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Appendix 8.4

Groundwater Dependent Terrestrial Ecosystems Assessment

Contents

A glossary and list of abbreviations is presented in Chapter 8: Geology, Hydrology and Hydrogeology of the EIAR.

8.1. INTRODUCTION

As part of the works undertaken in support of Chapter 8 of the proposed Daer Wind Farm Environmental Impact Assessment Report (EIAR), this appendix presents an assessment of the proposed infrastructure upon Groundwater Dependant Terrestrial Ecosystems (GWDTEs). GWDTEs are specifically protected under the Water Framework Directive (2000/60/EC). The assessment has been undertaken in accordance with guidance available from the Scottish Environment Protection Agency (SEPA), including:

- Land Use Planning System (LUPS) Guidance Note 4: Planning Guidance on Onshore Windfarm Developments; and
- LUPS Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems.

The purpose of this appendix is to identify 'potential' GWDTE using habitat survey information and to the further assess the 'likelihood' of groundwater dependency based on ecological, geological, hydrogeological and topographical context. Once GWDTE have been identified, potential impacts will be assessed which could occur as a result of the construction and operation of the proposed Daer Wind Farm (the Proposed Development). This will be achieved by providing a detailed site specific risk assessment for proposed infrastructure within 250 m of GWDTE where the infrastructure will require excavation deeper than 1 m, and for proposed infrastructure within 100 m of GWDTE where the infrastructure will require excavation shallower than 1m.

Based on the above information an assessment of potential effects for each of these zones has been presented that takes into account industry good practice mitigation. The assessment also considers the likely significance of these effects on the identified receptor.

8.2. APPROACH & METHODOLOGY

GWDTE Classification

The assessment of GWDTE has been completed by undertaking the following:

- Completion of a National Vegetation Classification (NVC) study and classification of these communities in line with SEPA LUPS 4 & 31; and
- An assessment of these habitats within the context of the hydrogeological environment involving the production of a conceptual model of the groundwater contribution supplying wetlands and an approximate calculation of the proportion of the landtake area within each defined zone of groundwater contribution.

The NVC survey were undertaken in 2019 and covered an area extending 250 m in either direction from the permanent and temporary infrastructure. Additional surveys were undertaken in 2020 along the proposed Primary access. The habitats were classified based on the published NVC descriptions for British Plant Communities and mapped in the field, with percentages used to proportion mosaics where multiple communities were present. Individual communities are referred to throughout this report as habitat "parcels". Where several parcels demonstrated similar ecological attributes, these may be grouped into habitat "clusters". Habitat parcels and habitat clusters have both been allocated unique IDs for ease of referencing.

In line with the classification systems in Table 2 of SEPA's LUPS Guidance Note 4 identified habitats have been classified as being those where a wetland is likely to be highly groundwater dependant or moderately groundwater dependant depending on the hydrological setting and the defined NVC. A qualitative description of site specific observations on the condition of habitats has also been presented to provide background context on the GWDTE setting. The likely groundwater dependency for GWDTE areas has been assessed through consideration of possible water supply mechanisms based on site observations, the local topography, underlying geology and the potential for surface water contributions to the habitats.

Hydrological & Hydrogeological Desktop Study

The following information has been reviewed to establish the hydrological and hydrogeological context of the proposed development area:

- Review of the site specific topographic wetness index (TWI) produced to determine topographical controls on the saturation of peat/soils; and
- Review of the British Geological Survey (BGS) data to establish the predominant flow conditions within the solid and superficial aquifers.

Additional anecdotal information has been incorporated that was obtained during both hydrology and ecology surveys undertaken as part of the wider EIAR.

Assessment of Potential Effects

It has been considered that a habitat is at risk if there is potential source- pathway receptor connectivity from the infrastructure location. Following identification of potential GWDTE based on NVC mapping data, the hydrological and hydrogeological desktop study information has been used to help qualitatively determine the likelihood of connectivity between the source and receptor. Note that if a receptor is positioned up gradient or considered to be hydrogeologically disconnected from infrastructure, it is not considered to be at risk due to the topographic barrier. For each receptor which is considered at potential high risk, the proportion of proposed infrastructure landtake within the GWDTE has been calculated in order to help provide an indication of the potential effects for the identified habitats within each zone. Hydrological hypothetical contribution zones using GIS were also calculated.

8.3. BASELINE CONDITIONS

The baseline condition of the proposed development area is presented within Chapter 8 Hydrology, Geology and Hydrogeology of the EIAR and to avoid duplication, only a summary is presented in the below sections.

Geology

The solid bedrock geology underlying the Proposed Development is illustrated in Figure 8.2 Bedrock Geology of the EIAR. As demonstrated in the figure, the underlying bedrock is predominantly steeply dipping sedimentary wackes from the Lower Palaeozoic. The southern and eastern part of the site around the Crook Burn, Kinnel Water, Garpool Water and Shiel Burn are dominated by units of sandstone, mudstone and conglomerate from the Queensberry Formation, which are likely to be at least 100 m in vertical thickness but may be substantially more. On the western end of the site closer to the Daer Reservoir and around the pour point of the Crook Burn catchment the bedrock geology is that of the Gala Unit 4, which is comprised of highly indurated wacke deposits and are likely to be very similar in character to the to the Queenberry Formation. The depth of the Gala Unit 4 may be in excess of ~1500 m. It is likely that there will be an extensive zone of highly fractured, weathered bedrock in the near surface. Both the Queensberry Formation and Gala Unit 4 exhibit regional stratification and tectonic features exemplified by most of the Lower Palaeozoic rocks in southern Scotland. These are manifested through the occurrence of fault lines orientated south west to north east, dipping north west with less frequent strike-slip faults orientated south east to north west. These rocks are likely to be more highly fractured closer to the surface as a result of post-glacial weathering, however the extent of this can be variable and will depend on the local level of abrasion during the last glacial maximum. No bedrock outcrops were observed during field surveys.

Soils

The surface cover soil types present in the proposed development area are illustrated in Figure 8.5 Predominant Soils and Figure 10.5 Carbon Soils of the EIAR. As demonstrated within the figures, dominant soils are peaty gleys, peaty podzols, peat, brown soils and mineral gleys. The soils are also classified under the SNH (2016) Carbon and Peatlands Assessment as predominantly Class 3 (vegetation cover does not indicate priority peatland habitat) and Class 5 (vegetation cover does not indicate peatland habitat) with small occurrences of Class 1 (soils which are considered to be of national importance).

The superficial geology is presented in Figure 8.3 Superficial Geology of the EIAR and shows assemblages Quaternary tills, alluvium and organic peat accumulations. The glacial till deposits are also likely to underlay much of the peat deposits and typically comprise of a heterogenous mixture of clay, sand, gravel, boulders and maybe massive, with varying levels of consolidation. The overlying peat varies in thickness from shallow (<0.5 m) on slopes and ridgelines in the north and east of the Development Area, to occasionally deep (>2 m) in the south and west.

Hydrogeology

According to the BGS Hydrogeological Maps of Scotland the underlying Lower Palaeozoic Gala Group are recognised as a low productivity aquifer with little potential for groundwater storage and transport other than in cracks and joints associated with tectonic features or surface weathering (BGS, 2020; 1990). Low productivity aquifers do not widely contain groundwater in exploitable quantities; however, some bedrock formations can locally yield water supplies in sufficient quantities for private/domestic use. BGS permeability indices for the bedrock assemblages indicates that fracture flow is the predominant transmission mechanism, with minimum permeability being low to a maximum of low/moderate. The bedrock groundwater underlying the Proposed Development area is mapped part of two bedrock aquifer unit under the SEPA River Basin Management Plan (RBMP). The East Dumfriesshire Groundwater is classified as have “good” overall status and the Leadhills Groundwater is classified as having “poor” overall status. In the case of the latter, the status is as a result of legacy mining and concomitant pollution of the aquifer.

Overlying the bedrock are quaternary sediments and organic peat accumulations which owing to the low permeability of the underlying bedrock, may host a shallow superficial aquifer. Alluvial or glacio-fluvial deposits with a high content of sand and gravel deposited by glacial meltwater rivers or post-glacial riverine processes will have the highest permeability but are mainly constrained to riparian zones. Conversely, where these sediments are interbedded with finer grained, lower permeability deposits such as silts and clays, water transmission will be more limited leading to highly heterogenous flow conditions. These glacial till type deposits are mapped intermittently across the proposed development area and are also likely to underly the peat. BGS permeability indices for the glacial till indicates that the predominant transmission mechanism will be a mixture of fracture/intergranular flow, with minimum permeability being low to a maximum of high/moderate. Minimum and maximum permeability indices for peat are very low and low respectively.

Hydrology

Hydrologically, the Proposed Development spans two main hydrological networks; Daer Water (River Clyde) and Evan Water (River Annan). Figure 8.1 of the EIAR shows a hydrological overview of the Proposed Development. The morphology of the streams is typical of an upland moorland catchment, with medium-small channels with variable flow gradients that are often incised into the superficial geology. Riparian zones are typically water saturated grassland with banks ranging in stability.

Walkover surveys to determine hydrology and ecology were undertaken in 2019 and 2020. Whilst extensive waterlogged areas are evident across the proposed development area, well defined springs were noted to be generally absent.

Topography

An analysis of the 10 m Digital Terrain Model (DTM) within ArcGIS has been undertaken to derive a Topographic Wetness Index (Figure 8.9) which is a function of the ratio between the local upslope contributing area and slope. This has identified those areas where water will accumulate on site and result in saturation of the surrounding peat and is discussed fully in the Baseline Conditions discussion in Chapter 8: Hydrology, Hydrogeology & Geology. As shown in the TWI, the results of the DTM analysis suggest that the areas of greatest flow accumulation and saturation of peat/soils occur within the riparian corridors of the mapped watercourses and potential flush zones, these conditions are therefore potentially conducive towards GWDTEs.

Groundwater Dependent Terrestrial Ecosystems

Identification

GWDTE are determined based on ecological and hydrological indicators. As such SEPA has classified numerous NVC communities as potentially dependent upon groundwater (SEPA, 2017a, 2017b). The communities identified within the proposed development which correspond to those which could be potentially groundwater dependent have been listed below in Table 8.1. NVC communities with potentially moderate groundwater dependency are highlighted yellow and those with potentially high dependency are highlighted in red.

Table 8.1: Identfied NVC communities with potential for groundwater dependency

NVC Community	NVC Community	Potential Dependency
M15	Scirpus cespitosus - Erica tetralix wet heath	Mod.
MG10	Holcus lanatus - Juncus effusus rush-pasture	Mod.
U6	Juncus squarrosus - Festuca ovina grassland	Mod.
M25	Molinia caerulea - Potentilla erecta mire	Mod.
M27	Filipendula ulmaria - Angelica sylvestris mire	Mod.
M6	Carex echinata - Sphagnum recurvum mire (acid/neutral flush)	High
M10	Carex dioica - Pinguicula vulgaris mire	High
M11	Carex demissa - Saxifraga aizoides mire	High
M23	Juncus effusus/acutiflorus - Galium palustre rush-pasture	High
M29	Hypericum elodes - Potamogeton polygonifolius soakway	High
M32	Philonotis fontana - Saxifraga stellaris spring	High
M35	Ranunculus omiophyllus - Montia fontana rill	High
W7	Residual alluvial forests (Alnus glutinoso-incanae)	High
CG10	Festuca ovina – Agrostis capillaris – Thymus praecox grassland	High

Source: Natural Power

Of the identified potential GWDTE habitats, the MG9 and MG10a semi-improved neutral grassland communities, U6a, b, c and d acid grassland communities, M15b wet heath community and M25a, b and c and M27 marshy grassland and/or wet modified bog communities are assessed by SEPA as having moderate dependency on

groundwater in certain hydrological settings. Furthermore, the W7 woodland community, CG10 calcareous grassland community, M23a and b rush pasture communities, M6a, c and d, M10 and M11 mire communities, M29 soakway community, M32 and M37 spring communities and M35 rill community are assessed as having high dependency on groundwater depending on the hydrological setting.

The locations and the aerial extent of the recorded potential GWDTE communities situated within respective 100 m and 250 m buffers for proposed infrastructure elements are presented in Figure 8.7 Potential GWDTE of the EIAR. Polygons with a dominant cover of potential moderately groundwater dependent NVC communities or sub-communities are shaded yellow, and polygons with a dominant cover of potential highly groundwater dependent NVC communities or subcommunities are shaded red. Not all of the habitat communities identified in Table 8.1 are situated within the respective 100 m or 250 m buffers for proposed infrastructure, however for those that were a short summary of the distribution of these habitats is presented below.

Potentially Moderately Dependent Habitats

M15 – Wet Heath

The M15b sub-community is present within the Proposed Development Area mostly in mosaic with other habitats, such as M17 and M19 blanket bogs, M20 and M25 modified bogs and U5 acid grassland. It was recorded as both smaller percentages (<30 % of area) of the mosaic as well as larger percentages. Areas of M15b were generally dominated by deer grass (*Trichophorum cespitosum*), with associates including bog asphodel (*Narthecium ossifragum*), cross-leaved heath (*Erica tetralix*) and Sphagnum bog mosses. There are also areas of habitat that were recorded as an intergrade between M15 wet heath and M17 or M19 blanket bog. In these areas the community present was a mixture of the descriptions of both communities and could not be defined as one or the other. These areas are most likely to be highly degraded blanket bog and therefore are unlikely to be ground water dependent.

M25 – Modified Bog

The M25a, b and c sub-communities are present across the Proposed Development Area in abundance. M25 is the most abundant community found at the Proposed Development Area and comprises of just over one fifth of the total area. These sub-communities are mostly found across the north of the Proposed Development Area and in lower and flatter areas in the south. Many areas of M25 were on deep peat (>50 cm) and are therefore classed as modified bog. These areas are therefore unlikely to be groundwater dependent. M25 communities were dominated by purple moor-grass (*Molinia caerulea*). The M25a sub-community shows an abundance of ericoid shrubs; the M25b sub-community shows an abundance of rushes and grasses; and the M25c sub-community has tall herb associates, such as marsh thistle (*Cirsium palustre*).

MG10 – Marsh Grassland

The MG10a sub-community is present within the Proposed Development Area in several fairly small areas and was mostly found in mosaic with M23 rush pasture or U4 acid grassland. There is one larger area around the confluence of Shiel Burn and Over Ornscleuch where mosaiced habitats of MG10a and U4/M25 were widespread. Other areas of MG10a were mostly associated with burns or areas of seepage. These areas were dominated by soft rush and Yorkshire fog.

U6 – Acid Grassland

The U6a, b, c and d sub-communities are present across the Proposed Development Area in small areas and as a small percentage within larger areas of mosaiced habitat. Communities that U6 tended to be in mosaic with were U4 and 5 acid grassland, M17 blanket bog, M20 and M25 modified bog. Areas of these communities tended to be on higher slopes. U6 communities were defined by an abundance of heath rush (*Juncus squarrosus*).

MG9 – Improved Grassland

The MG9 community is present within the Proposed Development Area in a few very small areas along the Primary proposed access route. These areas were dominated by false oat-grass (*Arrhenatherum eliatus*) and sharp-flowered rush.

Potentially Highly Dependent Habitats

M6 – Acid / Neutral Flush

The M6a sub-community is present within the Proposed Development Area in a few small areas, usually adjacent to watercourses. The sward is dominated by star sedge (*Carex echinata*) over a carpet of Sphagnum bog-mosses.

The M6c sub-community is present within the Proposed Development Area in a few small areas, usually adjacent to running water. It was also found as small patches in mosaic within larger areas of other mire communities, such as M15, M20, M23 and M25. The sward is dominated by soft rush (*Juncus effusus*) over a carpet of Sphagnum bog-mosses. There were areas along Crook Burn that showed base enrichment.

The M6d sub-community is present within the Proposed Development Area in a few small areas, usually adjacent to running water. It was also found as small patches in mosaic within larger areas of other mire communities such as M10, M19, M20, M23 and M25 and acid grassland communities U4 and U5. The sward is dominated by sharp-flowered rush (*Juncus acutiflorus*) over a carpet of Sphagnum bog-mosses.

Additionally, there are areas of M6 within the Proposed Development Area that were not classified to sub-community level. These were mostly found as small patches in mosaic within larger areas of other habitats. Areas given the community level code with no sub-community defined show poor quality habitat often found in drainage ditches. The identification of M6 communities in this hydrological setting suggests that it is most likely reliant upon the coalescence of surface drainage pathways which is further evidenced by the fact they are positioned in areas of high flow accumulation potential (as identified in Figure 8.9 Flow Accumulation of the EIAR).

M23 – Rush Pasture

The M23a sub-community is present in patches mostly distributed in the north of the Proposed Development Area. These areas are often associated with drainage ditches on upland pasture. There are also areas of M23 habitat around Crook Burn and on the slopes of Whiteside Hill where there are large areas of flushing. Here the community is in close mosaic with M10 and M6 flushes and CG10 calcareous grassland. M23a is dominated by sharp-flowered rush (*Juncus acutiflorus*) with herb associates such as meadowsweet (*Filipendula ulmaria*) and grasses such as Yorkshire fog (*Holcus lanatus*).

The M23b sub-community is present in patches mostly distributed in the north of the Proposed Development Area. These areas are often associated with drainage ditches on upland pasture. There were also some areas of M23b along the banks of Shiel Burn and Over Ornsleuch. M23b is dominated by soft rush (*Juncus effusus*) with associates including meadow buttercup (*Ranunculus acris*), sheep's sorrel (*Rumex acetosella*) and tufted hair-grass (*Deschampisa cespitosa*).

CG10 – Calcareous Grassland

The CG10 community is present within the Proposed Development Area in a few fairly small areas and was mostly found in mosaic with other communities as a small percentage of the overall habitat. The lower slopes of Whiteside Hill next to Crook Burn have large areas of mosaiced habitat, which include a small percentage of the CG10 community. This community is associated on the Proposed Development Area with base rich flushes on slopes. Most areas were of the wetter and Carex sedge rich sub-community CG10b, but there were also some areas of the drier CG10a sub-community.

M10 – Flush Mire

The M10 community is present within the Proposed Development Area in several small areas, mostly in hollows and soakways. It was also found as small patches in mosaic within larger areas of other mire communities such as M20 and M23 and U5 acid grasslands. Carex sedges and butterwort (Pinguicula vulgaris) were abundant and other common associates were lesser clubmoss (*Selaginella selaginoides*) and fairy flax (*Linum cartharticum*). These areas were usually in close association with M37 hard-water spring-heads, where groundwater emerges, surrounded by calcicolous moss assemblages.

M11 – Calcareous Flush Mire

The M11 community is present within the Proposed Development Area in only one very small area on the north-west side of Whiteside Hill and had similar associates as the areas of M10.

M32 – Spring Community

The M32 community is present within the Proposed Development Area in a few small areas and is associated with water seepage. These are clearly groundwater influenced habitats, presenting as small bryophyte-dominated spring-heads, sometimes with flush-lines running down slope. Interesting vascular associates included alpine willowherb (*Epilobium anagallidifolium*), pale forget-me-not (Myosotis stolonifera) and starry saxifrage (*Saxifraga stellaris*).

8.4. PRELIMINARY CONSIDERATIONS

A summary of the information presented in Section 8.3 which will be considered within the assessment of likely groundwater dependence is presented below:

- The baseline environmental setting at Daer is dominated by bedrock of generally low productivity, which is subsequently overlain by extensive accumulations of peat and glacial till, which are more variable in productivity but are still generally low;
- The habitats within the proposed development are diverse but comprised predominantly of wet heath and blanket peat with less frequent marsh grassland, acid / neutral flush and occasional spring communities. The M6 flush habitat is indicative of the interaction of rainwater and *sphagnum*, resulting in significant acidification. Where groundwater rises are present, water pH would be more basic which in turn would be reflected in the type of species present (i.e. M10, M11, M29, M32 / M38), however it is appreciated that diffuse spring sources would not necessarily enable the dominance of base dependent species; and
- The presence of peat across the site will not only impede drainage thus encouraging ombrotrophic habitat in areas of subdued topography, but it may also limit opportunities for spring rises to interact with the rooting layer.

8.5. ASSESSMENT OF LIKELY DEPENDENCE

A total of 51 potentially moderately or highly groundwater dependent habitat parcels covering 30 clusters were identified within the relevant 100 m and 250 m buffer distances for the proposed development infrastructure. Communities situated outside of these buffered distances have not been considered further in this assessment. Of those identified, 24 were classified as potentially highly dependent with a total area of 26.4 ha (2.64e5 m^2) and 27 were classified as potentially moderately dependent with a total area of 143 ha (1.43e6 m^2).

The SNIFFER (2007) guidance states that the dependence of wetlands on groundwater bodies is a result of the hydrological connectivity. The degree of dependency will vary depending upon 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. Therefore the determination of likely groundwater dependence is a function of the communities setting spatially within the landscape and the corresponding hydrological setting. To this end, an assessment of likely groundwater dependency has been undertaken for GWDTE communities based on the site specific hydrological setting combined with the GWDTE decision tool published by Botaneco (2016):

- Where GWDTE vegetation is evidently influenced by groundwater discharge, likely dependency will be high. Identifying features include water appearing in the absence of surface water features at a point source spring head (M31, M32 & M33), more diffuse sources such as a flush (M6, M23, M31, M32 & M33) or floristic indicators of base enrichment (M10, M11, M37 & M38);
- Where GWDTE vegetation is associated with surface water features, likely dependency will be no more than moderate and is likely to be low. Identifying features include association with seeps, sills or runnels; upslope / upstream presence of ombrotrophic bog / mire (wet heath or blanket bog); situated away from likely groundwater rises (flat areas, topographic highs) or where they are situated in a watercourse, floodplain, or other ponding locations; and
- Where GWDTE vegetation is associated within ombrotrophic systems (rain-fed), likely dependency will be no more than moderate and is likely to be low. Identifying features include; the presence of M6 or M25 in close association with M15 and / or M20; upslope / upstream presence of ombrotrophic bog / mire (wet heath or blanket bog); situated away from likely groundwater rises (flat areas, topographic highs) and the presence of peat (>0.5 m in thickness).

The results of the assessment are presented overleaf in Table 8.2. The assigned sensitivities are taken from Table 8.2 from Chapter 8 of the EIAR and are based on the identified likely groundwater dependency. The locations of the GWDTE parcels and clusters in relation to infrastructure is presented in Figure 8.7 Potential GWDTE & Contribution Zones.

Table 8.2: Potential GWDTE Assessment of Likely Dependence

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
1	619	High	Down / Cross Gradient	M23:M25 (60:40)	Peaty podzol soil overlying bedrock wacke. Peat depths recorded as 0.15 to 0.8 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic of Rush Pasture and Modified Bog situated on the concave westward slope of Beld Knowe. The hillsides in this area were noted to contain a high number of artificial drainage ditches. The underlying bedrock geology does not infer a groundwater component and the morphometry and presence of surrounding modified bog would suggest dependence is upon surface water inputs, primarily overland flow from drainage ditches. Whilst these may provide point sources for overland flow, shallow seepage was also noted by the surveyor. Therefore, dependence of vegetation on groundwater input is assessed to be moderate.	Moderate	Medium
2	3, 75, 563, 610, 615, 629, 614 & 749	Moderate	Overlain, Upgradient & Downgradient	U6, M25	Peaty podzol and peat gley soil with glacial sand, gravel, silt and clay (till) overlying bedrock wacke. Peat depths ranged from <0.1 m to 2.2 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	An extensive mosaic of Modified Bog and Acid Grassland blanketing the slopes south of Beld Knowe. The wider mosaic contained subcommunities of M20, M23 and M6 (considered separately) with these being generally situated adjacent to minor watercourses or drainage ditches. The underlying bedrock and superficial geology combined with the upland topography are likely to encourage waterlogged conditions fed from direct input from rainfall. It is acknowledged that small areas of modified bog may be locally supported by seepage downgradient of any areas of ephemeral standing water, however these areas were not distinguished during the survey and are likely to be minor. Notwithstanding, the dependence of vegetation on groundwater input is assessed to be no more than moderate, but is likely to be low.	Low	Low
3	638	High	Overlain, Upgradient & Downgradient	M20:U6 (85:15)	Peaty podzol soil overlying bedrock wacke. Peat depths 0.1 m to 0.9 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Several minor ribbons of acid / neutral flush situated adjacent to mapped / unmapped minor surface water channel / drainage ditch on the slopes south of Beld Knowe. Whilst the channels themselves may be sourced from a groundwater rise / ombrotrophic bog habitat (situated ~300 upslope), its noted that the M6 communities do not extend continuously adjacent to the channel. Therefore, these flush habitats will be primarily fed from the adjacent channels via overland flow or from shallow lateral seepage and not directly from groundwater as this may be limited by the presence of peat. As such, the groundwater dependency is considered to moderate / high.	Moderate / High	Medium
4	2019	High	Overlain, Upgradient & Downgradient	M23	Peaty podzol and peat gley soil with glacial sand, gravel, silt and clay (till) overlying bedrock wacke. Peat depths ranged from <0.1m to 0.4 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	An area of Rush Pasture set within a wider mosaic of Modified Bog (Cluster ID 2) on an area of subdued topography south of Beld Knowe. The area is noted to host a number of drainage ditches discharging in a variety of directions. Whilst peat depths are generally shallow, the low permeability of the underlying bedrock combined with the subdued topography are likely to encourage waterlogged conditions fed from direct input from rainfall or from overland flow from upslope areas. Whilst minor flush habitats might be present these will also be generally fed from overland flow or flow within artificial drainage ditches. Therefore, dependence of vegetation on groundwater input is assessed to be no more than moderate.	Moderate	Medium
5	875	High	Upgradient & Downgradient	M23	Peaty podzol and peat gley soil with glacial sand, gravel, silt and clay (till) overlying bedrock wacke. Peat depths ranged from <0.1m to 0.4 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	An area of Rush Pasture positioned within the riparian headwater of a mapped tributary of the Sheil Burn. Whilst the habitat parcels are noted to merge into an area of non-GWDTE (where the proposed access track has been situated), an additional parcel of Rush Pasture is observed to be present upslope. With both peat depths being shallow and the underlying superficial deposits and bedrock also being of low productivity, it's likely that the shape of the local topography is the driving factor behind wetting of these areas constraining runoff. Furthermore, as no GWDTE habitats were identified suggesting base enrichment, or the presence of a spring rise, it is conceptualised that the watercourse (which is likely to support these communities) is similarly derived from overland flow and drainage of water saturated soils. Notwithstanding, whilst	Moderate / High	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
						groundwater is unlikely to maintain these habitats, shallow seepage within near surface soils is likely to occur and therefore dependence of vegetation on groundwater input is assessed to be high / moderate. (a small area of M6 [~400m^2] is situated north of these parcels. The parcel is situated on top of an area of buried pipeline within a slight topographic hollow and therefore is likely to be associated with permeable backfill following installation)		
6	3	Moderate	Overlain & Downgradient	M25	Peaty podzol and peat gley soil with glacial sand, gravel, silt and clay (till) overlying bedrock wacke. Peat depths ranged from 0.6m to 1.9 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Several minor areas of Modified Bog situated several hundred meters upslope of the mapped extent of the Shiel Burn, just north of Mosshope Fell. The presence of deep peat would infer that base enrichment as a result of spring rises is unlikely, which is supported by the absence of any indicating habitats. The Modified Bog habitats are situated within minor topographic hollows / re-entrants and its likely the occurrence of water saturation hereabouts is a function of the convergence of overland flow pathways. This combined with the low productivity of the underlying bedrock and superficial deposits would suggest that dependence on groundwater inputs is considered to be no more than moderate, and is likely to be low.	Low	Low
7	1	High	Upgradient	M23	Peaty gley soil overlying bedrock wacke. Peat depths 0.3 m to 0.7 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Small linear area of Rush Pasture positioned on the watershed between the Clyde and Annan catchments, just west of Mosshope Fell. The parcel is situated adjacent / downgradient from a minor parcel of Modified Bog beyond which is an area of felled forestry. The position of the parcel on the watershed combined with the low productivity of the underlying bedrock and cover of superficial peat would suggest a dependency on groundwater seepages or spring rises is unlikely. Furthermore, the presence of forestry and forest ditches nearby would suggest a dependency on overland flow or direct rainfall and overland flow from the adjacent Modified Bog. Notwithstanding, dependence of vegetation on groundwater input is assessed to be no more than moderate	Moderate	Medium
8	3, 75, 695	Moderate	Overlain, Upgradient & Downgradient	M15-M19, M25	Peaty podzol and peat gley soil overlying bedrock wacke. Peat depths ranged from 0.1 m to 4 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Several parcels of Wet Heath and Modified Bog situated on predominantly level ground north of Earlside Hill. A large number of drainage ditches were observed in this area, with one of the parcels being bounded to the south by an area of commercial forestry. The underlying bedrock and occurrence of deeper peat, combined with the upland topography are likely to encourage waterlogged conditions fed from direct input from rainfall or fed via artificial / forestry drainage ditches. Due to these considerations, dependence on groundwater inputs is considered to be no more than moderate, but is likely to be low.	Low	Low
9	1	High	Upgradient & Downgradient	M23	Peaty podzol soil overlying bedrock wacke. Peat depths ranged from 0.15 m to 0.8 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Two parcels of Rush Pasture habitats situated adjacent to a series of drainage ditches north west of Earlside Hill. The topography is quite subdued, sloping slightly to the west. Whilst the peat depths are variable, the occurrence of peat / peat soil in the range of ~0.5 m within these areas, combined with the occurrence of low angle drainage ditches would suggest these habitats are fed as a result of overland flow / convergence of surface drainage. This is supported by the absence of any base enrichment species and low productivity of the underlying bedrock. As a result of these factors, dependence of vegetation on groundwater input is assessed to be no more than moderate.	Moderate	Medium
10	194	High	Downgradient	M6	Blanket peat soil with sands and gravels derived from fluvial / glacio-fluvial deposition overlying bedrock wacke. Peat depths were 0.65 m in thickness. Aquifer	Area of acidic / neutral flush situated within the riparian basin on the western bank of the Back Burn. The underlying bedrock geology does not infer a groundwater component, however the parcel being situated on flat and level ground on an area of peat would suggest ponding and pooling as a result of overland flow as well as rainfall are likely to be the main factors in	Moderate / High	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
					productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	maintaining water saturation. Its noted that the peat is also underlain by alluvial sand and gravel and thus being within the valley basin adjacent to the watercourse may also host a topographically constrained superficial aquifer. As a result of these factors, dependence of vegetation on groundwater input is assessed to be moderate / high.		
11	252, 441, 459	Moderate	Overlain, Upgradient & Downgradient	M25, M15	Blanket peat and peat podzol soil which in riparian zones are mapped with sands and gravels derived from fluvial / glacio-fluvial deposition, becoming dominated by glacial sand, gravel, silt and clay (till) in the east. The soil and superficial sediments are underlain by bedrock wacke. Peat depths ranged from <0.1 m to 0.6 m but were typically ~0.4 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic of Modified Bog and Wet Heath blanketing the western and southern flank of Earlside Hill. The habitats were generally indicative of highly degraded blanket peat. The habitats are likely to be part of a wider overall ombrotrophic system in this setting, receiving run-off and rainfall. Groundwater seepages / spring were not evident as indicated by the absence of any base enrichment communities. Drainage ditches were again noted across this area and were responsible for increased water saturation, providing evidence that overland flow pathways are significant. This is likely to be facilitated by the low topographic gradient and occurrence of peat / peat soils across the mosaic. It is acknowledged that small areas of wet heath may be locally supported by seepage downgradient of any areas of ephemeral standing water, however these areas were not distinguished during the survey and are likely to be minor. Furthermore, closer to the valley basin and where sands and gravels are mapped, a shallow aquifer may be present and supported by lateral seepage / topographically constrained through flow, however the degree to which this supports the habitats is unclear and will not extend far up the hillside. As a result of these factors, the dependence of vegetation on groundwater is considered to be no more than low in this setting.	Low	Low
12	440	High	Cross Gradient	CG10:M10	Peaty podzol soil overlying bedrock wacke. Peat depths were 0.1 m in thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor mosaic of Calcareous Grassland and Flush Mire on an area of more subdued topography just south of the summit of Earlside Hill. Whilst the low bedrock aquifer productivity and position of the parcel close to the top of Earlside Hill and the watershed would infer against the occurrence of a groundwater upwelling, the presence of species indicating base enrichment suggests water is perhaps emerging diffusely from the ground following some interaction with the bedrock. The emergence of shallow groundwater could be occurring as a result of the slight change in slope and be facilitated by the limited depth of peat hereabouts. Notwithstanding, the setting of the area suggests that surface water is also likely to be a significant component, as overland flow and also from surrounding ombrotrophic bog. Notwithstanding, the dependence of vegetation on groundwater is considered to be moderate / high.	Moderate / High	Medium
13	196, 443	High	Cross Gradient	M6, CG10:M10	Peaty podzol soil overlying bedrock wacke. Peat depths were 0.45 m in thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor parcel of acid / neutral flush situated immediately upslope of a minor mosaic of Calcareous Grassland and Flush Mire just south of the summit of Earlside Hill. Whilst the upslope occurrence of the acid flush habitat is likely to be associated with the convergence of surface flows, it's possible the lower mosaic demonstrating base enrichment could be associated with a shallow diffuse groundwater. Whilst surface water is likely to support the upper flush habitat, calcareous grassland is likely to be supported by some groundwater element. Therefore, the dependence of the vegetation on groundwater is considered to be moderate / high.	Moderate / High	Medium
14	196	High	Downgradient	M6	Peaty gley soil overlying bedrock wacke. Peat depths were 0.45 m in thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor parcel of acid / neutral flush situated slightly down the eastern slope from the summit of Sweetshaw Rig. The parcel is surrounded by a mosaic of blanket peat, Modified Bog and Acid Grassland and its likely the occurrence of the flush is as a result of surface water discharge and the convergence of overland flows from surrounding ombrotrophic habitats. The low bedrock productivity and occurrence of peat both support this conclusion and as such the dependence of vegetation on groundwater is considered to be no more than moderate.	Moderate	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
15	307, 312, 499, 500	Moderate	Overlain & Downgradient	M25, M15	Peaty gley soil overlying bedrock wacke. Peat depths were 0.1 m to 0.8 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A mosaic of predominantly Modified Bog and Wet Heath with subordinate communities of Acid Grassland, Dry Heath and occasional Rush Pasture. Evidence of field drainage was identified in eastern areas. The presence of the drainage channel and likely wider presence of peat in this area suggests a more significant surface water and run-off component. No evidence was identified to such as spring rises or diffuse base enrichment and therefore dependence on groundwater inputs is considered to be no more than moderate but is likely to be low.	Low	Low
16	196	High	Overlain	M6	Peaty gley soil overlying bedrock wacke. Peat depths were 0.1 m to 0.8 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor parcel of acid / neutral flush situated on the watershed between Daer Reservoir and the Back Burn, slightly north of High Knowe. The flush appears to be situated slightly downgradient of a large area of blanket peat and appears to be a natural surface drainage line. The presence of the drainage channel and likely wider presence of peat in this area suggests a more significant surface water and run-off component. Based on this and the topographical position of the parcel with consideration of the low bedrock aquifer productivity, dependence of vegetation on groundwater is considered to be no more than moderate.	Moderate	Medium
17	75, 282, 293	Moderate	Downgradient	M25, M25:M19 :M20 (60:20:20)	Peaty gley soil overlying bedrock wacke. Peat depths were 0.1 m to 0.9 m and were typically >0.5 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic of Modified Bog and Wet Heath blanketing the western slopes of Type Knowe. As with other areas of Modified Bog and Wet Heath within the Proposed Development Area the habitats were generally indicative of highly degraded blanket peat. The habitats are situated slightly downslope from the areas of blanket bog to the east and is likely to be part of a wider overall ombrotrophic system in this setting, receiving run-off and rainfall. Groundwater seepages / spring were not evident as indicated by the absence of any base enrichment communities. Drainage ditches were again noted across this area and were responsible for areas of increased wetting, providing evidence that overland flow pathways are significant. As a result of these factors, the dependence of vegetation on groundwater is considered to be no more than low in this setting.	Low	Low
18	36, 268, 280, 293	Moderate	Overlain, Upgradient & Downgradient	M25, M25:U5 (85:10), M25:M19 (60:40)	Peaty gley soil overlying bedrock wacke. Peat depths were variable, being deeper on the watershed (0.4m-1.9m) and shallower on the peripheral edges (0.1m – 0.6m). . Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic of Modified Bog with subordinate Acid Grassland on the watershed south of Type Knowe and on the western slopes of Whiteside Hill above the Crook Burn. Within this mosaic occasional and very minor areas of acid / neutral flush were observed but were not significant enough to be independently identified. The underlying bedrock and superficial geology combined with the gentle sloping topography are likely to encourage waterlogged conditions fed from direct input from rainfall. It is acknowledged that small areas of wet heath may be locally supported by seepage downgradient of any areas of ephemeral standing water, however these areas were not distinguished during the survey and are likely to be minor. Drainage ditches were again noted across this area and were responsible for areas of increased water saturation, providing evidence that overland flow pathways are the main mechanism for water saturation. As a result of these factors, the dependence of vegetation on groundwater is considered to be no more than low in this setting.	Low	Low
19	451, 236, 450, 342	High	Downgradient	M32, M10, M10:CG10 :U5 (60:20:20), M10:U5: CG10 (60:20 :20)	Peaty gley soil overlying bedrock wacke. A bedrock thrust fault orientated north east south west, dipping north west is also noted. Peat depths were 0.1 m to 0.85 m in thickness, being deeper in the north. Aquifer productivity is low to high for	A linear ribbon of Flush Mire habitat which was in a mosaic with Calcareous Grassland and Acid Grassland situated on the northern flank of Torrs, extending from just below the summit down to an area of subdued topography several hundred metres south of White Burn. At the head of the habitat is a parcel of Calcareous Grassland and at the base a Spring Community (M32). Whilst the bedrock is of low productivity and the superficial sediments are limited to shallow peat soil (which increases in depth as the slope descends) a fault is noted to bisect the habitat, running parallel with the slope direction. Given the upland location of community close to a topographic	Moderate / High	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
					superficial soils (intergranular) and low for bedrock (fracture).	high, the indurated rock structure as well as fractures often being limited in terms of flow potential (MacDonald *et al*. 2007), it's likely that emerging groundwater along the line of the habitat and at the Spring Community have infiltrated locally (perhaps on the summit of Torrs) discharging along the line of the fault. Overland flow may also be a supporting component, given the habitat is situated within a slight re-entrant feature. Notwithstanding, the occurrence of base enrichment indicator species as well as Spring Communities would suggest that these species have a moderate to high dependency on groundwater.		
20	339	Moderate	Overlain, Upgradient & Downgradient	M15:U5:M25 (45:35:20)	Peaty gley soil overlying bedrock wacke. Peat depths ranged from 0.15 m to 1 m thickness but were generally <1 m. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic of Wet Heath with subordinate Acid Grassland and Modified Bog situated on the southern flank of Torrs, extending down across a level area on the watershed between the Clyde and Annan catchments. A high density of drainage ditches discharging into both catchments is present in this area. Within this mosaic occasional and very minor areas of acid / neutral flush were observed within burn headwaters and are likely to be associated with surface flow convergence. The underlying bedrock and superficial geology combined with the gentle sloping topography are likely to encourage waterlogged conditions fed from direct input from rainfall. The drainage ditches also provide evidence that overland flow pathways are the main mechanism for water saturation. As a result of these factors, the dependence of vegetation on groundwater is considered to be no more than low in this setting.	Low	Low
21	393	High	Cross Gradient	M6	Peaty gley soil overlying bedrock wacke. A bedrock fault is also mapped orientated north north east, south south west (displacement & dip unknown). Peat depth was 0.75 m to 2.7 m thickness, Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor parcel of acid / neutral flush situated within a topographic re-entrant feature with a shallow gradient, south east of Annat Hill. The flush discharges towards a minor watercourse mapped within commercial forestry to the north east. The parcel is directly downgradient from an area of flat ground containing peat and its likely the occurrence of the flush is as a result of surface water discharge and the convergence of overland flows from surrounding ombrotrophic habitats. The low bedrock productivity and occurrence of peat both support this conclusion. The absence of any base enrichment habitats would suggest the bedrock fault is not productive hereabouts with acidic surface water being the primary means of saturation. As such the dependence of vegetation on groundwater is considered to be no more than moderate	Moderate	Medium
22	230, 342, 369	High	Downgradient	M6, M10, M10:M37 (90:10)	Blanket peat overlying bedrock wacke. Peat depths were <0.1 m to 0.35 m, being ~0.4 m on the summit. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Three discrete parcels of Acid / Neutral Flush and Flush Mire (with subordinate Spring Community) situated on the northern and eastern flanks of Over Law. The Acid / Neutral Flush and the Flush Mire Habitats are situated on a change in slope angle, where for the latter community peat was noted to be <0.1 m. For the Acid / Neutral Flush, its position at the base of a steeper slope, but at the start of a large flat area would suggest that it is primarily fed from overland flow and is saturated as a result the concave topography. For the Flush Mire, it's likely the steeper slope and shallower peat facilitates the emergence of locally infiltrated groundwater or perhaps present an opportunity for overland flow to infiltrate locally hereabouts. As peat depths on the summit of Over Law are slightly deeper it's likely that infiltration / emergence would take place close to the habitats. Overland flow may also be a supporting component, given the habitat is situated within a slight re-entrant feature. Notwithstanding, the occurrence of base enrichment indicator species would suggest that these species have a moderate to high dependency on groundwater	Moderate / High	Medium
23	230	High	Downgradient	M6	Blanket peat overlying bedrock wacke. Peat depths were 1 m in thickness. Aquifer productivity is low to high for superficial	A minor parcel of acid / neutral flush situated within a topographic re-entrant feature in a coire south of Over Law. The flush is adjacent to a minor watercourse discharging towards the Crook Burn. The parcel is directly downgradient from an area of flat ground containing blanket peat and	Moderate	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
					soils (intergranular) and low for bedrock (fracture).	its likely the occurrence of the flush is as a result of surface water discharge and the convergence of overland flows from surrounding ombrotrophic habitats. The low bedrock productivity and occurrence of peat both support this conclusion. The absence of any base enrichment habitats (emergence like to be impeded by the depth of the peat) would suggest surface water is the primary means of wetting. As such the dependence of vegetation on groundwater is considered to be no more than moderate.		
24	468	High	Upgradient	M10:M6:U5 (40:35:25)	Blanket peat and peaty gley soil overlying bedrock wacke. Peat depths were 0.1 m to 0.3 m in thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A mosaic of Flush Mire, Acidic / Neutral Flush and Acid Grassland situated on a spur on the northern flank of Lamb Hill. Similar to Cluster 22, peat depths were noted to be shallow and it's likely that the sporadic base enrichment is occurring as a result of the diffuse emergence of groundwater on the concave slope section where the soil is thin. Notwithstanding, the bedrock is of low productivity, limiting infiltration demonstrated by the occurrence of acid flush habitats. Therefore overland flow form upslope areas is also likely to be contributing factor. As such, the dependence of the vegetation on groundwater is considered to be moderate / high.	Moderate / High	Medium
25	473	High	Upgradient	U5:M6:M20:U4:U6 (40:35:15:10:<1)	Peaty gley soil overlying bedrock wacke. A bedrock thrust fault orientated north east south west, dipping north west is also noted. Peat depth is 0.45 m thickness, Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Mosaic of Dry and Wet Grassland with Mire and local Acid / Neutral Flush situated south west of the summit of Hammarty Hill. The presence of Mire and Flush habitats situated downslope of the broad and flat ombrotrophically fed summit area suggests surface overland flow is likely to be significant. Whilst no specific evidence of groundwater nourishment is obvious, the parcel is noted to end abruptly where the steeply dipping fault line is mapped and its possible that this habitat whilst being surface was fed, may contribute to groundwater recharge however this will be limited by the presence of peat. Notwithstanding, the dependence of the vegetation on groundwater is considered to be low / moderate.	Low / Moderate	Low / Medium
26	25	High	Cross / Downgradient	CG10:M10 (60:40)	Peaty gley soil overlying bedrock wacke. A bedrock thrust fault orientated north east south west, dipping north west is also noted. Peat depth is 0.15 m thickness, Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A minor mosaic of Calcareous Grassland and Flush Mire situated on steep, concave slope above the Crook Burn. Peat depths were noted to be shallow and it's likely that the sporadic base enrichment is occurring as a result of the diffuse emergence of groundwater on the concave slope section where the soil is thin. Its also possible that groundwater from deeper sources may also emerge as a result of the underlying fault line, however no specific Spring Communities were identified like in other sections of the Proposed Development Area. As a result of these factors, dependence of vegetation on groundwater input is assessed to be moderate / high.	Moderate / High	Medium
27	342, 859, 398	High	Downgradient	M10, M6:U4:M23:U5 (40:30:20:10), M10-CG10	Peaty gley soil overlying bedrock wacke. Two bedrock thrust fault orientated north east south west, dipping north west are situated immediately to the north and south. In both instances, thin wedges of steeply dipping mudstone are also mapped. Peat depths ranged from <0.1 m to 0.7 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	A large mosaic comprising predominantly of Acid / Neutral Flush and Acid Grassland, containing threads of Calcareous Grassland and Flush Mire. The mosaic is situated at the top of a concave slope on the southern flank of Hoarlaw, north of the Kinnel Water. Upgradient of the mosaic is a large flat area containing pockets of peat and ephemeral standing water. As such it is expected that the grassland and flush habitats will be primarily associated with runoff from the upslope areas. However the occurrence of habitats associated with base enrichment could suggest diffuse groundwater is also emerging in isolated areas, particularly where peat is noted to be shallow. The occurrence of groundwater in these locations could be associated with both the change in slope gradient as well as the proximity to tectonic bedrock features. However groundwater contributions appear to be minor and highly localised as indicated by the small proportion of Calcarous Grassland and Flush Mire. As a result of these factors, dependence of vegetation on groundwater input is assessed to be moderate / high.	Moderate / High	Medium

Cluster ID	Parcel ID	SEPA LUPS 31 GW Depend.	Position relative to proposed infrastructure	NVC Habitat Type	Hydrogeology	Assessment Notes	Likely GW Depend.	Sensitivity
28	1, 194, 230, 196	High	Overlain, Upgradient & Downgradient	M23, M6, M6, M6	Peaty gley soil overlying bedrock wacke. Multiple bedrock thrust fault orientated north east south west, dipping north west are situated within the vicinity. Around some faults, thin wedges of steeply dipping mudstone are also mapped. Peat depths were generally <0.5 m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Minor occurrences of Acid / Neutral Flush and Rush Pasture situated within riparian zones adjacent to headwater channels of the Rivox Burn, north and east of Rivox Fell. Positioned upslope and downslope of an existing track. Peat depths were variable but typically shallow, with these habitats occupying rides and areas of clear fell between forested blocks. The underlying low permeability bedrock is likely to inhibit infiltration and encourage overland flow towards the channels. It's possible that locally in minor topographic depressions or hollows the habitats are reliant upon shallow seepage from the nearby channels but are likely to be predominantly reliant upon surface water inputs. As such the dependence of vegetation on groundwater is considered to be no more than moderate.	Moderate	Medium
29	1, 26	High	Overlain, Upgradient & Downgradient	M23, M23:M25	Blanket peat / peat gley soil with sands and gravels derived from fluvial / glacio-fluvial deposition overlying bedrock wacke. Multiple bedrock thrust fault orientated north east south west, dipping north west are situated within the vicinity. Aquifer productivity is moderate to high for superficial soils (intergranular) and low for bedrock (fracture).	Linear ribbon of Rush Pasture and Modified Bog situated within riparian zones adjacent to headwater channel of the Duff Kinnel Water, west of Knockilsine. Positioned upslope and downslope of an existing track. The habitat parcels are constrained to riparian zones that have been felled. Similar to the flush habitats in the headwaters of the Rivox Burn, its likely that the low permeability of the underlying bedrock will limit infiltration encouraging surface overland flow towards the channel with ponding and saturation as a result of the low topographical gradient. However shallow groundwater flow may occur as a result of the underlying fluvial / glacio-fluvial sands and gravels which will be topographically constrained. Therefore, the dependence of the vegetation on groundwater is considered to be moderate / high.	Moderate / High	Medium
30	353, 459	Moderate	Overlain, Upgradient & Downgradient	M25, MG10	Brown earth soils and peat with glacial sand, gravel, silt and clay (till) overlying bedrock wacke. Several tectonic folding structures (syncline) are noted with the axis following regional orientations of south west to north east. In addition to these, several quaternary features (eskers and meltwater channels) were noted orientated north to south. Peat depths were <0.1 m to 0.5m thickness. Aquifer productivity is low to high for superficial soils (intergranular) and low for bedrock (fracture).	Several expansive areas of Modified Bog and Marsh Grassland situated upslope and downslope of an existing track, south of Haw Moss and Broadshaw Rig. The area is dominated by open grassland with the habitats typically being positioned within the broad vicinity of topographic re-entrant features or minor marked / unmarked watercourses. The low productivity of the bedrock will impede infiltration and constraining overland flow topographically within basin. Whilst some shallow groundwater seepage may occur around areas of increased primary porosity (i.e. around glacial sands and gravels), it's likely that overland flow from upgradient areas of ombrotrophically fed habitat are likely to be the main contribution to the potential GWDTEs. Notwithstanding, the dependence of the vegetation on groundwater is considered to be low / moderate.	Low / Moderate	Low / Medium

Source: Natural Power

As identified in Table 8.2, the ecological, hydrology and hydrogeological circumstance of potential GWDTE parcels has been assessed to determine the likelihood of groundwater dependence. The table denotes that the majority of areas which exhibit potentially groundwater dependent species are unlikely to have groundwater as a significant contributory source, primarily due to the low productivity of the underlying hydrogeology, combined with the expanse of peat across the development area limiting interaction of the root systems with any spring rises. A summary of the key findings are presented below:

- 11 habitat clusters were identified as exhibiting moderate / high dependency upon groundwater inputs, primarily associated with either spring communities / base enrichment species (M10, M11, CG10 & M32) suggesting groundwater emergence on concave slopes or acid / neutral flush (M6) habitat being supported from possible groundwater seeping from steeper slopes, where no obvious ponding or other surface water storage could otherwise provide a source of water;
- 9 habitat clusters identified as exhibiting moderate dependency upon groundwater inputs, and again associated with acid / neutral flush but also occasional areas of modified bog, wet heath and marsh grassland. These features were most typically situated in riparian zones adjacent to mapped / unmapped channels and with contributions from surface water runoff as well as possible upslope contributions from areas of diffuse groundwater discharge. Whilst its possible shallow seepage could be occurring downgradient parallel to the channel, it's expected these areas are predominantly fed by the channel itself, or runoff from peripheral areas and therefore do not act as flow pathways. Additional geological and topographical considerations generally negated against groundwater being a significant component of water dependency in these areas; and
- All of the remaining habitat clusters identified that groundwater is unlikely to be a contributory source particularly for areas of modified bog, wet heath, marsh grassland and acid / neutral flush, where surface water inputs or water logging arising from ombrotrophic conditions were the dominant cause of water saturation.

8.6. MITIGATION AND SIGNIFICANCE OF EFFECTS

The design process has aimed to balance engineering and infrastructure layout requirements with the need to avoid environmental receptors, including areas of sensitive habitat such as GWTDE. An example of this is embedded within the design is for tracks, which have been orientated to bisect linear GWDTE habitats at perpendicular angles, where crossing was unavoidable. Further details are provided in Section 8.6 of Chapter 8 of the EIAR.

It is expected that the potential effects would be minimised through the implementation of appropriate mitigation measures as outlined in Section 8.7 of Chapter 8 of the EIAR. Table 8.2 demonstrates that no specific additional mitigation would be required outside of both embedded and standard good practice mitigation. Appropriate drainage design will include the placement of sufficiently sized culverts and cross drainage to ensure that surface and subsurface flows are maintained below and across tracks and other areas of infrastructure. This is of particular importance in riparian flush areas, or close to identified areas of diffuse groundwater emergence, where cross drains should be installed to facilitate the migration of shallow seepage downgradient.

During excavation works for excavations >1 m in depth, dewatering of excavations will be carefully monitored and groundwater flow disruption and drawdown will be minimised as much as possible. Sediment mitigation and pollution prevention measures will also be implemented throughout the construction phase to help minimise contamination of GWDTEs from potential upgradient sources. Precautions will also be taken to ensure that linear excavations do not result in the modification of flow pathways i.e. cut tracks will be designed to allow the flow of groundwater (made up of permeable material, use of cross drains and check dams) and cable trenches will contain intermittent clay stoppers / dams at regular intervals. Where tracks are existing, in the event a GWDTE is positioned only on one side, track widening will progress on the opposite site. A list of specific measures such as these will be provided in greater detail within the Construction Environmental Management Plan (CEMP), provided prior to construction, and it is considered that these good practices would also be maintained during the operational and decommissioning phase where applicable.

Assuming the successful implementation of these measures where required, the areas of GWDTE identified as moderate or moderately / highly dependent on groundwater have been assessed below in Table 8.3 to evaluate the significance of impact on each GWDTE. The causes of impact related to the potential for direct and indirect effects of water level drawdown, potentially resulting in a modification of groundwater contribution. The areas of GWDTE determined in Table 8.2 as unlikely to have dependency on groundwater input are excluded, as direct impacts on these areas are considered as part of the ecological impact assessment in Chapter 8 and indirect effects related to groundwater are not considered to be applicable. Excluded areas will still be subject to good practice mitigation methods employed during the construction of the proposed development.

The calculation of potentially affected areas includes sections where GWDTE parcels are directly impacted by infrastructure.

Table 8.3: Identfied GWDTE areas and potential effects. Magnitude of effects assumes implementation of mitigation

Cluster ID	Inferred groundwater dependency	NVC Habitat	Sensitivity	GWDTE Cluster Area (Ha)	Contribution Zone Area (Ha)	% area of Cluster overlain by Infra. (Direct)	% area of cont. zone overlain by Infra. (Indirect)	Nearest Proposed Infrastructure & potential effects summary	Magnitude of effect	Significance of effect
1	Moderate	M23:M25 (60:40)	Medium	19.99	42.15	None	None	Turbine 1, Crane Pad and Access Track situated up / cross gradient of GWDTE parcel with all infrastructure outside of contribution zone. Impacts are not expected.	Low	Minor
3	Moderate / High	M20:U6 (85:15)	Medium	4.77	57.46	1.46	3.01	Access track bisects short section of flush habitat. Percentage of contribution zone area loss in small but there is potential for minor disruption. Mitigation will mediate potential modification of flow pathways. Effects associated with habitat loss are discussed in Chapter 6: Ecology.	Medium / Low	Minor / Moderate
4	Moderate	M23	Medium	17.17	48.32	0.92	0.67	Turbine 2, Crane Pad and Access Track situated generally up / cross gradient of GWDTE mosaics, with access track directly overlaying. Complex microtopography but major infrastructure situated on periphery / outside of contribution zone. Potential for minor disruption. Effects associated with habitat loss are discussed in Chapter 6: Ecology.	Medium / Low	Minor / Moderate
5	Moderate / High	M23	Medium	12.76	46.26	None	2.46	Turbine 2, Crane Pad and Access Track situated generally up / cross gradient of GWDTE mosaics. High dependency GWDTE not overlain. Percentage of contribution zone area loss in minor. Habitat mainly supported by minor overland flow channels / surrounding saturated ground so potential for minor disruption. Mitigation will mediate potential modification of flow pathways.	Medium / Low	Minor / Moderate
7	Moderate	M23	Medium	1.02	20.22	None	None	Turbine 3, Crane Pad and Access Track situated downgradient of GWDTE parcel and outside of contribution zone. Mitigation will mediate potential modification of flow pathways. Demarcation should be used to minimise / avoid habitat disturbance. As such, impacts will be low.	Low	Minor
9	Moderate	M23	Medium	5.57	53.85	None	2.18	Access track bisecting the contribution area in two locations, but not overlaying GWDTE parcels. Percentage of contribution zone area loss in minor. Mitigation will mediate potential modification of flow pathways. As such, impacts will be low.	Low	Minor
10	Moderate / High	M6	Medium	3.03	-	None	-	Contribution zone could not be determined as any groundwater seepage could be from watercourse and therefore contribution area could be potentially catchment wide. Notwithstanding, parcel is situated downgradient and on the far side of the watercourse from the nearest infrastructure (Access Track). As such, impacts are not expected.	Negligible	Negligible
12	Moderate / High	CG10:M10	Medium	0.92	3.41	None	None	Turbine 3, Crane Pad and Access Track situated cross gradient from GWDTE parcel and outside of contribution zone. Mitigation will mediate potential modification of flow pathways. Demarcation should be used to minimise / avoid habitat disturbance. As such, impacts will be low.	Low	Minor
13	Moderate / High	M6, CG10:M10	Medium	5.30	17.90	None	None	Turbine 4, Crane Pad and Access Track situated cross gradient from GWDTE parcel and outside of contribution zone but microtopography and drainage of surface water / seepage supporting flush habitats could be complex and therefore there is potential for minor disruption. Mitigation will mediate potential modification of flow pathways.	Medium / Low	Minor / Moderate

Cluster ID	Inferred groundwater dependency	NVC Habitat	Sensitivity	GWDTE Cluster Area (Ha)	Contribution Zone Area (Ha)	% area of Cluster overlain by Infra. (Direct)	% area of cont. zone overlain by Infra. (Indirect)	Nearest Proposed Infrastructure & potential effects summary	Magnitude of effect	Significance of effect
14	Moderate	M6	Medium	1.86	10.28	None	None	Turbine 7, Crane Pad and Access Track situated up gradient from GWDTE parcel but outside of contribution zone. Mitigation will mediate potential modification of flow pathways but still possibility for minor impacts.	Medium / Low	Minor / Moderate
16	Moderate	M6	Medium	0.86	9.82	7.36	2.49	Access Track overlays GWDTE parcel bisecting a minor area of the contribution zone. Parcel likely to be fed from ombrotrophic habitat to the west, which is upgradient and will not be modified by the Proposed Development. As such, impacts will be low. Effects associated with habitat loss are discussed in Chapter 6: Ecology.	Low	Minor
19	Moderate / High	M32, M10, M10:CG10 :U5 (60:20:20), M10:U5: CG10 (60:20 :20)	Medium	17.24	106.65	None	0.49	Turbine 7, Crane Pad and Access Track situated up gradient from GWDTE parcel with minor loss of contribution zone area. Spring Communities at the top and bottom of the slope are unlikely to be affected by infrastructure which is positioned predominantly on the far side of the hill. Mitigation from the effects of access tracks which are situated within the contribution zone will mediate potential modification of flow pathways. The design of SUDs will encourage the use of local soakaways and therefore mitigate any indirect effects upon local infiltration and the Spring Communities. Notwithstanding, there is potential for some impacts associated with the setting of the GWDTE and infrastructure.	Medium	Moderate
21	Moderate	M6	Medium	0.39	34.25	None	None	Turbine 13, Crane Pad and Access Track situated over the watershed (cross gradient) from GWDTE parcel. Likely to be partially fed from ombrotrophic habitat on the fringe of the contribution zone. Complex microtopography could result in actual contribution zone being constrained and may have a minor impact on the volume of overland flow discharging towards habitat however this will be mitigated by track design and SUDs..	Medium / Low	Minor / Moderate
22	Moderate / High	M6, M10, M10:M37 (90:10)	Medium	3.39	28.20	None	3.42	Turbine 17 situated on Over Law with minor GWDTE parcels situated downslope. Contribution zone is overlain, however as GWDTE parcels are generally associated with the diffuse emergence of groundwater, the effects associated with causing minor modifications to surface water flow routes is likely to be minor. Percentage of contribution zone area loss in minor. The design of SUDs will also encourage the use of local soakaways and therefore mitigate any indirect effects upon local infiltration and the base-enrichment dependent communities. Notwithstanding, there is potential for minor impacts associated with the setting of the GWDTE and infrastructure	Medium / Low	Moderate
23	Moderate	M6	Medium	4.59	59.95	None	4.64	Access track is situated upgradient of GWDTE parcel with a Met Mast also upgradient. Only the track bisects the contribution zone area, with the loss being minor. Parcel is associated with surface overland flow from surrounding ombrotrophic habitats and therefore mitigation associated with access track construction will minimise associated impacts.	Low	Minor
24	Moderate / High	M10:M6:U5 (40:35:25)	Medium	8.37	21.55	None	None	The maximum likely zone of dewatering influence from Turbine 16 is expected to be proximal the lower extent and downgradient boundary of this	Low	Minor

Cluster ID	Inferred groundwater dependency	NVC Habitat	Sensitivity	GWDTE Cluster Area (Ha)	Contribution Zone Area (Ha)	% area of Cluster overlain by Infra. (Direct)	% area of cont. zone overlain by Infra. (Indirect)	Nearest Proposed Infrastructure & potential effects summary	Magnitude of effect	Significance of effect
								groundwater community. As the parcel is located on sloping ground and elevated in relation to construction, dewatering extents are unlikely to occur particularly as diffuse groundwater is likely to be emerging directly underneath / upslope. As such, impacts are not expected. Demarcation should be used to minimise / avoid habitat disturbance.		
26	Moderate / High	CG10:M10 (60:40)	Medium	1.29	5.49	None	None	Turbine 15, Crane Pad and Access Track situated well upgradient of GWDTE parcel and contribution zone. The diffuse emergence of groundwater within the vicinity of the GWDTE parcel and contribution zone are unlikely to be impacted.	Low	Minor
27	Moderate / High	M10, M6:U4:M23: U5 (40:30:20:10), M10-CG10	Medium	60.30	118.79	None	3.38	Turbine 14, Crane Pad and Access track are not situated within GWDTE habitats but bisect part of the contribution zone. Impacts on the constituent base enrichment indicator communities are likely to be low as these are a more substantial distance downslope (~160 m) and associated with local diffuse emergence of groundwater. Notwithstanding, more proximal areas of surface water / shallow seepage dependent communities may experience minor indirect effects however it is expected that mitigation and SUDS design can avoid modification of flow pathways.	Medium / Low	Minor / Moderate
28	Moderate	M23, M6, M6, M6	Medium	12.64	74.33	0.80	0.16	GWDTE parcels and contribution zones are bisected by Proposed Primary Access Route. A track already exists in these locations with GWDTE habitats situated in forest rides, areas of clear fell or in riparian zones. Widening techniques will incorporate effective drainage and use permeable materials to minimise flow modification. As such, it is expected that following the implementation of mitigation, impacts will be low. Effects associated with habitat loss are discussed in Chapter 6: Ecology.	Low	Minor
29	Moderate / High	M23, M23:M25	Medium	9.19	-	3.65	-	GWDTE parcels are bisected by Proposed Primary Access Route. A track already exists in this location with the GWDTE habitat situated in areas of clear fell in the riparian zones. Widening techniques will incorporate effective drainage and use permeable materials to minimise flow modification. As such, it is expected that following the implementation of mitigation, impacts will be low. Effects associated with habitat loss are discussed in Chapter 6: Ecology.	Low	Minor

Source: Natural Power

****Please note that GWDTE Cluster Area & Contribution Zone Area were undertaken in QGIS and only considers areas of habitat within the SEPA LUPS 31 buffer (as outlined in Section 8.2). As such calculations may differ from other habitat area estimations elsewhere in the EIAR. Where habitats are assumed to draw seepage from proximal watercourses of substantial size (i.e. Cluster ID 10 & 29) no calculation of the contribution zone or % area of the contribution zone overlain by infrastructure are provided.**

8.7. CONCLUSION

Table 8.3 indicate that as a result of the mitigation measures in place there would be minor, minor/moderate to moderate effects on GWDTEs associated with the proposed Development. This conclusion is reinforced by the site specific information in Section 8.3 and 8.4, which highlighted that the absence of productive hydrogeological conditions suitable for groundwater dependent habitat are absent, with waterlogging across the site being primarily a function of reduced infiltration capacity, topography and proximity to surface water channels. Based upon the assessment methodologies provided in the Chapter 8 of the EIAR: Hydrology, Hydrogeology & Geology, which assumes the successful design and implementation of mitigation measures, the residual effects on all of the identified receptors is considered to be **not significant**.

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