2.3 Occurrence of Potential GWDTE

Areas of potential GWDTE have been identified using the NVC communities which are cited in the SEPA guidance (see Annex B thereof) and are shown on **Figure 10.8**.

The location of potential GWDTE and a discussion on their likely dependency on groundwater is discussed in **Table 2-1**.

NVC Community	Distribution within the Study Area and Likely Groundwater Dependency
M4	M4 polygons are noted within the eastern extent of the site and are shown to be underlain by low permeability peat and glacial till deposits and sloped ground near existing watercourses. It is therefore considered that the habitat is sustained by high rainfall, surface water runoff and waterlogging of soils above the low permeability deposits rather than groundwater. In addition, no development is proposed upgradient of the habitats and therefore it is considered that the water which sustains the M4 habitats will not be impaired by the proposed development. Therefore, no further assessment is required.
M6	M6 dominant polygons within the site are generally noted within the watercourse corridors. M6 is also noted as part of mosaic habitats within the centre of the site which has been confirmed to be underlain by low permeability peat deposits. This distribution is not typical of that attributable to a dominant groundwater discharge but rather by rainfall and surface water and waterlogging of soils above the low permeability deposits or adjacent to the watercourses.
	recorded within the NVC survey. These are discussed further in Section 3.
M15	M15 dominant polygons and mosaics which contain M15 habitat are located within the north western extent of the site and are shown to be underlain by sandstone bedrock which allows groundwater storage and movement. It is noted that M15 habitats are common and are regionally present across wide areas of Scotland. The only development within 250m of the polygons comprises widening of the existing road from the A9 and the proposed access track to the turbine area from near Carim Cottage.

Table 2-1: Stage 1 GWDTE Assessment

NVC Community	Distribution within the Study Area and Likely Groundwater Dependency
	The majority of the polygons are shown to be west of the Carim Burn, on the opposite side of the watercourse to the proposed development. The Carim Burn will act as a hydraulic barrier to any potential groundwater originating within the site which may sustain these habitats and therefore any groundwater which supports these habitats will be not impacted by the proposed development. No further assessment is therefore required.
	The remainder of the polygons are shown as linear features along the existing access track or in areas where existing surface water flow paths were noted on site. Given this distribution it is considered that these habitats are sustained by high rainfall and surface water runoff rather than groundwater. No further assessment is required.
M23	M23 dominant polygons and mosaics which contain M23 are noted across the site and are generally underlain by low permeability peat and glacial till deposits or within existing watercourses corridors or surface water flow paths recorded across the site. Little groundwater is present in the peat and glacial till deposits by virtue of their low bulk permeability. The distribution of M23 recorded on site is not typical of that attributable to a dominant groundwater discharge but rather by rainfall and surface water and waterlogging of soils above the low permeability deposits or adjacent to the watercourses. It is not considered groundwater dependent.
M32	M32 habitats are considered flush features which are at least partially dependent on groundwater or base rich and/or calcareous waters. No M32 dominant or mosaic polygons are recorded within the NVC survey area however several M32 target notes are recorded. Those within 250m of the proposed development are discussed further in Section 3.
MG9	MG9 polygons are noted within the centre of the site. The habitats are generally noted within watercourse corridors and where existing surface water flow paths are witnessed. It is therefore considered that this habitat is sustained by high rainfall, surface water runoff and waterlogging of soils near watercourses rather than groundwater. Therefore, no further assessment is required.
MG10	MG10 polygons are noted within the centre and northern extent of the site. The habitats are generally noted within the watercourse corridors and where existing surface water flow paths are evident. It is therefore considered that the habitat is sustained by high rainfall, surface water runoff and waterlogging of soils near watercourses rather than groundwater. Therefore, no further assessment is required.
U6	U6 habitats are located within the southern extent of the site and are confirmed to be underlain by low permeability peat and glacial till deposits. It is therefore assessed that the U6 habitats are sustained by high rainfall, surface water runoff and waterlogging of soils within the low permeability deposits rather than emerging groundwater. No further assessment is required.
U16	No U16 dominant or mosaic polygons are recorded within the NVC survey area however two U16 target notes (TN2 and TN29) are recorded within 250m of the proposed development, both of which are located within the watercourse channel of the Finglen Burn and tributaries of the East Cameron Burn. These target notes are sustained by surface water rather than groundwater and therefore not assessed further.

With the exception of the M6 and M32 habitat and flush target notes, **Table 2-1** shows that the areas of potential GWDTE are generally located on ground adjacent to watercourses or within existing overland surface water (pluvial) flow paths and underlain by either low permeability peat and bedrock deposits or alluvium deposits which are hydraulically

connected to the adjacent surface watercourses. This distribution is not typical of that which is sustained by emerging groundwater, such as springs or seepage lines, or associated with breaks of slopes or changing topography or geology, but rather is likely to be supported by rainfall, surface water ponding and water logging of soils adjacent to watercourses or above the low permeability deposits.

It is therefore considered that the majority of potential GWDTE habitat is not sustained by groundwater. However, safeguards to maintain these habitats, and sustain the surface water flows to them and preserve water quality to these habitats, will need to be implemented during construction and operation of the proposed development, details of which are included **Chapter 10** of the EIA Report. These habitats are not considered further in this assessment, in accordance with Step 1 of SEPA's guidance.

Further assessment of the M6 and M32 habitat and flush target notes which are considered groundwater dependent is undertaken in accordance with Step 2 of the SEPA's guidance in Section 3 of this report.

3.0 Qualitative Risk Assessment (Step 2)

This Section of the report provides further assessment of the M6, M32 and flush target notes recorded within the NVC survey.

3.1 Committed Mitigation

Chapter 10 of the EIA Report details the mitigation measures that would be deployed and used to safeguard the water environment and areas of GWDTE. Of relevance to this report and assessment are the following:

- the production of a final Construction and Environmental Management Plan (CEMP) which would be agreed with statutory consultees prior to commencement of any works which will include a site-specific drainage plan and pollution prevention plan;
- the adoption of good practice measures and drainage measures to safeguard existing surface water flow paths, shallow groundwater flow and maintain existing water quality; and
- the deployment of an Environmental Clerk of Works (EnvCoW) to oversee all works and with the authority to cease works should a risk to the water environment (e.g. change in water flow or quality) become apparent.

3.2 Assessment of M6, M32 and Flush Target Notes

As discussed in **Table 2-1**, further assessment of M6, M32 and flush target notes has been undertaken in accordance with Step 2 of SEPA's guidance. The location of the target notes within 250m of the proposed development are shown on **Plate 1** and are discussed in **Table 3-1**.



Plate 1: Location of Target Notes

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required in accordance with SEPA guidance. No additional mitigation required over and above that specified in **Chapter 10** of the EIA Report and confirmed above is required.









<u>Assessment</u>: TN10 and TN11 are located approximately 240m and 230m south west of proposed turbine T2 hardstanding respectively. The target notes are shown to be underlain by low permeability igneous bedrock.

There is potential for shallow groundwater within the upper weathered surface of the bedrock, however, no development is proposed upgradient of the target notes and therefore it is considered that the water which sustains the target notes will not be impaired by the proposed development.



<u>Assessment</u>: TN12 is located approximately 90m west of a proposed access track and 140m north west of the proposed turbine T3 hardstanding. The target note is shown to be underlain by low permeability peat deposits. No groundwater flush or seepage was observed at this location during the site survey, however waterlogged soils were recorded. It is therefore considered that the habitat is sustained by surface water runoff and waterlogging of soils above the low permeability peat deposits.



<u>Assessment</u>: TN13 is located approximately 90m south west of the proposed access track and 50m north east of the proposed turbine T1 hardstanding. The target note is shown to be underlain by low permeability peat deposits. There is no change in topography / break of slope nor change in bedrock geology associated with the target note location. No groundwater flush or seepage was observed at this location during the site survey. It is therefore considered that the habitat is sustained by surface water runoff and waterlogging of soils above the low permeability peat deposits.



<u>Assessment</u>: TN44 is located approximately 180m south east of the proposed turbine T11 hardstanding and is shown to be located at the top of a slope, underlain by peat and not associated with any geological boundary or discontinuity. It lies upstream of the turbine and locally in a different surface water catchment.



Assessment: IN22 is located approximately 200m east of the proposed access track and is shown to be underlain near the boundary between peat and glacial till deposits, both of which are contain little groundwater. No development is proposed upgradient of the target note and therefore it is therefore considered at risk. The target note is located at a higher elevation than the proposed development.



<u>Assessment</u>: TN43 is located approximately 140m south east of the proposed access track whilst TN46 is located approximately 190m south east of the proposed access track and 150m north east of the proposed turbine T3 hardstanding.

The target notes are shown to be underlain by low permeability peat and glacial till deposits. No bedrock geological discontinuity is recorded at the target note locations. No groundwater flush or seepage was observed at these locations during the site survey. It is therefore considered that the habitat is sustained by surface water runoff and waterlogging of soils above the low permeability deposits. In addition, no development is proposed upgradient of the target notes and therefore it is considered that the water which sustains the target note will not be impacted by the proposed development.

Conclusion:

Potential impact to GWDTE is assessed as Low and therefore no further risk assessment is required in accordance with SEPA guidance.



underlain by peat. No groundwater seepage was observed at this location during the site survey. TN44 is not located at a break of slope or at a geological boundary which are commonly associated with emergent groundwater conditions. It is therefore considered that the habitat is sustained by surface water runoff and waterlogging of soils above the low permeability peat deposits. Provision has been made in the EIA Report to maintain existing surface water flow paths.



<u>Assessment</u>: TN45 is located approximately 40m south west of proposed turbine T12 hardstanding and is shown to be underlain by low permeability glacial till. No change in bedrock geology is recorded at the target note location. It does not lie downstream of the turbine and therefore any temporary dewatering of the low permeability geology at this location will not impair the habitat at the target note.

The access track to turbine T12 passes west of the target note and upstream of it. Committed best practice measures will be required to maintain surface water flow paths across the track to sustain the habitat.

Review of **Table 3-1** indicates that in all instances potential impacts to GWDTE habitats are considered Low and the committed best practice specified in the EIA Report will safeguard these habitats as they are sustained predominantly by surface water (pluvial) water flows.

A shallow groundwater flow contribution to target note TN4 has been confirmed. Measures to maintain existing water flow paths to this target note and habitat have been specified, and with their adoption the impact on the GWDTE habitat is assessed as Low.

It is noted that no permanent dewatering or groundwater management is required for any part of the proposed development and therefore no permanent change to groundwater levels and flow direction will occur. Any existing groundwater contribution to habitats will therefore continue.

4.0 Summary and Conclusions

Review of **Figure 10.8** and **Table 2-1** confirms that the majority of potential GWDTE habitat record at site is underlain by low permeability superficial deposits or in/adjacent to watercourse corridors. This distribution is not consistent with habitats sustained by groundwater but rather habitats predominantly sustained by rainfall, surface water runoff and waterlogging of soils near the watercourses and within the low permeability deposits.

It is concluded therefore that buffers to these areas of potential GWDTE specified in SEPA guidance need not apply in these instances, but safeguards will be required during construction to maintain existing surface water flow paths to these habitats.

A number of potential flush habitats identified by target notes in the NVC survey have been subject to more detailed assessed as specified by Step 2 of SEPA's GWDTE assessment guidance.

It has been shown that with the exception of target note TN4, all the target notes are sustained by surface water and pluvial (surface) flow paths. Mitigation measures required to safeguard the flow and quality of water to target note TN4, have been specified.

The assessment concludes the impact to GWDTE habitat as a consequence of the proposed development is low.

No permanent dewatering or groundwater management is required as part of the proposed development and therefore no permanent change to groundwater levels and flow direction will occur. Any existing groundwater contribution to habitats will therefore continue.

Examples of proposed safeguards which will be used to maintain existing surface water flow paths and maintain existing water quality are provided in **Chapter 10** of the EIA Report. A commitment has been made to include these in the final CEMP, which also includes the provision of an EnvCoW to supervise construction works with the authority to ensure that suitable cross drainage measures are implemented during the construction phase of the project. With these measures, no significant effect on identified flush habitats is anticipated.



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