

Appendix A10.2: Ecological Receptors with Potential Groundwater Component

1 Introduction

- 1.1.1 This Appendix provides a baseline review and impact assessment of potential groundwater dependant ecological receptors present within the study area, supporting Chapter 10 (Geology, Soils, Contaminated Land and Groundwater).
- 1.1.2 The information is based on updated Phase 1 Habitat surveys undertaken in 2016, and targeted NVC and hydro-ecological surveys undertaken in 2016, in areas potentially considered as Groundwater Dependent Terrestrial Ecosystems (GWDTE).
- 1.1.3 A tiered approach has been adopted in the screening of ecological receptors with potential groundwater components, this has included:
- A Tier 1 Screening involving a desk and field based ecological review of existing Phase 1 habitat data collected by CH2M Hill in 2015 augmented by additional Phase 1 Habitat surveys undertaken by Jacobs in 2016 to determine (i) the presence or absence of a wetland habitat and (ii) the likelihood of a groundwater component based on the habitat characteristics and association of the habitat with watercourses. The results of the Tier 1 Screening are presented in Section 2, Table 1.
 - A Tier 2 Screening was undertaken on ecological receptors which were determined as 'Possible GWDTE' from the Tier 1 Screening Assessment. This involved NVC habitat surveys and an hydro-ecological conceptualisation of the wetland water supply mechanisms based on site observations, ground investigation data, geological data, hydrotopography and hydrogeological data. The results are summarised in Section 2, Table 1. The detailed survey observations and hydro-ecological conceptualisation are provided in Section 3, Tables 2 to 14.
- 1.1.4 It should be noted that in this process, the determination of the degree of groundwater dependency was derived starting with the SEPA GWDTE rating (Land Use Planning System Guidance Note 31: Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. Scottish Environment Protection Agency, LUPS-GU31, Version 2, 27 October 2014), and adjusted based on site observations and the hydro-ecological understanding of each site. As a result, GWDTEs are discussed as having a high, moderate or low groundwater dependency.
- 1.1.5 Figure 10.3 shows the location in relation to the general proposed scheme of Target Notes discussed in this Appendix, and where no Target Note reference was available, the Grouping reference has been added to the figure.
- 1.1.6 The impact assessment of the proposed scheme on the GWDTE is undertaken in Section 4 on the GWDTE identified through the the screening tiered process described above. The outcome of the assessment is summarised in Chapter 10 (Geology, Soils, Contaminated Land and Groundwater), Section 10.4 (Potential Impacts).

2 Baseline Identification of GWDTEs

2.1.1 A summary of the results from the Tier 1 and Tier 2 Screening is provided in Table 1 below. The details supporting the Tier 2 Screening are provided in Section 3.

Table 1: Review of ecological receptors with potential groundwater component

Target Note From Stage 2 (Figure 10.3)	Grouping following updated Phase 1 Surveys (Jacobs 2016)	Tier 1 Screening Assessment	Tier 1 Screening Assessment Results	Tier 2 Screening Assessment Results
TN66	N/A	Rush dominated areas with dense bracken and creeping thistle. The wetter areas are linear and associated with field ditches, and therefore are considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN89	N/A	Dominated by rush species, identified as a species-poor M23. Partly mown and in a grazed field. The habitat area does not follow the original boundary defined by CH2M Hill. The habitat is in a different location and is smaller than originally shown. The area appears poorly-drained and appears to follow a surface water flow path. Tier 2 Screening Assessment required to determine groundwater dependency.	Possible GWDTE	Non-GWDTE (Table 2)
TN95	N/A	Broadleaved semi-natural woodland. The (riparian) woodland is very limited consisting of a few trees, including larch and birch on top of River Garry bank protection. The habitat is not a wetland and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN137	N/A	Marshy grassland which could be M23 rush pasture. Tier 2 Screening Assessment required to determine groundwater dependency.	Possible GWDTE	Non-GWDTE (Table 6)
TN139	N/A	The habitat area does not follow what is shown on the original Phase 1 habitat boundary defined by CH2M Hill. This habitat has been found at ch12750-12800. Area of original target note appears to be more rush-like with patches of dry heath and acid grassland. Tier 2 Screening Assessment required to determine groundwater dependency.	Possible GWDTE	Moderate Dependency GWDTE (Table 7)
TN142, TN143, TN149	WHAG01	The area of wet heath is overstated here as the vegetation is far more fragmented and in a mosaic. The habitat areas do not follow the lines shown on the Phase 1 habitat survey maps. The wet heath/mire was identified as M15, but there are some elements of M17. Sphagnum is quite patchy, and almost absent (and purple moor-grass often dominant). The wetland habitat areas are associated with small streams and surface water flow paths, and therefore it is considered unlikely to have any dependency on a groundwater component	Non-GWDTE	n/a
TN154	N/A	The habitat area does not follow the areas shown on the original Phase 1 habitat boundary defined by CH2M Hill. The TN refers to an area adjacent to a small watercourse. The wetland habitat is linear and associated with a watercourse, and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a

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Target Note From Stage 2 (Figure 10.3)	Grouping following updated Phase 1 Surveys (Jacobs 2016)	Tier 1 Screening Assessment	Tier 1 Screening Assessment Results	Tier 2 Screening Assessment Results
TN155	N/A	The habitat area does not follow the areas shown on the original Phase 1 habitat boundary defined by CH2M Hill. The TN refers to an area adjacent to a small watercourse. The wetland habitat is linear and associated with a watercourse, and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN156	N/A	TN refers to area of managed (garden) grassland. Rush present in adjacent woodland. Further surveys have identified that there is no wetland habitat present at this location.	Non-GWDTE	n/a
TN160, TN162	TN160-162	Flush associated with minor watercourse. Surrounded by heath rush, bog myrtle, devil's-bit scabious, marsh thistle, occasional sphagnum, purple moor-grass, bog asphodel and buttercup. This has been identified within area of 'marshy grassland'. The marshy grassland is clearly much less extensive than is shown (more fragmented) on the Phase 1 habitat survey figures, and the bracken is more extensive. Tier 2 Screening Assessment required to determine groundwater dependency.	Possible GWDTE	Moderate Dependency GWDTE (Table 8)
TN166	N/A	Wet vegetation includes sphagnum, bog asphodel, heath rush, purple moor-grass. Hazel, willow and birch hedge. Dense woodland makes up the first 3.5m from lower road then open grassland/bracken with scattered trees. Small fragmented and discontinuous areas with no coherent single habitat. The wetter areas are linear and associated with surface water flow paths, and therefore are considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN167	N/A	Small patches of bog asphodel and purple moor-grass which are acid indicators. Neutral grassland and dry stone wall nearby with parts dominated by purple moor-grass. The wet area is not extensive and the habitat is fragmented and not coherent. This habitat is not considered to be a wetland at this location.	Non-GWDTE	n/a
TN170	N/A	Vegetation composition has been modified and degraded. Small patchy and fragmented habitats on highway verge. Not extensive. Further surveys have identified that there is no wetland habitat present.	Non-GWDTE	n/a
TN173, TN174	WHAG02	Broadly similar to WHAG01, except that the acid grassland (and dry heath) is a much greater component of the vegetation than indicated by the Phase 1 habitat survey. Small areas of soft rush were present within the mosaic. The wetland habitat is small and associated with minor streams and flow lines, and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN176	N/A	Mapped as fen. Abundant deergrass, purple moor-grass and cross-leaved heath. The mapped area corresponds properly with the aerial photography and is in fact located further away from the existing A9 than shown. Further surveys have identified the Phase 1 habitat mapping to be incorrect at this location and there is no wetland habitat present.	Non-GWDTE	n/a
TN180	N/A	Disturbed and degraded area of woodland which is not a wetland.	Non-GWDTE	n/a
TN182	TN182-187	A complex area mapped as fen and dominated by heather. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Non-GWDTE (Table 9)

Target Note From Stage 2 (Figure 10.3)	Grouping following updated Phase 1 Surveys (Jacobs 2016)	Tier 1 Screening Assessment	Tier 1 Screening Assessment Results	Tier 2 Screening Assessment Results
TN185	N/A	Acid mosaic which consists of heather, cross-leaved heath, purple moor-grass, tormentil, thistle, ragwort, sweet vernal and mat-grass. Habitat then changes with frequent self-seeded conifers, bird's-foot-trefoil and mouse-ear hawkweed. Partially disturbed ground is likely to be recolonized bare ground with patches of cross-leaved heath and conifer. Bog asphodel, purple moor-grass, heather and cross-leaved heath, sphagnum and cotton grass are present with exposed peat in areas where vehicles have tracked over. Habitat continues into mire but becomes increasingly dry and modified in places moving into a dry acid heath/grassland mosaic with some signs of improvement. Species here include heather, harebell, tormentil, sweet vernal grass, bird's-foot-trefoil, ribwort plantain and carnation sedge. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Non-GWDTE (Table 10)
TN187	TN182-187	Like TN182 - highly variable, but this area is much less dominated by heather. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Non-GWDTE (Table 9)
TN189	N/A	Dry channel running from woodland into field. Marshy indicators near to channel include purple moor-grass, sphagnum, carnation sedge, soft rush, mat-grass, marsh violet and deergrass. The wetland habitat is small and associated with a drainage ditch, and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN190	TN190-193	Acid grassland with purple moor-grass grassland, wavy hair-grass, tormentil, bog asphodel, bog myrtle, cross-leaved heath, common sorrel, fescues, meadowsweet, soft rush and perennial rye-grass. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Low Dependency GWDTE (Table 12)
TN193	TN190-193	Flush (acid/neutral), lots of moss, bog asphodel, cotton grass and adders tongue fern, surrounded by soft and compact rush, marsh orchids and heath bedstraw. Flush is within acid grassland. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Low Dependency GWDTE (Table 12) – grouped with TN190
TN194	N/A	Large area of wet heath between a slope and a watercourse. Separating the watercourse and the 'fen' is an area of dry acid grassland. Area partly already comprised by drainage ditches, forestry and existing A9. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Moderate Dependency GWDTE (Table 13)
TN195	N/A	Large area of mixed habitat including dry acid grassland (dominated by mat-grass), stands of bog myrtle, wet heath and some marshy grassland. Actual TN refers to a channel with some marshy grassland to either side. The wetland habitat is associated with a drainage ditch, and therefore it is considered unlikely to have any dependency on a groundwater component.	Non-GWDTE	n/a
TN197	N/A	Mire with wet channels running through containing species such as bog myrtle, purple moor-grass, bog asphodel and bog pondweed. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Non-GWDTE (Table 14)
TN203	N/A	The habitat is mainly dry acid grassland rather than wet heath (wet heath is a very small fragmented/discontinuous component). The Phase 1 habitat does not represent a wetland at this location.	Non-GWDTE	n/a
none	ANF02	This is a fragmented and disturbed habitat, affected by local infrastructure and drainage. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Low Dependency GWDTE (Table 11)

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Target Note From Stage 2 (Figure 10.3)	Grouping following updated Phase 1 Surveys (Jacobs 2016)	Tier 1 Screening Assessment	Tier 1 Screening Assessment Results	Tier 2 Screening Assessment Results
none	CF01	Area CF01. Calcareous spring/flush. Follows a surface water flow path down with suspected groundwater seepage. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	High Dependency GWDTE (Table 3)
none	Area Q	Area identified from SNH NVC habitat data as containing calcareous grassland and wet heath. Potential for further calcareous flushes in this area. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Low Dependency GWDTE (Table 4)
none	Area R	Area identified from SNH NVC habitat data as containing calcareous grassland and wet heath. Potential for further calcareous flushes in this area. Tier 2 Screening Assessment required to determine groundwater dependency of this receptor.	Possible GWDTE	Low Dependency GWDTE (Table 5)

3 Detailed survey observations

- 3.1.1 Table 2 to Table 14 below provide the detailed survey and hydro-ecological conceptualisation results of the targeted wetland habitat areas for the Tier 2 Screening Assessment.
- 3.1.2 Sources of information used within the assessment are detailed in Chapter 10 (Geology, Soils, Contaminated Land and Groundwater).

Table 2: Wetland habitat area 'TN89'

Overview	
<p>Legend • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems ■ High dependency ■ Moderate dependency ■ No/Low dependency</p> <p>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100049588. Contains public sector information licensed under the Open Government Licence v2.0.</p>	<p>NGR: NN 90956 63637</p> <p>Location (chainage): Killiecrankie (ch2300)</p> <p>Reason for selection: Mapped as basin mire fen within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M23 rush pasture
SEPA GWDTE rating	High
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Killiecrankie Schist
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Low / fracture flow
Hydrotopography	Stagno-topogenous
Wetland type	Percolation basin
Visual signs of groundwater	None
Local groundwater level from GI data	4.35 to 4.61mbgl (5m away from the wetland area)
Hydro-ecological Conceptualisation	
<p>The localised stand of M23 rush pasture occurs within a minor topographic basin within an area of improved grassland. The lack of a visible surface water outflow from the wetland area, and lack of any obvious groundwater seepage, would suggest that surface waters collect within this hollow and percolate into the underlying glacial deposits. This is supported by the depth of groundwater (>4mbgl) recorded from an adjacent borehole. This wetland is therefore considered to be dependent on surface water (primarily from adjacent runoff) and is not a GWDTE in this setting.</p>	Groundwater Dependency None

Table 3: Wetland habitat area 'CF01'

Overview	
	<p>NGR: NN 86992 64712</p> <p>Location (chainage): Tulach Hill and Glen Fender Meadow SAC (ch6400) Tulach Hill SSSI</p> <p>Reason for selection: Target noted as calcareous flush within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M10 & M11 mire / M37 spring / M26 mire
SEPA GWDTE rating	High
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Blair Atholl Dark Limestone and Dark Schist
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Low / fracture flow
Hydrotopography	Soligenous
Wetland type	Groundwater-flushed slope
Visual signs of groundwater	Yes – springs and tufa formation
Groundwater level from GI data	2.8 to 3.6mbgl 160m away, water strike at 5.7m (70m away)
Hydro-ecological Conceptualisation	
<p>These narrow linear flushes occur on a steep sided hillslope and are associated with groundwater springs at the upslope extent of the habitats. The vegetation type (base-rich / calcareous) and tufa formation strongly indicate a dependency on groundwater sourced from the underlying metalimestone bedrock and / or limestone rich glacial drift (derived from metalimestone). The habitat is considered to be a GWDTE with a high dependency on groundwater.</p>	
Additional Comments	
<p>The GWDTE is located upslope from the proposed A9 mainline and access road.</p> <p>GI data indicates that the glacial drift deposits in the area have a thickness of 5.4mbgl (though noted that the nearest borehole is 70m away and downslope from the GWDTE) and water strikes were encountered at the interface between the glacial drift and bedrock. During the site visit bedrock exposures were noted upslope of the GWDTE (where BGS maps record glacial till) indicating the depth or occurrence of drift deposits to be locally variable. The steep hillside features numerous minor watercourses and narrow topographic depressions which will influence the water table within the drift deposits. The localised and isolated occurrence of the GWDTE suggests that the supply of groundwater is driven by micro-topography and local hydrogeological conditions (e.g. the interaction between geological units of differing permeabilities and / or groundwater flow from fractures within bedrock), rather than being sourced from a more extensive and interconnected groundwater body.</p>	
Groundwater Dependency	
High	

Table 4: Wetland habitat area 'Area Q'

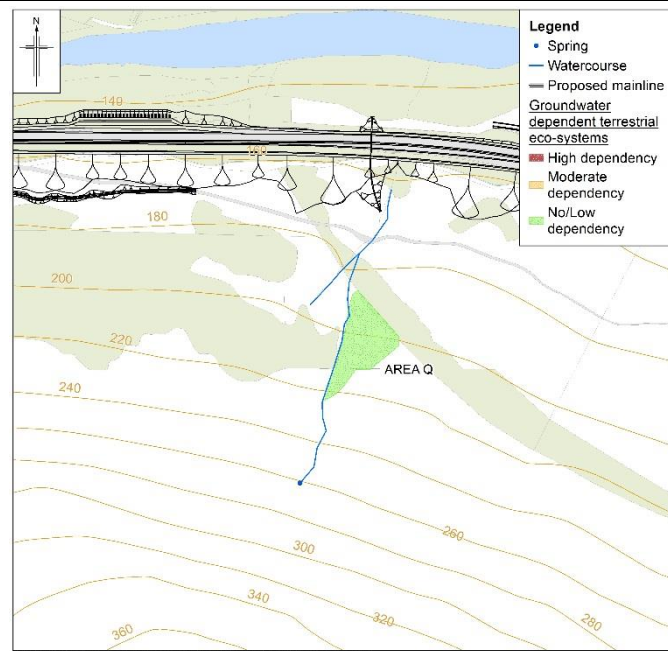

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems <ul style="list-style-type: none"> ■ High dependency ■ Moderate dependency ■ No/Low dependency <p><small>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100049698. Contains public sector information licensed under the Open Government Licence v2.0.</small></p>	 <p>NGR: NN 86082 65030</p> <p>Location (chainage): Tulach Hill and Glen Fender Meadow SAC (ch7600) Tulach Hill SSSI</p> <p>Reason for selection: Mapped as calcareous grassland within existing SNH NVC data (available from http://gateway.snh.gov.uk/natural-spaces/index.jsp).</p>
NVC habitat	M26 mire / CG10 grassland
SEPA GWDTE rating	Moderate
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Blair Atholl Dark Limestone and Dark Schist
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	Spring 90m upslope
Groundwater level from GI data	None available
Hydro-ecological Conceptualisation	
Groundwater Dependency	
<p>The localised area of wetter mire habitat (M26) occurs on a steep hillside within a shallow topographic depression. The habitat was observed to be supplied by a spring-fed watercourse which dispersed flows across the wetland area. Owing to the topographic setting, the wetland area is also likely to receive significant inputs from surface water runoff. The spring source of the watercourse is located at a considerable distance (90m) from the wetland. Subsequently the habitat is not considered to be directly dependent on a groundwater source.</p> <p>The surrounding areas of CG10 calcareous grassland are dry (not a wetland) and are located over limestone rich deposits, and therefore are not considered to be GWDTE in this setting. However, targeted Area Q has a low groundwater dependency potential.</p>	
Low	

Table 5: Wetland habitat area 'Area R'

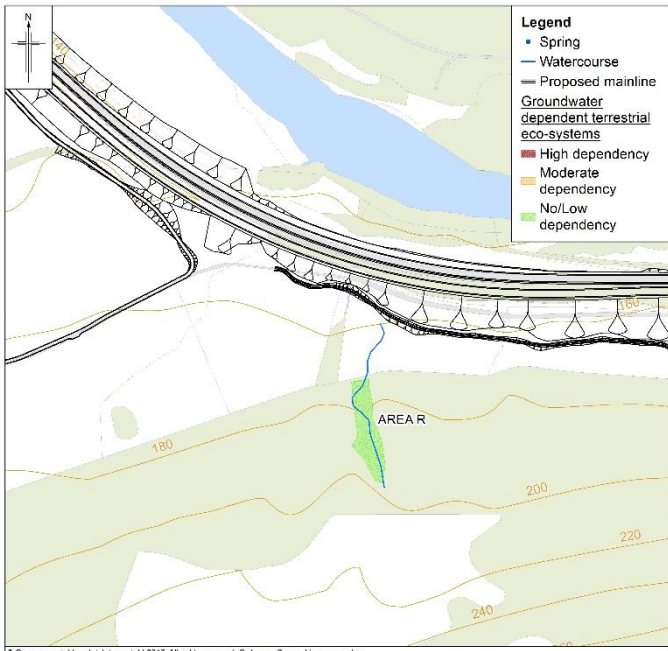

Overview	
	 <p>NGR: NN 85035 65088</p> <p>Location (chainage): Tulach Hill and Glen Fender Meadow SAC (ch8500) Tulach Hill SSSI</p> <p>Reason for selection: Mapped as calcareous grassland within existing SNH NVC data (available from http://gateway.snh.gov.uk/natural-spaces/index.jsp).</p>
NVC habitat	M15 wet heath
SEPA GWDTE rating	Moderate
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Blair Atholl Dark Limestone and Dark Schist
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	No
Groundwater level from GI data	3.23 to 5.21mbgl (250m away from the wetland area)
Hydro-ecological Conceptualisation	
<p>The localised area of wet heath (M15) occurs within a shallow topographic basin and is associated with a minor watercourse. A fault is indicated on geological map as underlying the habitat which may be associated with an increase in groundwater supply from fractured bedrock, however no springs or seepages were observed. The habitat is likely to receive significant inputs of surface water runoff due to the topographic setting. Due to the hydrotopography and association with a watercourse, the habitat is assessed as having a low dependency on groundwater inputs.</p>	<p>Groundwater Dependency</p> <p>Low</p>

Table 6: Wetland habitat area 'TN137'

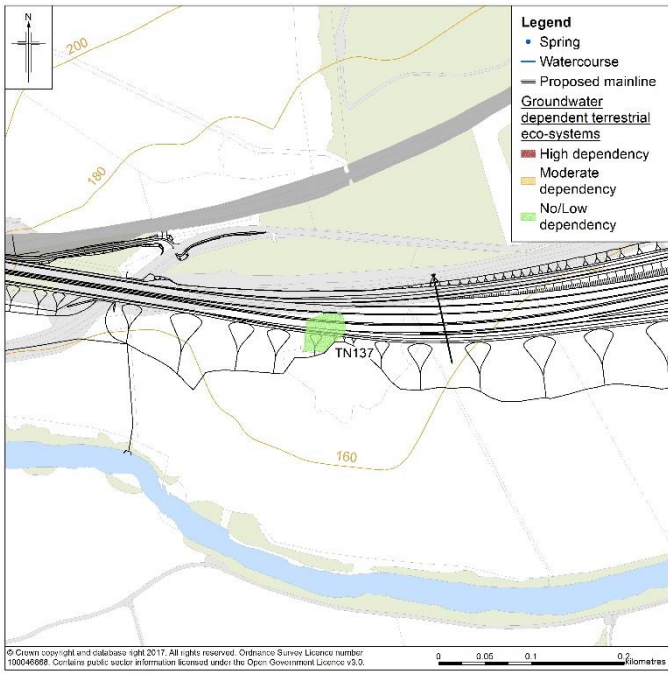

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems ■ High dependency ■ Moderate dependency ■ No/Low dependency <p><small>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</small></p>	 <p>NGR: NN 81593 65708</p> <p>Location (chainage): Pitagowan (ch12300)</p> <p>Reason for selection: Mapped as marshy grassland within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M23 rush pasture
SEPA GWDTE rating	High
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Stagno-topogenous
Wetland type	Percolation basin
Visual signs of groundwater	No
Groundwater level from GI data	0.39 to 1.35mbgl 80m away from the wetland area
Hydro-ecological Conceptualisation	
<p>The area of rush pasture (M23) occurs within a topographic basin between the existing A9 and an area of raised bedrock. The lack of a clearly visible surface water outflow from the wetland area, and lack of any visual signs of groundwater seepage, would suggest that surface waters collect within this basin (including runoff from the A9) and percolate into the underlying drift deposits. This wetland is therefore considered to be dependent on surface water and is not a GWDTE in this setting.</p>	Groundwater Dependency None

Table 7: Wetland habitat area 'TN139'

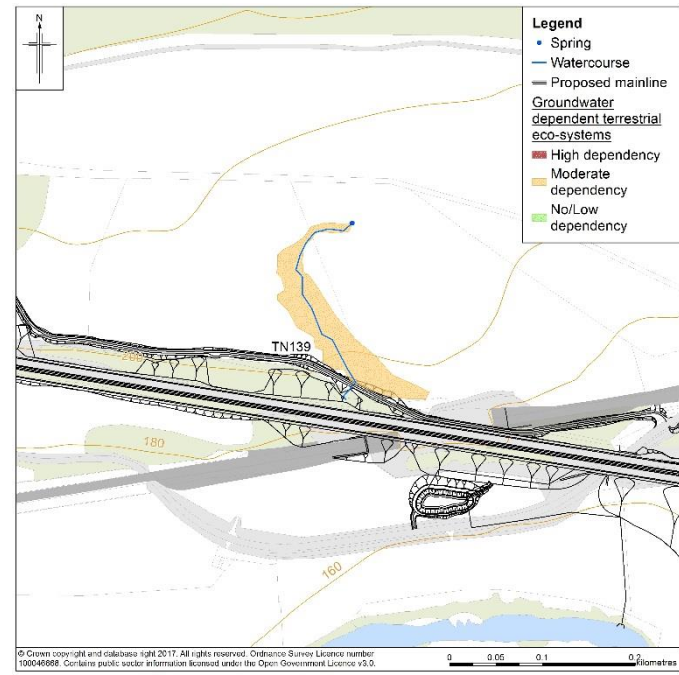

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems High dependency Moderate dependency No/Low dependency <p>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</p>	 <p>NGR: NN 81060 65901</p> <p>Location (chainage): Calvine (ch12800)</p> <p>Reason for selection: Mapped as marshy grassland within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M23 rush pasture
SEPA GWDTE rating	High
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	Yes – spring associated with minor watercourse headwaters
Groundwater level from GI data	0.95 to 3.31mbgl 15m away from the wetland area
Hydro-ecological Conceptualisation	
<p>The area of rush pasture (M23) occurs within a linear topographic depression on a gently sloping hillside. The habitat was observed to be associated with a spring-fed watercourse. Owing to the topographic setting, the wetland area is likely to receive significant inputs of surface water runoff from surrounding area. The spring source of the watercourse is located at the upslope extent of the wetland area. GI data from an adjacent borehole to the southern end of the wetland area indicates that the superficial glacial deposits extend to a depth of >24.7m and the groundwater level within these deposits is relatively shallow. The habitat is assessed as having a moderate dependency on groundwater inputs from the underlying drift deposits.</p>	
Additional Comments	
<p>The GWDTE habitat is located upslope of the proposed dual A9. It is noted that the wetland has already been disrupted by a significant cutting associated with existing A9 at the downslope extent of the habitat.</p>	
Groundwater Dependency	
Moderate	

Table 8: Wetland habitat area 'TN160-162'

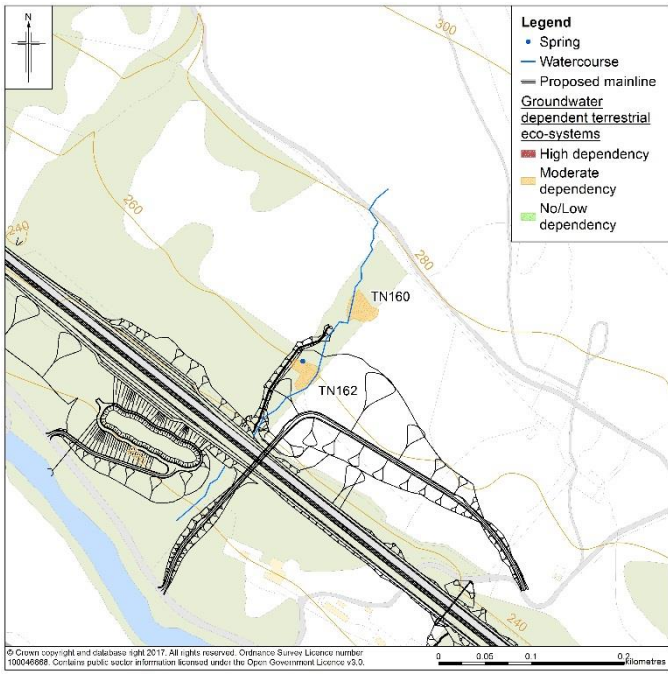

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems <ul style="list-style-type: none"> ■ High dependency ■ Moderate dependency ■ No/Low dependency <p><small>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</small></p>	 <p>NGR: NN 78161 67341</p> <p>Location (chainage): Clunes Lodge (ch16200)</p> <p>Reason for selection: Mapped as marshy grassland within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M6 acid flush
SEPA GWDTE rating	High
BGS Superficial deposits	Glacial till
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	Yes – localised seepage
Groundwater level from GI data	None available
Hydro-ecological Conceptualisation	
<p>The localised acid flushes (M6) occur within shallow topographic basins in an area dominated by dry habitat types (bracken and acid grassland). It should be noted that a larger area had previously been incorrectly mapped as marshy grassland. The occurrence of these habitats within topographic basins, in association with a minor watercourse and overlying low permeability geology, indicates a more significant surface water component than groundwater. These habitats are considered to have a moderate dependency on groundwater inputs in this setting.</p>	Groundwater Dependency Moderate

Table 9: Wetland habitat area 'TN182-187'

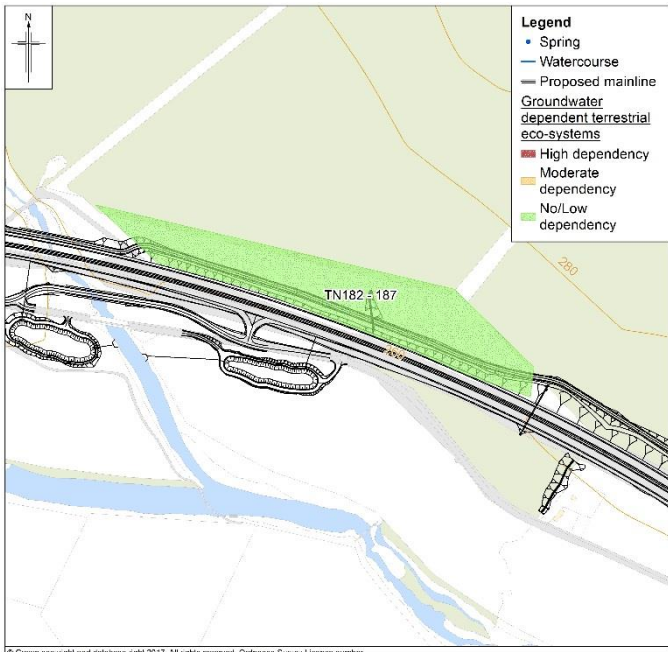

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems High dependency Moderate dependency No/Low dependency <p>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</p>	 <p>NGR: NN 75828 69575</p> <p>Location (chainage): Dalnamein Lodge (ch19500)</p> <p>Reason for selection: Mapped as fen within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M15 wet heath / M25 mire
SEPA GWDTE rating	Moderate
BGS Superficial deposits	Hummocky glacial deposits
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Ombrogenous
Wetland type	Ombrotrophic peatland
Visual signs of groundwater	No
Groundwater level from GI data	3.9 to 4.6mbgl within the survey area
Hydro-ecological Conceptualisation	
<p>The habitat was observed over flat topography with peat depths generally >1m (as evidenced from probing during the site visit). There were no indications of a groundwater component supplying the wetland area. The land upslope of the wetland area has been afforested, with stunted tree growth indicating a significant accumulation of peat. The wetland area is considered to part of an ombrotrophic (rain fed) system and is not a GWDTE in this setting.</p>	Groundwater Dependency
None	

Table 10: Wetland habitat area 'TN185'

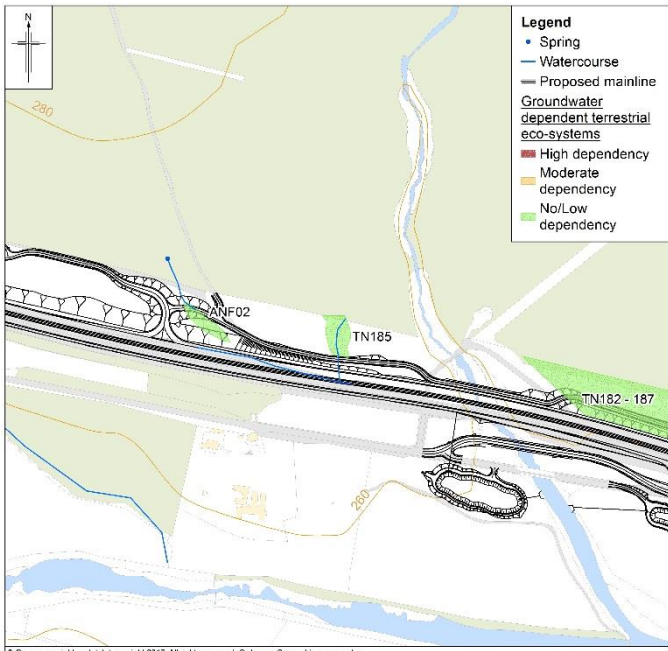

Overview	
 <p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems ■ High dependency ■ Moderate dependency ■ No/Low dependency <p><small>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number: 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</small></p>	 <p>NGR: NN 75359 69686</p> <p>Location (chainage): Dalnamein Lodge (ch20000)</p> <p>Reason for selection: Mapped as fen within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M15 wet heath
SEPA GWDTE rating	Moderate
BGS Superficial deposits	River terrace deposits
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	High / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Stagno-topogenous
Wetland type	Percolation trough / ombrotrophic peatland
Visual signs of groundwater	No
Groundwater level from GI data	1.27 to 1.6mbgl 65m away from the wetland area
Hydro-ecological Conceptualisation	
<p>The localised area of wet heath occurs within a shallow depression directly downslope of an area of deep peat (as evidenced through probing during the site visit and observed stunted tree growth). There were no indications of a groundwater component supplying the wetland area. The wetland area is considered to be directly dependent on surface water runoff from the upslope ombrotrophic (rain fed) system, which would naturally drain to this location. In addition the localised wetland is associated with a minor watercourse. The wetland is not considered to be a GWDTE in this setting.</p>	<p style="background-color: #0056b3; color: white; padding: 5px;">Groundwater Dependency</p> <p style="font-weight: bold; padding: 5px;">None</p>

Table 11: Wetland habitat area 'ANF02'

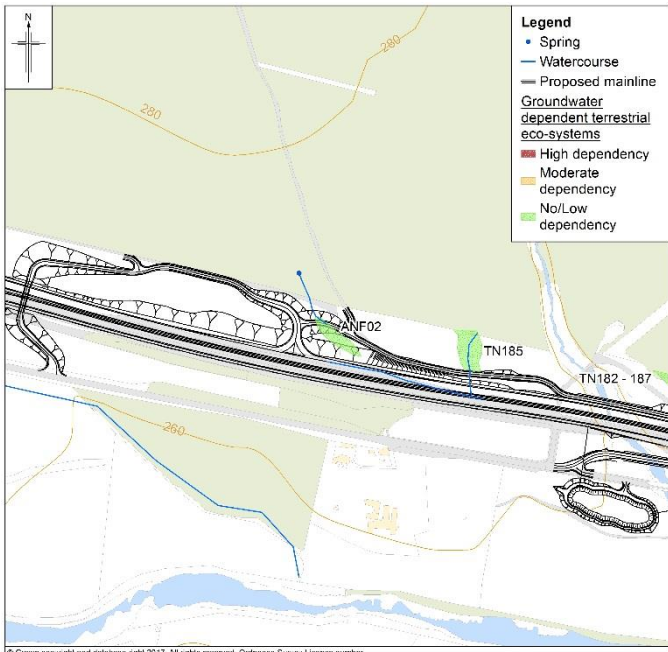

Overview	
	
	
<p>NGR: NN 75210 69703</p>	
<p>Location (chainage): Dalnamein Lodge (ch20100)</p>	
<p>Reason for selection: Mapped as acid / neutral flush within Phase 1 habitat data (CH2M Hill, 2015).</p>	
NVC habitat	M25 mire
SEPA GWDTE rating	Moderate
BGS Superficial deposits	Hummocky glacial deposits
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	Low / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	Spring approximately 50m upslope
Groundwater level from GI data	2.11 to 5.48mbgl 190m away from the wetland area
Hydro-ecological Conceptualisation	
<p>The stand of M25 occurs within a shallow linear depression. The wetland is supplied by surface water from a minor watercourse which spreads flows diffusely over the wetland area. This watercourse was observed to be fed by a spring approximately 50m upslope of the wetland area. Due to the distance between the spring source and the wetland, and the likely contribution of surface water runoff due to the hydrotopography of the wetland, the habitat is considered only to have a low dependency on groundwater inputs.</p>	
Groundwater Dependency	
Low	

Table 12: Wetland habitat area 'TN190-TN193'

Overview	
<p>Legend</p> <ul style="list-style-type: none"> • Spring — Watercourse — Proposed mainline Groundwater dependent terrestrial eco-systems ■ High dependency ■ Moderate dependency ■ No/Low dependency <p><small>© Crown copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100040688. Contains public sector information licensed under the Open Government Licence v3.0.</small></p>	<p>NGR: NN 74729 69730</p> <p>Location (chainage): Tigh-na-Coille (ch20600)</p> <p>Reason for selection: Mapped as acid / neutral flush within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M23 rush pasture
SEPA GWDTE rating	High
BGS Superficial deposits	Alluvium
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	High / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Percolation trough
Visual signs of groundwater	No
Groundwater level from GI data	None available
Hydro-ecological Conceptualisation	
<p>The M23 rush pasture occurs as a narrow stand alongside two modified watercourses which run underneath and parallel to the existing A9 embankment. The habitat surrounding the rush pasture is acid grassland. The identified area is probably a fragment of a larger wetland area that would have been connected with GWDTE survey area 'F10' prior to the construction of the existing A9 and diversion of watercourses. Due to the occurrence of the M23 alongside minor watercourses, the current habitat is considered only to have a low dependency on groundwater inputs. The minor watercourses will locally control groundwater levels within the superficial alluvial deposits, and therefore the habitat is considered only to have a low dependency on groundwater inputs.</p>	<p>Groundwater Dependency</p> <p>Low</p>

Table 13: Wetland habitat area 'TN194'

Overview	
<p>NGR: NN 74304 69876</p>	
<p>Location (chainage): Tigh-na-Coille (ch21000)</p>	
<p>Reason for selection: Mapped as valley mire / marshy grassland within Phase 1 habitat data (CH2M Hill, 2015).</p>	
NVC habitat	M15 wet heath / M25 mire
SEPA GWDTE rating	Moderate
BGS Superficial deposits	River terrace deposits
BGS Bedrock deposits	Strathummel Group
Superficial aquifer productivity / flow mechanisms	High / intergranular
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Rheo-topogenous
Wetland type	Seepage percolation trough
Visual signs of groundwater	Yes – frequent seepage at the upslope extent
Groundwater level from GI data	At ground level within the wetland area
Hydro-ecological Conceptualisation	
<p>The wetland area occurs within a linear topographic depression and on the left bank (looking downstream) of a modified watercourse. There are frequent springs at the upslope extent of the wetland area which primarily feed into minor watercourses and flushes. The habitat is assessed as having a moderate dependency on groundwater inputs based on the site observations of groundwater springs and association of the habitat with permeable superficial river terrace deposits.</p>	
Additional Comments	
<p>The watercourse between the proposed A9 mainline and the GWDTE will locally control groundwater levels within the river terrace deposits, as evidenced by the lack of any wetland habitat on the right bank (where it is disconnected from the groundwater inputs).</p>	
Groundwater Dependency	
Moderate	

Table 14: Wetland habitat area 'TN197'

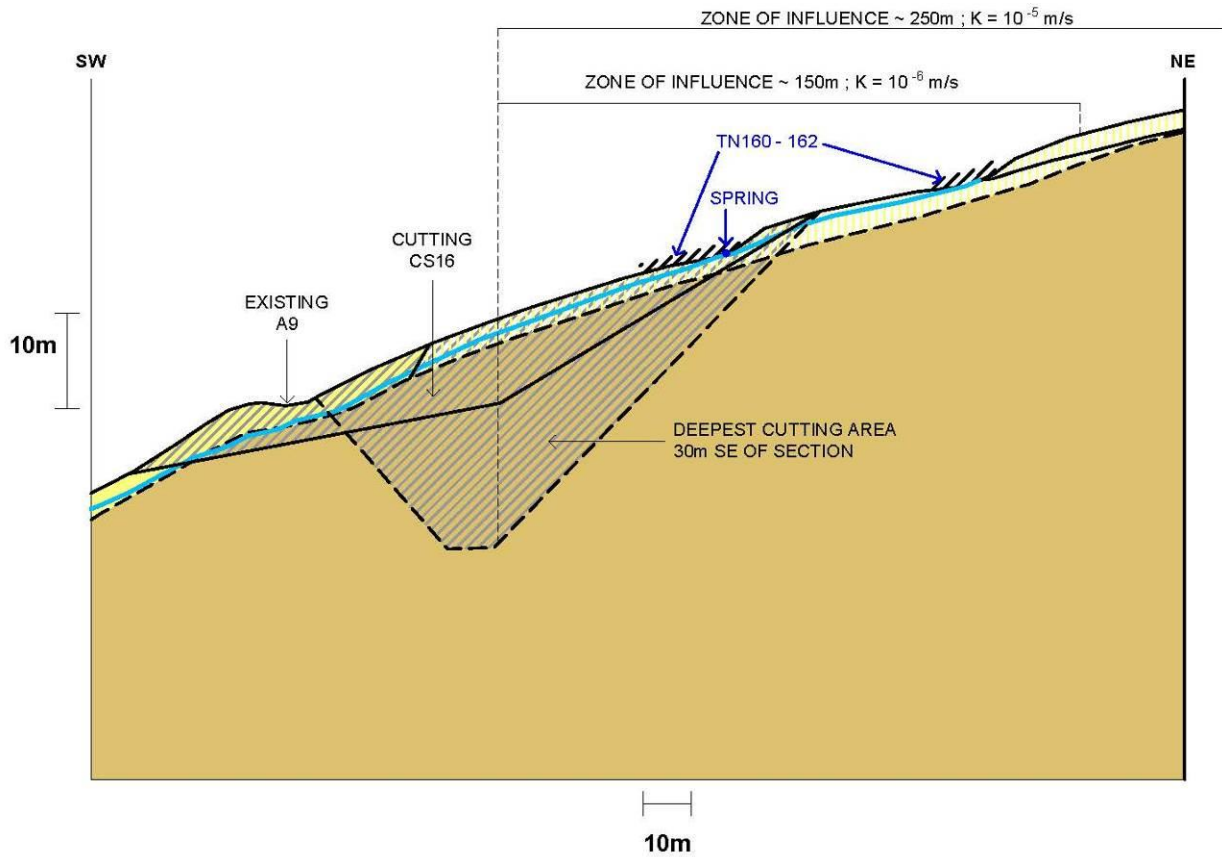
Overview	
	<p>NGR: NN 73683 70264</p> <p>Location / chainage: Tigh-na-Coille (ch21900)</p> <p>Reason for selection: Mapped as fen / marshy grassland within Phase 1 habitat data (CH2M Hill, 2015).</p>
NVC habitat	M15 wet heath / M25 mire / acid grassland / dry heath
SEPA GWDTE rating	Moderate
BGS Superficial deposits	None recorded
BGS Bedrock deposits	Strathtummel Group
Superficial aquifer productivity / flow mechanisms	N/A
Bedrock aquifer productivity / flow mechanisms	Very low / fracture flow
Hydrotopography	Ombrogenous
Wetland type	Ombrotrophic peatland
Visual signs of groundwater	No
Groundwater level from GI data	None available
Hydro-ecological Conceptualisation	
<p>This large area contains a mosaic of wet heath (M15), dry heath and acid grassland with some localised wetter areas of mire (M25). The underlying geology does not suggest a groundwater component, and this was supported by the lack of any field observations of groundwater seepage. The wetter areas were generally underlain by peat (>0.5m as evidenced from probing during the site visit). The M15 and M25 habitats, in mosaic with dry heath and acid grassland habitat types, are considered to be part of a broader ombrotrophic (rain-fed) system which extends up the hillside to the north. These habitats are not considered to be GWDTE in this setting.</p>	Groundwater Dependency None

4 Impact assessment on identified GWDTE

- 4.1.1 A high level review of potential impacts has been undertaken for the GWDTEs identified through the tiered process in Section 2 in relation to road cuttings and widenings and information provided in Chapter 10 (Geology, Soils, Contaminated Land and Groundwater). The outcome of this review is the following:
- TN139 : No impact on the spring feeding the GWDTE is expected as a result of CS14.
 - TN160-162 : Direct loss of habitat and spring as a result of CS16 in the lowest part. Detailed assessment needed to ascertain the level of impact on the upper portion.
 - TN190-193 : Potential impact as a result of CS20. A detailed assessment is required.
 - TN194 : No impact is expected on the hydrogeological function of this receptor as no road cutting or widening is proposed in this area.
 - ANF02 : Detailed assessment needed to ascertain the level of impact on hydrogeological – hydrological functioning of the receptor as a result of W18.
 - CF01 : Potential impact as a result of CS12. No impact expected as a result of W5 and W22. A detailed assessment is required.
 - Areas Q and R : potential impact as a result of W6. A detailed assessment is required.
- 4.1.2 Detailed assessments identified as being required are provided below.

TN160-162

Diagram 1: Cross Section for TN160-162



KEY:

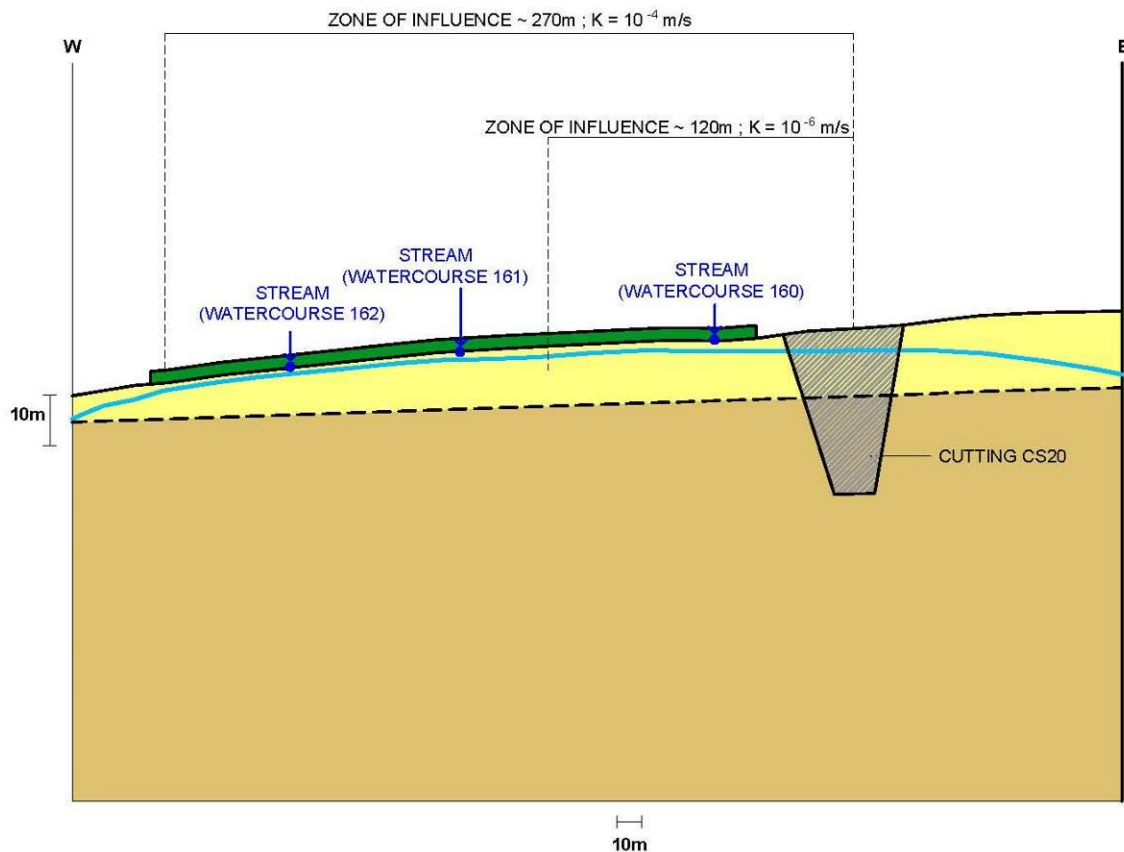
- Groundwater Level (maximum)
- Drift Deposits (sand and gravel)
- Glacial Till
- Bedrock : Psammite (coarse / medium)

4.1.3 Cutting CS16 is a deep cutting, expected to generate a dewatering effect with a zone of influence of 150 to 250m based on the Sichardt method, despite the presence of glacial till and psammite intercepted by the cutting.

4.1.4 The lowest part of TN160-162 will be directly impacted by the foot print of the cutting and the upper part of TN160-162 may also be impacted indirectly. This is because, in addition to a potential minor groundwater drawdown at the upper TN160-162 location, the surface water which supports TN160-162 may also be indirectly affected. The impact on this surface water will depend on the degree of interconnectivity with the burn and groundwater which remains unclear, especially as no GI information is available outside the CPO for the proposed scheme. This is expected to result in a moderate magnitude of impact on TN160-162.

TN190-193

Diagram 2: Cross Section for TN190-193



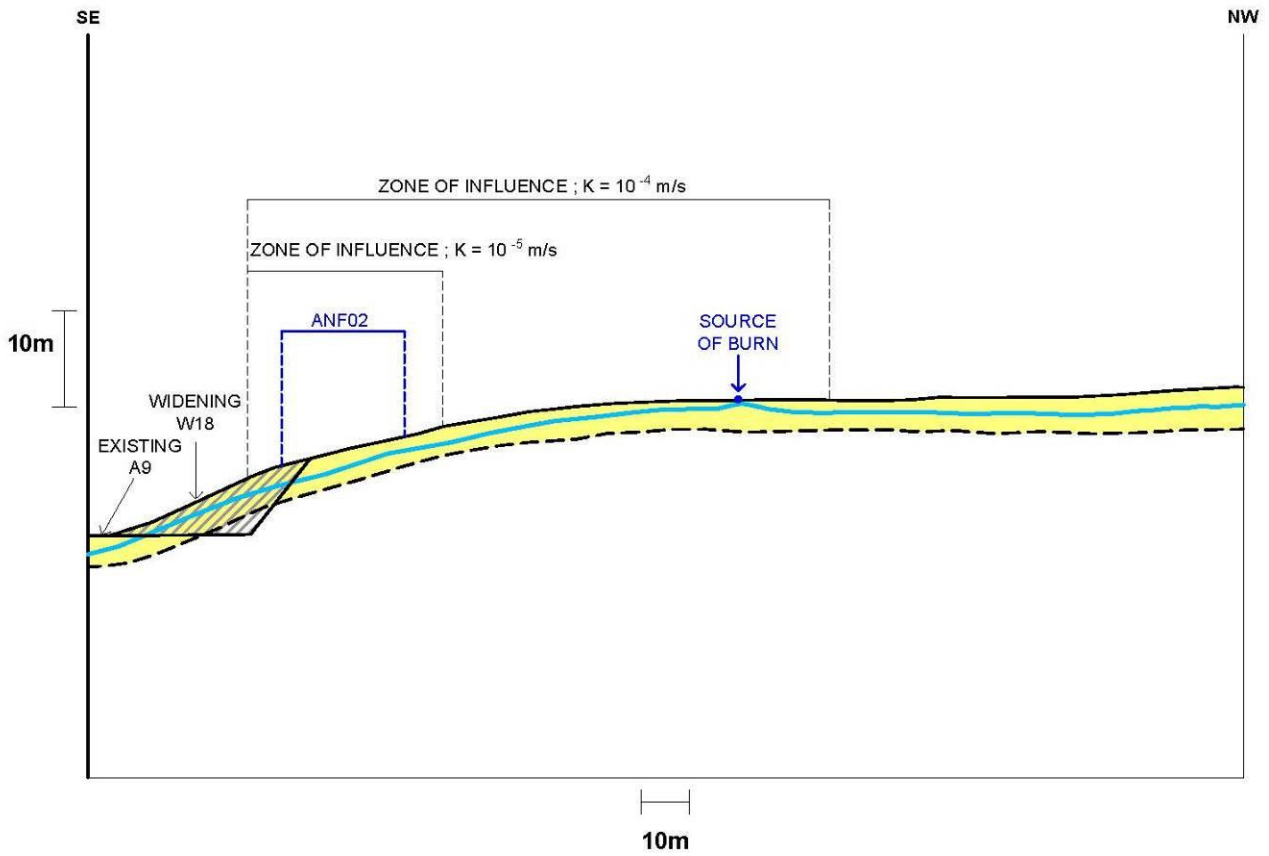
KEY:

- Groundwater Level (maximum)
- GWDTE (TN190 - 193)
- Drift Deposits (sand and gravel)
- Bedrock : Psammite (coarse / medium)

- 4.1.5 Cutting CS20 is a moderately deep cutting, expected to generate a dewatering effect with a zone of influence of 120m to 270m based on the Sichardt method; because of the presence of sand and gravels within the cutting area.
- 4.1.6 The eastern end of the GWDTE in the area surrounding watercourse 160 is likely to be indirectly impacted by the predicted dewatering at cutting CS20. Due to the close proximity of cutting CS20 and depending on the degree of connectivity between groundwater and surface water / sub-surface water, this is likely to result in a noticeable impact on this eastern part of the GWDTE.
- 4.1.7 However, because of the presence of watercourses 160 and 161, impacts are unlikely to be of significance in the western part of the GWDTE, beyond watercourse 161.
- 4.1.8 Overall, at the scale of the TN190-193 site, this is expected to result in a moderate magnitude of impact.

ANF02

Diagram 3: Cross Section for ANF02



KEY:

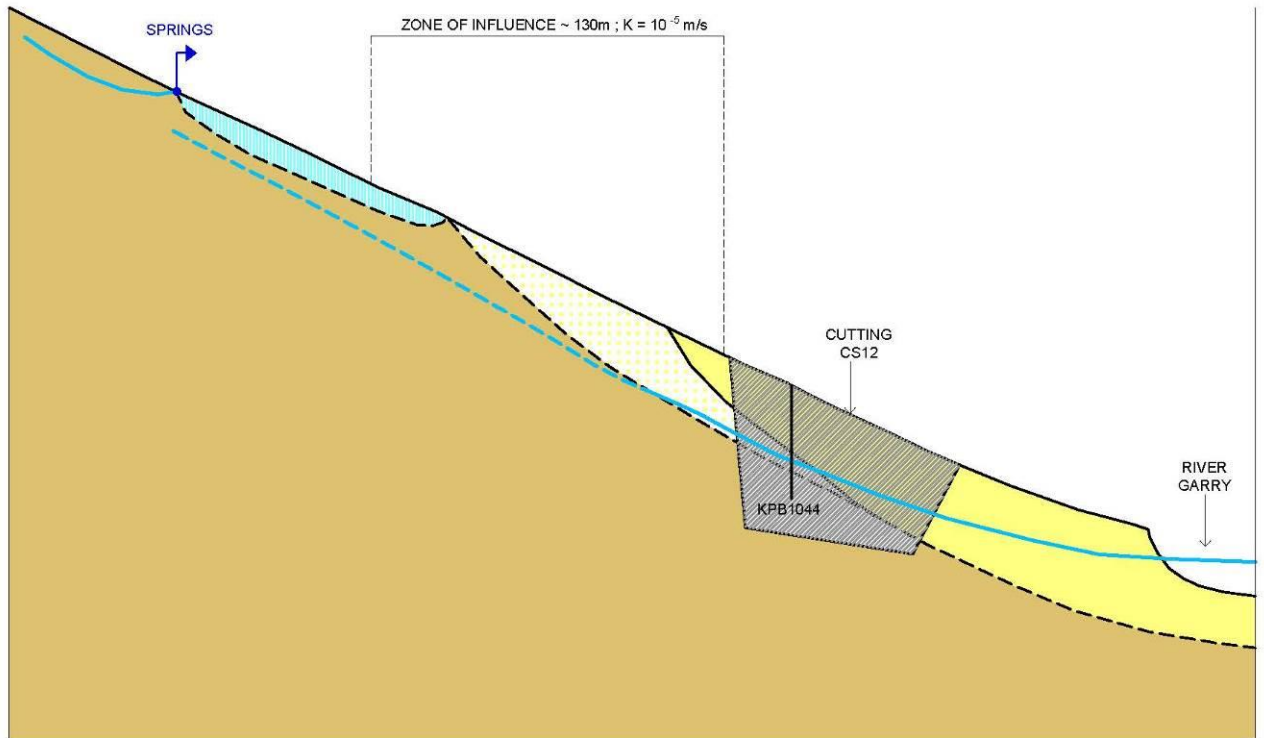
- Groundwater Level (maximum)
- Drift Deposits (sand and gravel)

4.1.9 ANF02 is expected to be fully part of the zone of influence generated by Widening W18 and the impact is expected to be direct and of major magnitude.

CF01

- 4.1.10 Given the sensitivity of CF01 further work was recommended to reduce the uncertainty surrounding the local geology and complement ground investigation findings. A subsurface coring survey was conducted on 23 March 2017 aimed at confirming the nature and extent of the superficial deposits in the area between cutting CS12 and CF01, the mechanism sustaining the GWDTE and to confirm whether the dewatering effect from cutting CS12 would have any impact on the habitat.
- 4.1.11 Sixteen subsurface samples were collected using a hand corer from the vicinity of CS12 and CF01 at locations as set out in Figure 10.4. Depth of samples retrieved varied between 0.12m and 0.51m. In the vicinity of cutting, CS12, samples were dry and superficial deposits consisted of silty sand with some gravel. Samples collected adjacent to the GWDTE contained glacial till overlain by saturated topsoil, whilst to the west of the GWDTE, on a topographical ridge running parallel to CF01, samples were comprised of dry silty sand, and are considered to represent hummocky glacial deposits. Cores sunk above the GWDTE habitat encountered thin (<0.15m) topsoil layers directly above unweathered bedrock, and bedrock exposures were noted further upslope with horizontal and vertical jointing visible.
- 4.1.12 As previously discussed in Table 3, CF01 is a flush habitat in topographic lows overlying till, though water was also noted flowing directly over the exposed bedrock in the upper reaches of CF01.
- 4.1.13 Based on the evidence collected, the GWDTE habitat lies above a layer of glacial till, and is fed by groundwater flowing out of the bedrock, forced to the surface at the interface between the till and bedrock. The water flows over the ground surface where the low permeability till is present, creating the CF01.
- 4.1.14 Overall, the superficial deposits encountered between CF01 and cutting CS12 are likely to have hydraulic conductivity in the region of 10^{-5} - 10^{-6} m/s, which would result in dewatering zones of influence of 130m and 80m respectively applying Sichardt calculations. In addition, the mechanism feeding CF01 is isolated from the silty sand and gravel in which cutting CS12 will be constructed by the presence of glacial till.
- 4.1.15 Based on this conceptual understanding and semi-quantitative assessment, no impact is anticipated on CF01.

Diagram 4: Cross Section for CF01

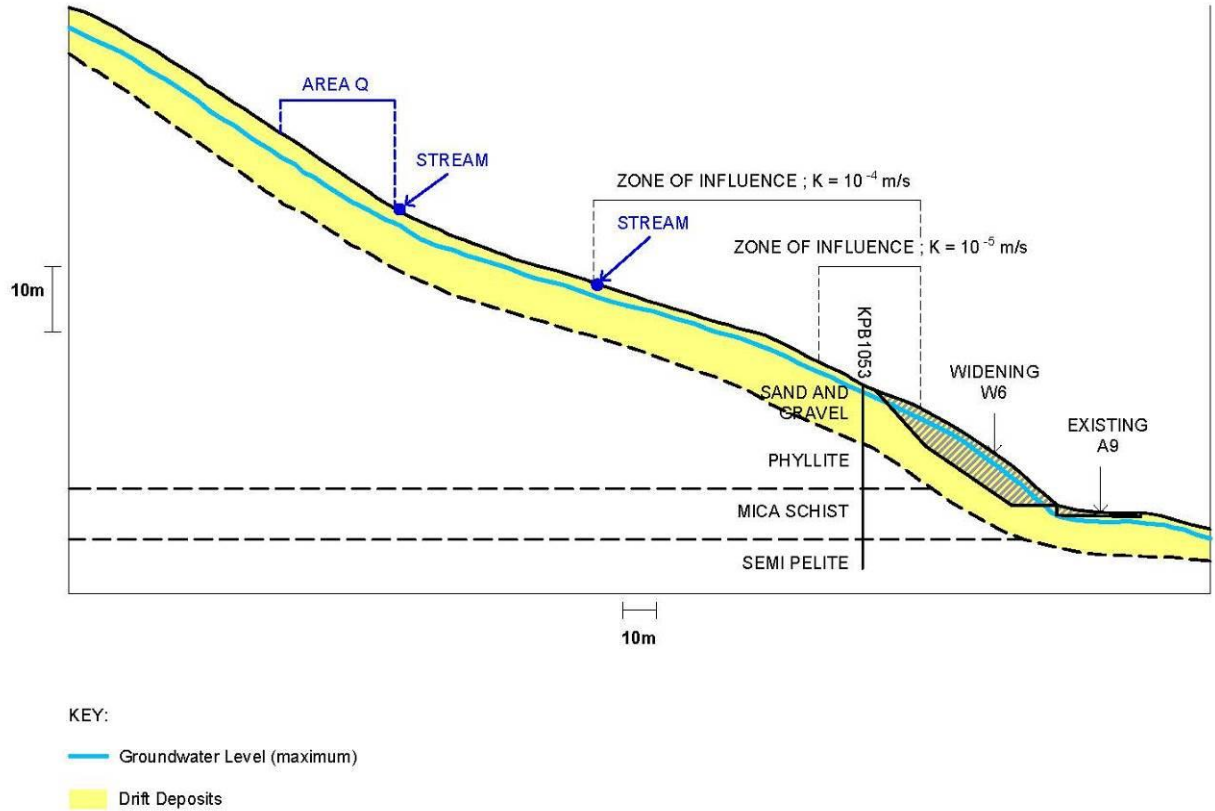


KEY:

-  Groundwater Level (maximum)
-  Sand and Gravel
-  Bedrock
-  Glacial Till
-  Silty Sand

Area Q

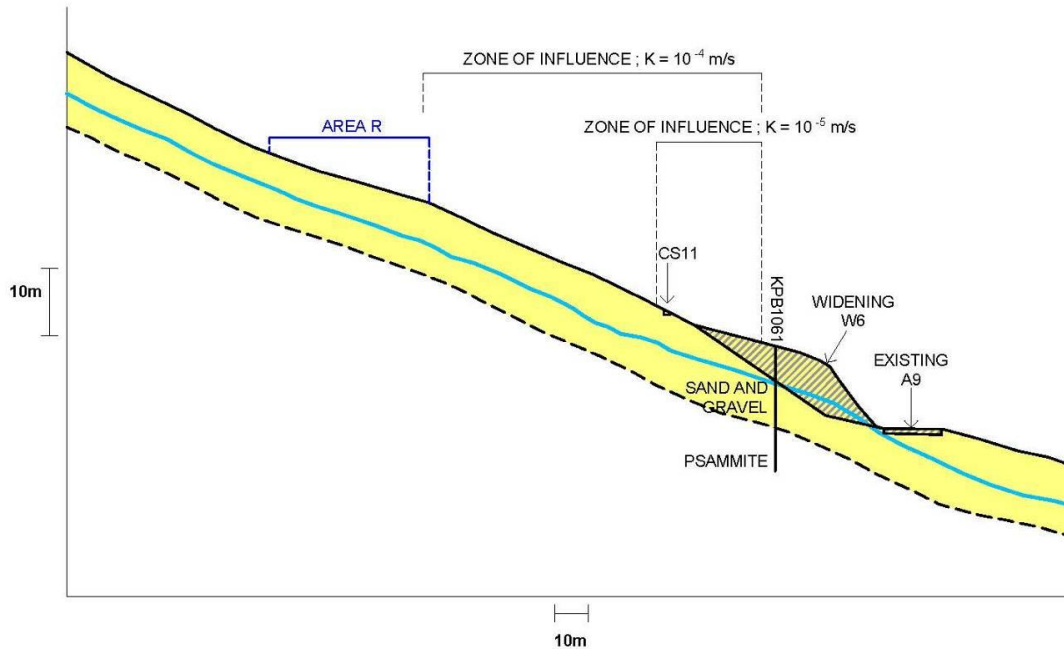
Diagram 5: Cross Section for Area Q



4.1.16 Cutting W6 is expected to generate a dewatering effect with a zone of influence of up to 100m, based upon calculations using the Sichardt method. This is not expected to intercept Area Q and is downgradient of the water that supplies this GWDTE, so no impact is envisaged.

Area R

Diagram 6: Cross Section for Area R



KEY:

- Groundwater Level (maximum)
- Drift Deposits

- 4.1.17 Cutting W6 is expected to generate a dewatering effect with a zone of influence of 30m to 100m, based upon Sichardt calculations.
- 4.1.18 The maximum predicted dewatering zone of influence is expected to just reach the lower, downgradient boundary of the Area R GWDTE. This estimate is based upon a relatively high hydraulic conductivity estimate for the superficial deposits in this area, however as the nature of drift deposits changes away from the cutting and become less permeable, actual dewatering impacts are not expected to occur up to 100m. On this basis, no impact is expected.

5 Conclusion

- 5.1.1 The assessment suggests the following outcome :

Table 15: GWDTE impact assessment summary

Cutting	GWDTE	Sensitivity	Magnitude of Impact	Significance of Impact
CS14	TN139	high	none	N/A
CS16	TN160-162	high	moderate	Moderate/Large
CS20	TN190-193	medium	moderate	Moderate
N/A	TN194	high	none	N/A
W18	ANF02	medium	major	Large
CS12	CF01	very high	none	N/A
W6	Area Q	medium	none	N/A
W6	Area R	medium	none	N/A