Appendix 8.6: Groundwater Dependent Terrestrial Ecosystem Assessment

EDF Energy Renewables Ltd

Dunside Wind Farm

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1 Introduction

Groundwater Dependent Terrestrial Ecosystems (GWDTEs) are types of wetlands that are specifically protected under the Water Framework Directive. GWDTEs should be considered in terms of their hydrology and their ecology. This Appendix has been provided to 'bridge the gap' between the two disciplines of Ecology and Hydrology by providing information from both disciplines to complete the assessment of potential effects of the proposed Dunside Wind Farm (hereafter referred to as the Proposed Development) on GWDTEs.

This Appendix should be read in conjunction with Chapter 8: Hydrology, Hydrogeology and Geology (including Peat), Chapter 6: Ecology and Appendix 6.2: Habitats and Vegetation (including National Vegetation Classification) Survey Report of the EIA Report. The assessment draws together detailed information from both chapters, summarising where applicable.

The Scottish Environmental Protection Agency (SEPA) has produced detailed guidance[1] on how to assess impacts of proposed development on GWDTEs and the following assessment is based on the SEPA guidance.

[1] SEPA (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.

2 Identification of GWDTE

The following is an excerpt from the EU GWDTE Technical Report[2] which defines a GWDTE in the context of the Water Framework Directive:

'*In order for terrestrial ecosystems to be considered as part of the classification for groundwater bodies (GWBs), they need to be 'directly dependent' on the groundwater body (GWB). This means that the GWB should provide quantity (flow, level) or quality of water needed to sustain the ecosystems which are the reasons for the significance of the GWDTE. This critical dependence upon a GWB is most likely where groundwater supplies the GWDTE for a significant part or a significant time period of the year*.'

Therefore, for a habitat to be designated as a GWDTE, there must be significant hydrogeologic connectivity between the groundwater body and the habitat.

Potential GWDTEs were initially identified during Phase 1 habitat and National Vegetation Classification (NVC) surveys (see below). Potential GWDTEs were then visited by hydrologists to characterise the hydrogeological connectivity of each habitat unit and to determine the level of groundwater dependency. The results of the GWDTE assessment are described below.

2.1 Habitat and Vegetation Surveys

Phase 1 habitat and NVC surveys were undertaken between June and September 2022. The survey extent and results are described in Appendix 6.2. Where Phase 1 habitat types had potential to support GWDTE vegetation communities1, further investigation was undertaken. Phase 1 habitat types that have potential to support GWDTE communities include:

- B5 Marshy Grassland;
- D2 Wet dwarf shrub heath
- E2.1 Acid Flush;
- E2.3 Bryophyte-dominated spring

Where appropriate, within habitats coded as above, the NVC method[3] was used to identify potential GWDTE communities. However, to avoid unnecessary extensive botanical study, where Phase 1 habitat types were obviously attributable to surface water movement, rather than groundwater movement, no NVC was completed. This included stands of marshy grassland in hollows on steep slopes, obviously ombrogenous bogs etc.

However, where water influence was less clear, NVC was completed. As above, NVC data was also considered in light of wider influencing factors. Upon determining the NVC community, a decision tool was used to establish the level of dependency of each community on groundwater. **Table 1** below shows the decision-making tool used in determining GWDTE presence.

Table 1: GWDTE Decision Tool[4]

Criteria	Yes	No
A. Is the GWDTE vegetation evidently influenced by groundwater? (i.e. base-enriched (M10, M11, M37 and/or M38) and/or discharging from an evident point source such as a spring head (M31, M32, M33).		

[2] European Commission, Directorate-General for Environment, Technical report on groundwater dependent terrestrial ecosystems . Technical report. No 6, Publications Office, 2012, https://data.europa.eu/doi/10.2779/93018

[3] Rodwell, J.S. 1991-2000. British plant communities. 5 Volumes. Cambridge University Press

[4] Botanaeco (2018) GWDTE Decision Tool. Available at: https://botanaeco.co.uk/gwdte [Accessed May 2023]

Criteria	Yes	No
If the answer to A is 'Yes' then field assessment ends at this stage and the GWDTE is treated as 'high', as per the guidance. If 'No', continue to B.		
B. Is the GWDTE polygon associated with an evident surface water feature? i.e. is the vegetation located within one of the following topographic locations:		
Watershed/ridge		
Watercourse		
Floodplain		
Ponding location, pond, loch, etc (localised depression)		
Surface water conveyance (drain, gully, rill, etc.)		
If the answer to B is 'Yes' then the GWDTE polygon is no more than 'moderate' and very likely to be 'low'. Additional floristic and environmental data should be collected, including photographs to allow for further, desk-based determination of the groundwater dependency. If 'No', continue to C.		
C. Is the GWDTE polygon associated with an ombrogenous system? i.e. with blanket bog or wet heath habitat. This is especially relevant to M6 and M25:		
Presence/persistence of distinctive bog habitat, species and/or associations.		
Deep peat not confined to depressions/valleys (>0.5 m visible in drains or hagged areas).		
If the answer to C is 'Yes' then the GWDTE is no more than 'moderate' and very likely to be 'low'. Additional floristic and environmental data should be collected, including photographs to allow for further, desk-based determination of the groundwater dependency.		

2.2 GWDTE Baseline

Chapter 6: Ecology and **Appendix 6.2: Habitats & National Vegetation Classification Report and Figures 6.3, 6.4 and 6.5** presents the Phase 1 habitat survey results, the NVC survey results, and the potential GWDTEs identified. The habitat survey results are discussed in detail in **Appendix 6.2** and are not repeated here. The GWDTE baseline is presented below.

During surveys undertaken by the ecology team and following the steps outlined in Table 1, it was identified that there are a number of GWDTE Target Notes (TNs) located across the Site with potential to have a high dependency on groundwater. These are point locations associated with the following habitats

- B5 Marshy Grassland;
- D2 Wet dwarf shrub heath
- E2.1 Acid Flush;
- E4 Peat - bare
- J4 Bare ground

Other habitats that have the potential to be groundwater dependent were mapped by the ecology team as shown in **Table 2**. Based on SEPA guidance[1] the *potential* groundwater dependency of these communities, based on the vegetation alone is also provided in the table.

Table 2: Potential GWDTEs, based on NVC code.

Potential GWDTE NVC Code	Groundwater Dependency as per SEPA (2017)[1]
M6 *Carex echinata - Sphagnum recurvum mire;*	High
M23 *Juncus effusus/acutiflorus-Galium palustre rush-pasture*;	High

Potential GWDTE NVC Code	Groundwater Dependency as per SEPA (2017)[1]
M37 *Cratoneuron commutatum springs*;	High
M15 *Scirpus cespitosus - Erica tetralix wet heath*;	Moderate
M25 *Molinia caerulea-Potentilla erecta mire*;	Moderate
MG10 *Holcus lanatus - Juncus effusus rush-pasture.*	Moderate

Based on the SEPA guidance, NVC classes M15, M25 and MG10 have the potential to have a moderate dependency on groundwater and M23, M37 and M6 have the potential to have a high dependency on groundwater. Areas of habitat that have the potential to be groundwater dependent are widespread across the Site (see **Figure 6.5**). However, it is noted that the areas shown in **Figure 6.4** often comprise a mosaic of NVC communities, for example M15 might only cover 20% of a polygon, with the remaining 80% being some other non-GWDTE communities (e.g. likely bog communities associated with the peatland). To be conservative, the entire polygon was mapped by ecologists as potentially groundwater dependent on **Figure 6.5**.

The ecology team considered that the habitats that indicate a high likelihood of ground water dependency (i.e. M6, M23 and M37) were generally located close to watercourses (indicating a surface water influence) or associated with hillside flushes and within gullies. Therefore, it is considered that these plant communities have, at-most, low groundwater dependency.

Those habitats indicating moderate likelihood of ground water dependency (i.e. M15, M25 and MG10) were recorded within the study area as follows:

- M15 was restricted to fragmented patches to the east in proximity to watercourses, historical burning has resulted in only small patches remaining, therefore it is considered that this plant community has, at-most, low groundwater dependency.
- M23 was recorded throughout the ecology study area and was common in the east along the edges of watercourses, drains, gullies, valley floors and gently sloping hillsides. Therefore, it is considered that this plant community has, at-most, low groundwater dependency.
- M25 was recorded once in a small area to the south-west of the study area, in an area of deeper peat, therefore this is likely to have low/ moderate ground water dependence.

The hydrology team recorded two springs (TN3 and TN4) during the Phase 1 hydrology and peat surveys in March 2022. TN3 corresponds with the high potential GWDTE M23 NVC community as illustrated in Table 6.4 of the EIA Report. TN4 corresponds with phase 1 habitats D1 Dry dwarf shrub heath/ E1.8 Dry modified bog as illustrated in Table 6.3 of the EIA Report. These were buffered by 250 m and avoided during early design iterations, as they indicate a confirmed GWDTE with high dependency om groundwater (based on **Table 1**).

A further specific survey was undertaken by the hydrology team in May 2023 to visit the potential GWDTE polygons identified by ecology based on vegetation (see **Table 2** and **Figure 6.5**) to confirm the level of groundwater dependency associated with each one. Potential GWDTEs within the 250 m infrastructure buffer were ground truthed. The hydrology survey confirmed the ecologists' findings of low groundwater dependency in all but one of the potential GWDTE polygons (P2). The hydrologists also identified another potential GWDTE (P1) fed by two flushes which indicated a groundwater source. The GWDTE point sources (TNs) and confirmed GWDTE polygons are shown on **Figure 8.3** in the EIA Report.

It is noted that many of the several of the *potential* GWDTE polygons do have some habitats which have a surface or sub-surface water influence and any proposed tracks that pass through these areas should include suitable drainage to avoid blocking hydrological pathways and maintain hydrological connectivity.

Based on the results of the TN survey by hydrologists and ecologists and the desk-based assessment, a number of adjustments were made to the turbine locations to consider the presence of GWDTEs. Where possible, the 250 m buffer has been avoided for siting turbines and borrow pits, and 100 m buffer has been avoided for siting roads, tracks and trenches, as per SEPA guidance[1]. However, it has not been possible to avoid these in all locations. Confirmed GWDTEs within 100m of the access tracks (<1m excavation) and within 250m of proposed turbines and borrow pits (>1m excavation) are described in **Table 3** and shown on **Figure 8.3**. Target Notes TN1 and TN2 as identified in Table 3 below correlate with the ecology team's target note number 46 as illustrated in Figure 6.3 of the EIA Report and as described in Appendix 6.2 of the EIA Report.

Table 3: Details of GWDTEs within 100m of excavations <1m deep and 250m from excavations >1m deep

Potential GWDTE Polygon (P) or Target Note (TN)	Phase 1	NVC	Potential groundwater dependency based on NVC class[1]	Hydrogeological setting	Actual groundwater dependency based on site surveys	Distance from infrastructure
P1 (and TN1 and 2) (identified by hydrologists)	E1.8 Dry modified bog/ D1 Dry dwarf shrub heath	M32 -P*hilonotis fontana - Saxifraga stellaris* spring	High	Located upgradient of a small watercourse on gently sloping ground. Two small seeps/flushes (TN1 and TN2) were observed coming out of hillside (**Photo 1**) and there was an oily film on the water, indicating a groundwater contribution. Based on setting, it is likely that there is both surface water and groundwater contribution to the flow.	Moderate, based on presence of two small discharges (flushes). However, the flow rates from the flushes are low and there is likely to be a surface water contribution.	P1 is 133m north of T4 and 68m east of track. TN1 and TN2 (flushes) are 68m and 98m east of access track, respectively. TN1 and TN2 (flushes) are 171m and 144m north of T4.
P2 (and TN3)	B1.1 Acid Grassland/C 1.1 Bracken	M23 *Juncus effusus/acutiflorus-Galium palustre rush-pasture*	High	There is an obvious spring (TN3) upwelling at the top of the GWDTE polygon (**Photo 2**). The spring is on the opposite valley side of the small watercourse (Chapman's Grain) from T5.	High (at and downgradient of spring TN3) The southern part of the polygon (along the watercourse) is associated with surface water and has Low groundwater dependency.	P2 is 220m southeast of T5. TN3 is 330m southeast of T5 and 331m southwest of Construction compound 2. This spring was buffered and avoided early in the design iterations.

3 Effects Assessment

Following ecological identification of groundwater dependent habitats and an assessment of the levels of groundwater dependency of the specific habitats, this section provides an assessment of the potential effects of the Proposed Development upon groundwater flow to each of the identified areas of GWDTE described in **Table 3**.

A site-specific qualitative risk assessment of each GWDTE was carried out based on the available data on local geology, hydrology, ecology and hydrogeological regime at each location. There is no available data on sub-surface flows and in the absence of data, it is considered that the movement of sub-surface water is primarily driven by topography.

Flow routing analysis was carried out in QGIS software using Phase 3 0.5m LiDAR DTM data. In the absence of data on ground water levels and flow paths, analysis of topography and surface water flows paths was used to infer hydrological and hydrogeological connectivity to the project infrastructure.

The assessment of impact on a groundwater flow path is made with reference to distance, slope, aspect, typical water table levels and features such as watercourses. This assessment is made with imperfect knowledge of the exact extent that a particular impact may have and imperfect knowledge of specific sub-surface flow paths. As such, it takes a precautionary approach using the available information.

Two specific aspects are considered in the assessment. One is the likelihood of an impact upon a flow path feeding an area of groundwater. The second aspect is the likelihood that an area of groundwater may be drained at an un-naturally fast rate following the introduction of drainage for infrastructure / access tracks / turbine bases.

The SEPA Guidance[1] for assessing impacts of development on GWDTEs recommends a 250m buffer zone from all excavations deeper than 1m and a 100m buffer for excavations less than 1m deep. The two buffers are shown on **Figure 8.3** in the EIA report and **Images 1 and 2** in this appendix. Based on the project description and construction methods outlined in **Chapter 3: Development Description** of the EIA Report, excavations for the turbine foundations and borrow pits will be deeper than 1m, while access tracks and other infrastructure (compounds and battery storage) will be less than 1m.

Table 3 identifies the GWDTEs that are either moderately or highly dependent on groundwater and within 250m of proposed infrastructure. All other potential GWDTEs were considered to have a low dependency on groundwater and are not considered further. A site-specific assessment of the moderate and high GWDTEs follows.

3.1 GWDTE P1, including TN1 and TN2

This GWDTE is located upgradient of a small watercourse on gently sloping ground. Two small seeps/flushes were observed coming out of hillside (**Photo 1**) and there was an oily film on the water, indicating a groundwater contribution. The water appears to feed a small peat filled depression to the east of the TNs and this location is also the upstream part of a small watercourse. Based on setting, it is likely that there is both surface water and groundwater contribution to the flow.

The track to T4 is within the 100m buffer of two GWDTE point locations (flushes at TN1 and TN2). In addition, T4 is within 250m of the GWDTE point locations and the polygon. Based on site surveys (see **Table 3**), the GWDTE is considered to be moderately dependent on groundwater. Thus the sensitivity of the receptor is medium (based on **Table 8.2** in the EIA Report). The location of the GWDTE is shown on **Image 1** and described in context with available geological, peat and hydrological information.

Image 1: Location of moderately dependent GWDTE P1 (and TN1 and TN2) in hydrological setting, showing indicative surface water flow paths and proposed infrastructure (100m and 250m buffers from infrastructure also shown).

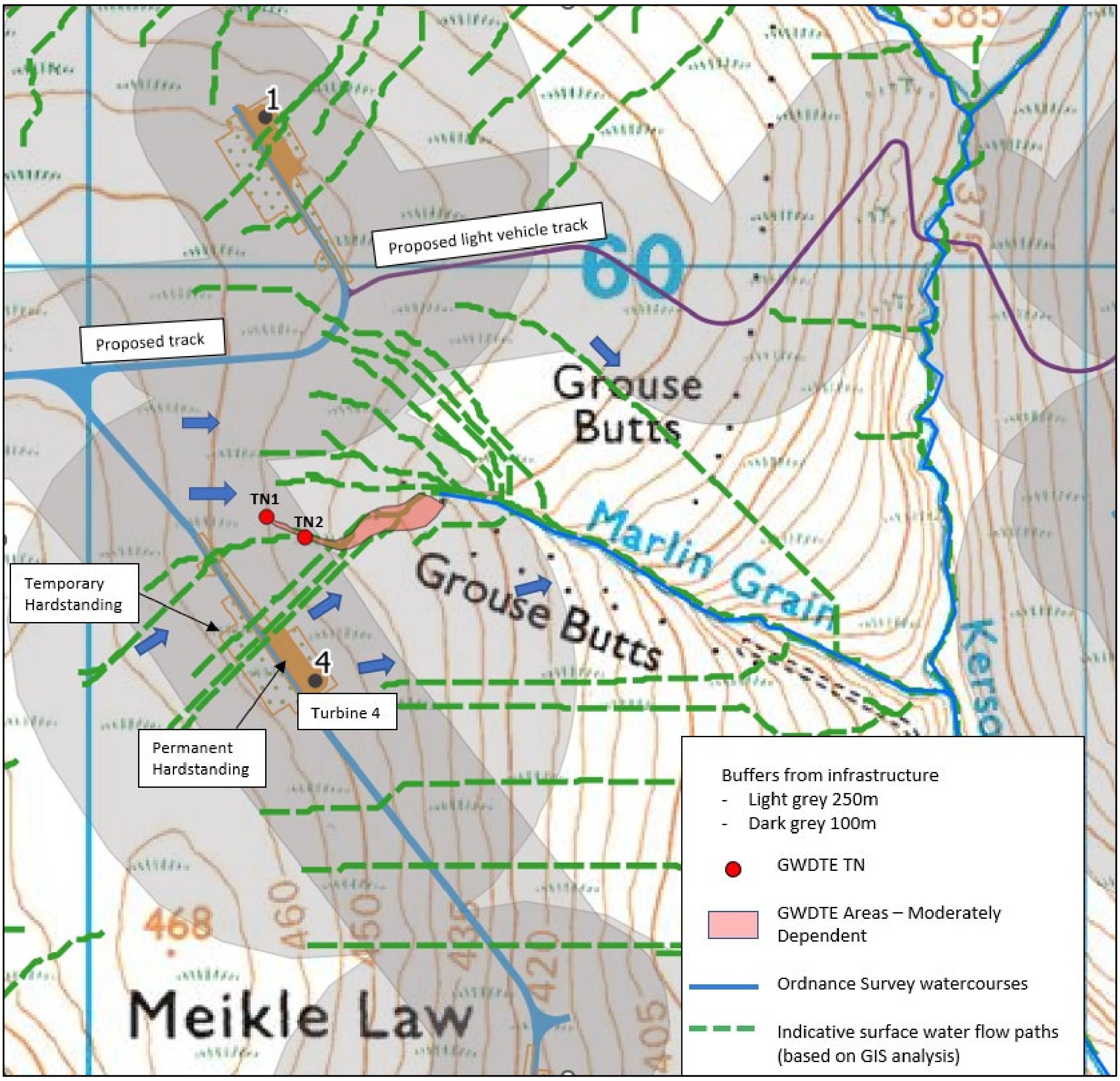

Photo 1: (a) Flush TN2 and (b) Moderately Dependent GWDTE 1, looking east (downgradient).

 

British Geological Survey (BGS) 1:50K bedrock geology maps indicate that the geology around the GWDTE comprises of Wacke Sedimentary of the Gala Group (**Figure 8.4** in the EIA report). These highly indurated greywackes are classified as having low aquifer productivities (Class 2C), with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities.

BGS 1:50K superficial geology maps indicate that the superficial drift geology at the GWDTE site comprises peat deposits (**Figure 8.4** in the EIA report). The NatureScot Carbon and Peatlands Map 2016 (**Figure 8.6** in the EIA report) shows that GWDTEs are within a Class 5 peatland area: "Soil information takes precedence over vegetation data. No peatland habitat recorded. May also include areas of bare soil. Soils are carbon-rich and deep peat." The peat depth survey (**Figure 8.7a** in the EIA report) indicates peat depths of between 85 – 100cm at the GWDTE. There is a peat filled depression downslope of the GWDTE and peat of depths up to 2m just west of the GWDTE.

The GWDTE is located on the northeast flank of the Meikle Law hill and surface water flow paths indicate that the area drains towards the Marlin Grain watercourse to the east (**Image 1**). Flow path analysis indicates that the GWDTE is within a surface water flow path towards the watercourse to the east. Based on this, and confirmed on the site visit, it is likely that the GWDTE is partially surface water fed.
The proposed turbine (T4) is ~133m south of the GWDTE polygon, upslope on the eastern flanks of Meikle Law. Flow path analysis shows that the associated track and the northern part of the temporary T4 infrastructure drains north towards the GWDTE. The turbine itself and the permanent infrastructure drains eastwards to enter the Marlin Grain watercourse further downstream from the GWDTE (**Image 1**). T4 is located at an elevation of 449m Above Ordnance Datum (AOD). The flushes (TN1 and TN2) are located ~171m and ~144m north of T4 and are downgradient at elevations of 445m AOD and 441m AOD, respectively. It is considered possible that excavations for the Proposed Development will have a slight, temporary impact on the GWDTEs, as the infrastructure location is potentially hydrologically connected to the GWDTEs.

TN1 and TN2 (flushes) are 68m and 98m east of the proposed track, respectively. Based on the analysis surface and sub-surface flow paths could be intercepted by the track if it is not designed to maintain hydrological connectivity and allow sub-surface flow. There is also a risk runoff from infrastructure could result in increased sediment/pollution draining towards the GWDTE.

Based on the above, with embedded mitigation, it is considered that the Proposed Development could have a temporary, local effect of slight magnitude on the GWDTE. Given the medium sensitivity of the receptor, this effect is considered to be of **minor significance** during construction before additional mitigation.

Embedded mitigation measures (e.g. SUDS and best practice site management and construction techniques) will minimise the risk of pollution/sediment to the GWDTE. Best practice construction techniques as set out in the guidance document "Good Practice during Wind Farm Construction" (2019[5]) will be employed to ensure that the infrastructure does not affect groundwater flow or chemistry to sensitive receptors. Additional mitigation measures will be put in place during construction to maintain the baseline subsurface flows towards the GWDTEs and provide suitable permanent drainage under the track such that the track does not create a barrier to the natural drainage conditions . Specific measures will be implemented on a case-by-case basis as directed by the Environmental Clerk of Works (ECoW) during construction.

The track will be designed with suitable drainage to enable subsurface flows to be maintained. Thus, there is not expected to be any long-term effect on hydrology and sub-surface flows during operation. Monitoring will be put in place to assess the quantitative and chemical effect of the infrastructure to check that the groundwater flow and quality to the GWDTEs are not statistically significantly changed post construction. Monitoring will be carried out based on SEPA guidance[1] and will comprise groundwater monitoring at the two seeps. Pre-construction monitoring will commence at least six months before construction commences. Monitoring reports will be prepared, and remedial actions identified if statistically significant changes to the groundwater flow or chemistries to sensitive receptors resulting from the Proposed Development are identified.

Additional mitigation and monitoring will reduce the likelihood of any significant effects on the GWDTE and the residual effect is considered to be **neutral** during construction and **none** during operation.

3.2 GWDTE P2, including TN3

There is a spring (TN3) upwelling at the top of the GWDTE polygon (**Photo 2**). The spring is on the opposite valley side of the small watercourse (Chapman’s Grain) from proposed turbine (T5) and is outwith the 250m buffer. This high dependency GWDTE was buffered at the early design stage. Only a small part of the GWDTE polygon, along the route of Chapman’s Grain watercourse, is within the 250m buffer (**Image 2**).

Based on site surveys (see **Table 3**), the GWDTE downgradient of the spring source is considered to be highly dependent on groundwater. Thus the sensitivity of the receptor is high (based on **Table 8.2** in the EIA Report). It is noted that part of the GWDTE polygon along the course of the watercourse is linked to surface water (hence this part has low dependency on groundwater and is of low sensitivity). The location of the GWDTE is shown on **Image 1** and described in context with available geological, peat and hydrological information.

[5] Scottish Renewables, SNH, SEPA & Forestry Commission Scotland (2019) Good Practice during Windfarm Construction, 4th Edition 2019.

Image 1: Location of highly dependent GWDTE P2 (and TN3) in hydrological setting, showing indicative surface water flow paths and proposed infrastructure (100m and 250m buffers from infrastructure also shown).

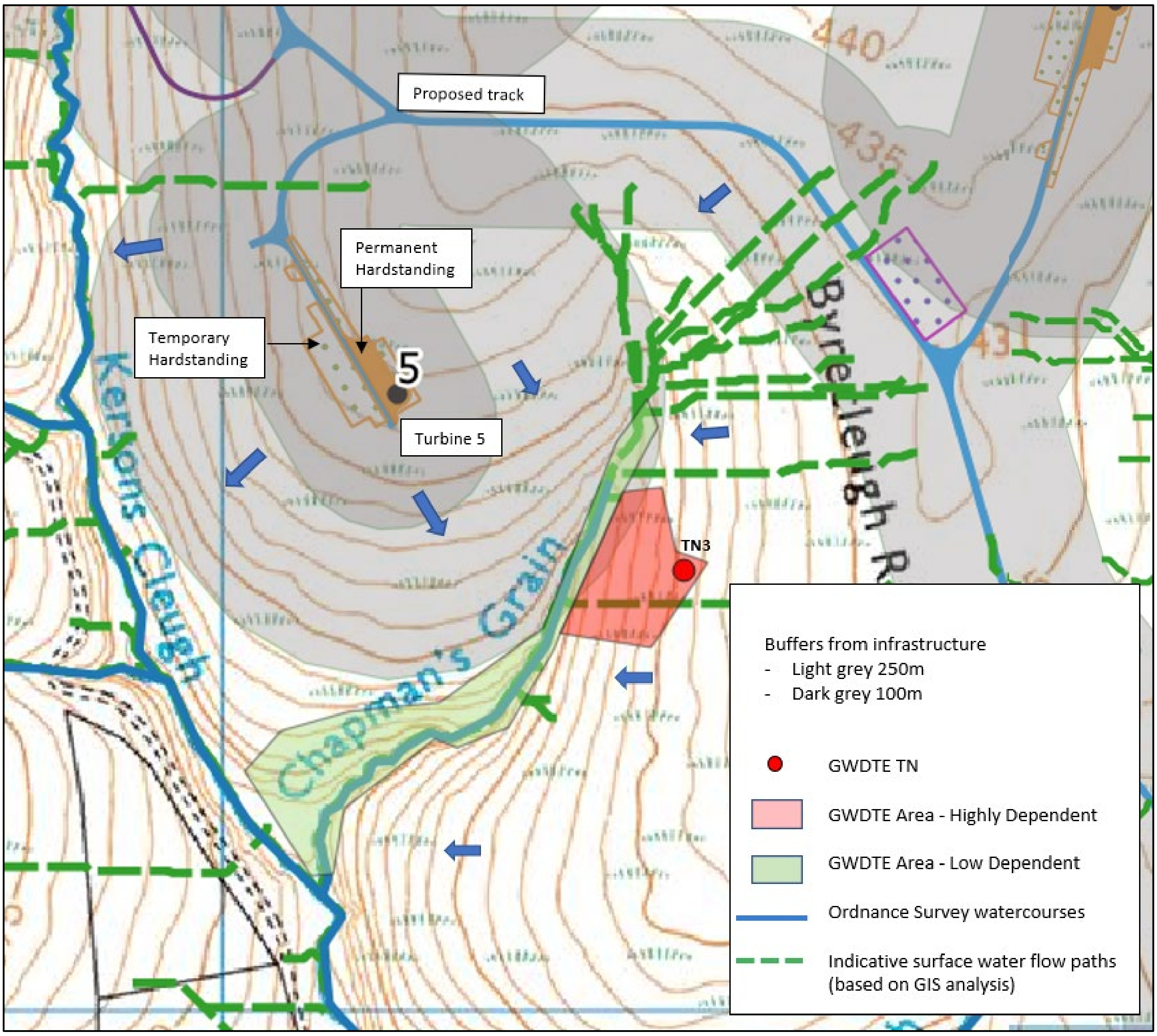

Photo 2: (a) Spring TN3 and (b) Highly Dependent GWDTE 2, looking west towards Chapman's Grain watercourse (downgradient).

British Geological Survey (BGS) 1:50K bedrock geology maps indicate that the geology around the GWDTE comprises of Wacke Sedimentary of the Gala Group (**Figure 8.4** in the EIA report). These highly indurated greywackes are classified as having low aquifer productivities (Class 2C), with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities.

BGS 1:50K superficial geology maps indicate that there are no drift deposits at the GWDTE site (Figure 8.4 in the EIA report). The NatureScot Carbon and Peatlands Map 2016 (Figure 8.6 in the EIA report) shows that GWDTEs are within a Class 4 area: " Area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils." The peat depth survey (Figure 8.7a in the EIA report) shows probed depths of between 0 – 40cm, which is not considered to be peat.

The spring (TN3) is located high up on the valley side at ~ 402m AOD, on the opposite side of the Chapman's Grain watercourse from the infrastructure (**Image 2**) outside of the 250m buffer and will not be impacted by the Proposed Development. Flow path analysis confirms that surface water flow paths from the proposed infrastructure at T5 are towards the watercourse and will not impact the highly dependent GWDTE. It is noted that the mapped potential GWDTE along the watercourse is not related to the spring source and is mainly surface water fed, due to proximity to the watercourse, and it is considered to have at most a low dependency on groundwater. Thus the magnitude of effect on the GWDTE is considered to be none, which results in an effect significance of **none**.

4 Summary

GWDTE were buffered and considered early in the design process for the Proposed Development. Where possible, the recommended 250m buffer has been avoided for siting turbines and borrow pits, and 100m buffer has been avoided for siting roads, tracks and trenches, as per SEPA guidance[1]. However, it has not been possible to avoid all buffers.

There are two GWDTEs where infrastructure is proposed within the recommended buffers. These are assessed in detail and reported herein. Based on the GWDTE Decision Tool (**Table 1**) they have been assessed to have either a moderate or high dependence on groundwater, although part of GWDTE P2 (close to the watercourse) has been assessed to have a low dependence on groundwater.

The effects of the Proposed Development on each GWDTE location (assuming embedded mitigation measures, such as construction SUDS, are in place) are summarised in **Table 4** below. Additional mitigation measures are summarised in the second last column of the table.

Table 4: Summary of Assessment of GWDTEs within 100m of excavations <1m deep and 250m from excavations >1m deep

Potential GWDTE Polygon (P) or Target Note (TN)	Groundwater dependency based on site surveys	Distance from infrastructure	Significance before additional mitigation (including embedded mitigation measures)	Additional Mitigation	Significance after additional mitigation
P1 (and TN1 and TN2)	Moderate	P1 is 133m north of T4 and 68m east of track. TN1 and TN2 (flushes) are 68m and 98m east of access track, respectively. TN1 and TN2 (flushes) are 171m and 144m north of T4.	Minor	Track will be designed to enable subsurface flows to be maintained during construction and operation. Pre and post-construction monitoring.	Neutral
P2 (and TN3)	High (at and downgradient of spring TN3) Low along the watercourse	TN3 is 330m southeast of T5 and 331m southwest of construction compound 2. This spring was buffered and avoided early in the design iterations.	None	None	None