

# An integrated hydro-ecological approach to the identification of sensitive groundwater dependent terrestrial ecosystems within wind farm Environmental Impact Assessment

HELEN CULSHAW AND ANDREW HALCRO-JOHNSTON, GOLDER ASSOCIATES (UK) LTD,  
BELFAST OFFICE: 1ST FLOOR CARMONEY HOUSE, EDGEWATER BUSINESS PARK, EDGEWATER ROAD, BELFAST, BT3 9JQ.  
TADCASTER OFFICE: GOLDER HOUSE, TADCASTER ENTERPRISE PARK, STATION ROAD, TADCASTER, LS24 9JF.  
EDINBURGH OFFICE: 2ND FLOOR EAST, SIRIUS BUILDING, THE CLOCKTOWER, SOUTH GYLE CRESCENT, EDINBURGH EH12 9LB.

## Abstract

The identification of groundwater dependent terrestrial ecosystems (GWDE) that may be affected by wind farm developments requires close collaboration between ecologists and hydrogeologists involved in the Environmental Impact Assessment process. An integrated hydro-ecological approach to the identification of these sensitive systems has recently been made for a proposed site in Scotland to allow direct or indirect impacts to be avoided by design, or appropriate mitigation measures considered.

The National Vegetation Classification (NVC) system is used to identify and map wetland vegetation communities in order to ecologically assess whether they are likely to be potentially groundwater dependent ecosystems. Wetland ecosystems lie on a continuum between being purely groundwater dependent and being purely surface water runoff dependent. A hydrogeomorphic classification is used to identify the degree of dependence that the wetland ecosystem is likely to have to groundwater. This classification is based on the nature of the superficial and bedrock geology at the site. A matrix, which combines the results of the ecological and hydrogeomorphic classifications, is applied to identify the potential sensitivity of the ecosystems to the proposed development. Where sensitive ecosystems are identified, mitigation measures may be required to protect the quality and quantity of groundwater reaching the area.

## Wind Farm Environmental Impact Assessment Requirements

The EU Water Framework Directive (WFD) requires those terrestrial ecosystems that are dependent on groundwater (GWDEs) to be identified and the anthropogenic pressures acting on the ecosystems analyzed. As such, Environmental Impact Assessments for proposed wind farm developments are required to identify, assess and if necessary provide mitigation measures to protect sensitive wetland ecosystems that may be at risk from the development.

The Scottish Environment Protection Agency (SEPA) has produced a planning guidance note (2012) for wind farm developments, which includes a standard approach for the assessment of disruption to GWDEs. SEPA requires applicants to detail the measures that will be employed to protect sensitive GWDEs in proximity to site infrastructure: within 100 m of roads, tracks and trenches; or within 250 m of borrow pits and turbine foundations.

UK Technical Advisory Group for the Water Framework Directive (UKTAG) guidance on identification and risk assessment of GWDE (2004) identifies two complementary paths that can be used to identify GWDEs, the first through the presence of distinctive groundwater dependent plant communities (ecological assessment) and the second through identification of ground-surface water interactions (hydrogeological assessment). Golder has used an integrated hydro-ecological approach to identify whether sensitive GWDEs are present at a proposed wind farm site in the Scottish Borders, and assess the risks posed to them from the development.

1. M23 JUNCUS EFFUSUS/ACUTIFLORUS-GALIAM PALUSTRE RUSH-PASTURE, A HIGHLY GROUNDWATER DEPENDENT NVC COMMUNITY
2. M15 SCIRPUS CESPITOSUS-ERICA TETRALIX WET HEATH, A MODERATELY GROUNDWATER DEPENDENT NVC COMMUNITY
3. WETLAND WATER AND NUTRIENT SOURCES
4. CONCEPTUAL ZONES OF GROUNDWATER CONTRIBUTION
5. MARSHY GRASSLAND, A SENSITIVE WETLAND HABITAT

## Ecological Assessment using National Vegetation Classification of Wetland Communities

Broad wetland communities were identified at the site with the aid of SNIFFER (2009) guidance WFD95 – A Functional Wetland Typology for Scotland. A mosaic of upland wetland communities was mapped across the site, which included areas of peat bog, wet heath, wet acid grassland, marshy grassland and flush. This was followed by a detailed (NVC) survey, adapted from the NVC survey method (Rodwell, 2006), which identified wetland vegetation communities within 100 m of roads, tracks and trenches and 250 m of borrow pits and turbine foundations. A map was produced showing the location of NVC communities in relation to the proposed site infrastructure.

Eight distinct NVC communities of wetland vegetation were mapped, of which two are recognised by SEPA (2012) as highly groundwater dependent and three as moderately groundwater dependent. Highly groundwater dependent communities, such as M23 - *Juncus effusus/acutiflorus-Galium palustre* rush-pasture, were associated with areas of marshy grassland and flush over shallow peat (Plate 1). Moderately groundwater dependent communities, including M15 - *Scirpus cespitosus-Erica tetralix* wet heath, were largely associated with wet heath and bog communities over moderately deep peat (Plate 2). These communities were identified as potential GWDEs for which a hydrogeological risk assessment would be required.

## Hydrogeomorphic Classification to Identify Groundwater Dependent Wetlands

UKTAG guidance (2004) recognises that most "water dependent terrestrial ecosystems lie along a continuum between always only groundwater dependent and always only surface water dependent (Plate 3 indicates the water sources for wetlands). The source of water supply for some wetlands does not appear to be critical, therefore the task of identifying dependence upon groundwater is sometimes complex".

The SNIFFER (2007) guidance document Wetland Hydrogeomorphic Classification for Scotland produced a hydrogeomorphic classification for potential wetland areas within the Scottish landscape. This document 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.

The classification provides three levels of the likelihood of dependency of wetlands on a groundwater body:

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

At the proposed wind farm site the published geological information classified the underlying superficial geology as a low productivity drift aquifer and the bedrock as a fractured very low productivity aquifer, giving rise to a low likelihood of groundwater dependency.

## Identification of Sensitive Groundwater Dependent Ecosystems and Mitigation

The UKTAG (2004) guidance provides criteria for identification and inclusion of GWDEs in the risk assessment process, based on the complementary ecological and hydrogeological assessments. These criteria have been used to produce the matrix given in Table 1, which provides an identification of the sensitive and potentially sensitive GWDEs that will require a qualitative assessment to ascertain the significance of the risks the proposed development poses to them.

Since the aquifer beneath the proposed site was identified as having a low likelihood of groundwater dependence, using the matrix given in Table 1, only highly groundwater dependent NVC communities were identified as potentially sensitive GWDEs requiring further risk assessment. Moderately groundwater dependent communities were classified as not sensitive and therefore excluded from further assessment.

Conceptual zones of groundwater contribution were developed for these potentially sensitive GWDEs using the area identified as being up hydraulic gradient of the GWDE based upon the topographic information for the site. An example of how this was undertaken is presented in Plate 4.

The layout of the proposed wind farm was designed to avoid wetland habitats (Plate 5) as far as possible, thereby minimising direct effects on potentially sensitive GWDEs. However, the assessment identified that Turbine 1, located within the conceptual zone, could have a limited, short term effect on the groundwater supply to a nearby potentially sensitive GWDE. Turbine 2, located outside the conceptual zone, was unlikely to have an effect on GWDEs.

The access tracks were identified to potentially lead to a small reduction in groundwater recharge, and as a result SEPA requested the use of non alkaline porous material in track construction be considered in these areas. Along with other mitigation measures, including the adoption of best practice guidelines for access track construction (SNH, 2005) and pollution prevention (SEPA, 2007), no significant effects to GWDEs were predicted to arise from the proposed wind farm.

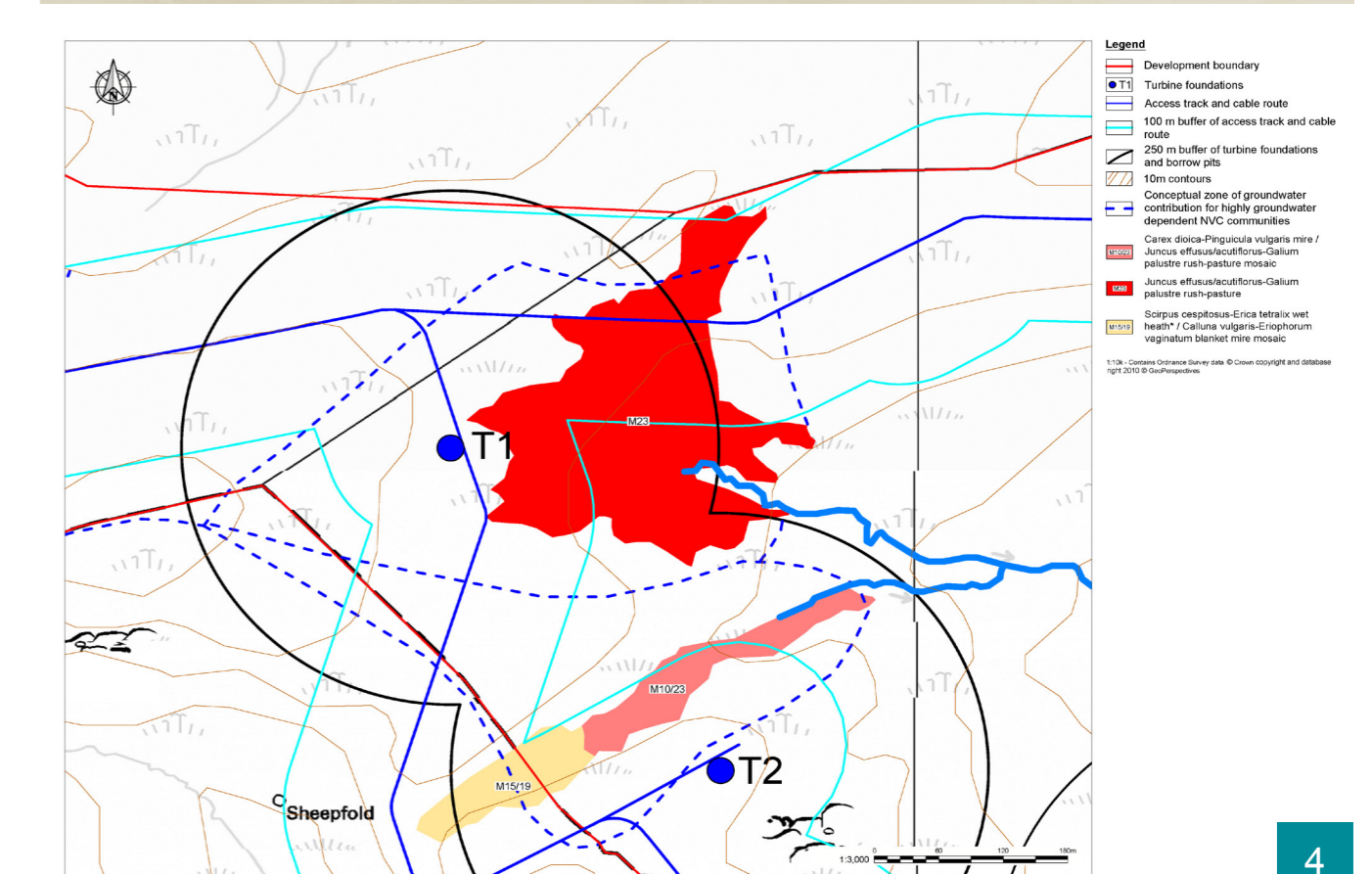
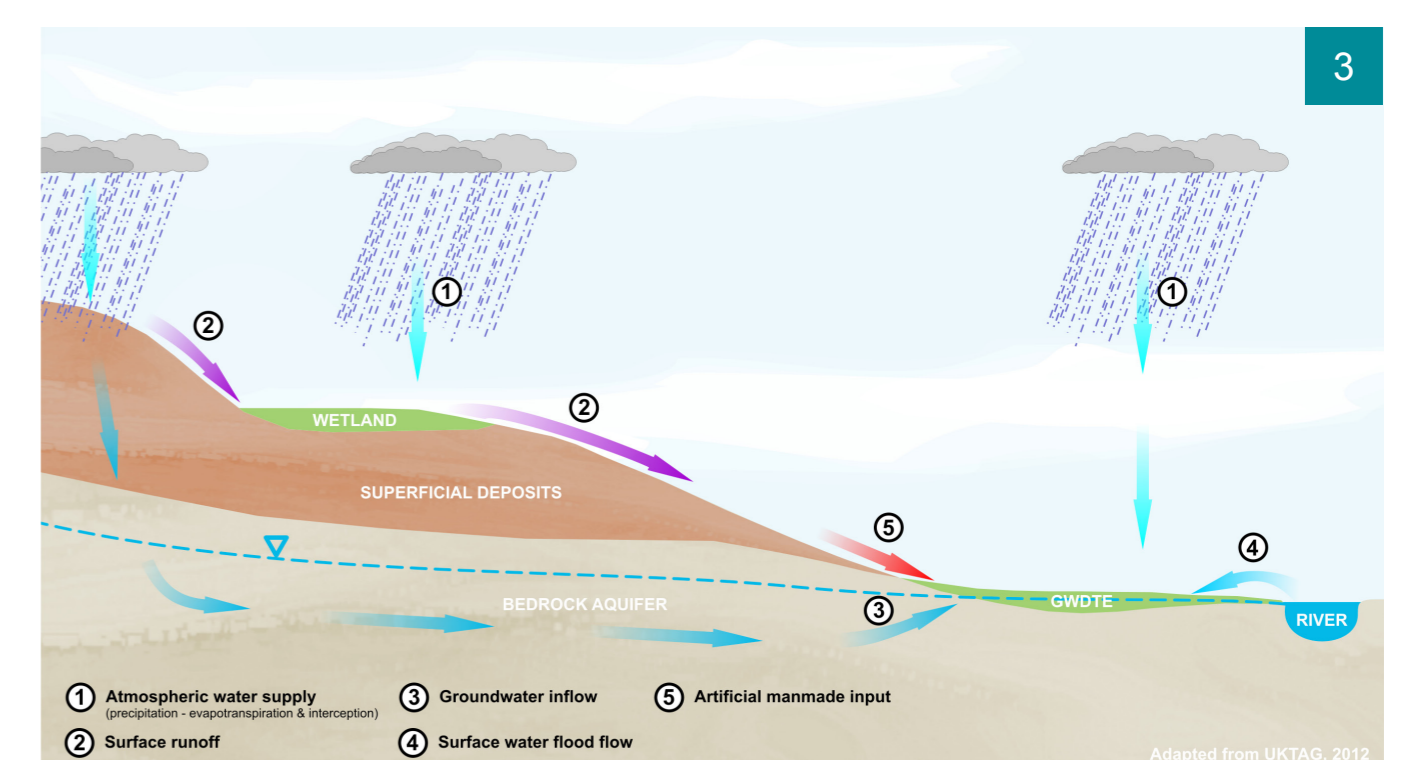


Table 1: Matrix for Identification of Sensitive GWDEs from Ecological and Hydrogeological Assessments

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

## References

- Rodwell, J.S. (2006) National Vegetation Classification: Users' Handbook. Peterborough: Joint Nature Conservation Committee.
- Scottish Environment Protection Agency (2007) Pollution Prevention Guidelines 5: Works and Maintenance in or near Water. Stirling: SEPA.
- Scottish Environment Protection Agency (2012) Land Use Planning System – SEPA Guidance Note 4: Planning Guidance on Windfarm Developments. Stirling: SEPA.
- Scottish Natural Heritage (2005) Constructed Tracks in the Scottish Uplands. Battleby: SNH.
- SNIFFER (2007) WFD66 – Wetland Hydrogeomorphic Classification for Scotland. Edinburgh: SNIFFER.
- SNIFFER (2009) WFD95 – A Functional Wetland Typology for Scotland. Edinburgh: SNIFFER.
- UKTAG (2004) Guidance on the identification and risk assessment of groundwater dependent terrestrial ecosystems (Working Draft).
- UKTAG (2012) Technical report on groundwater dependent terrestrial ecosystem (GWDE) threshold values.

