NORTHCONNECT
CONNECTING RENEWABLES

Chapter 8: Geology and Hydrogeology

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Contents

8 Geology and Hydrogeology

8.1 Introduction

The chapter provides a background baseline description of the existing geology and soil features of the area in relation to the HVDC cabling activities. It then assesses the key issues raised regarding the effects associated with construction activities which could impact land quality. Operational effects on land quality and possible decommissioning effects were scoped out of the assessment.

8.1.1 Planning Framework

8.1.1.1 National

The (NPF3) sets as one of the four key priorities for the Scottish Government the protection and promotion of Scotland's key environmental resources, whilst supporting their sustainable use (Scottish Ministers, 2014a). The Scottish Planning Policy (Scottish Ministers, 2014b) identifies two principles guiding policies and decisions relating to land quality. These are:

'Having regard to the principles for sustainable land use set out in the Land Use Strategy; and

Avoiding over-development, protecting the amenity of new and existing development and considering the implications of development for water, air and soil quality'.

It is stated in the Scottish Planning Policy that:

'The planning system should seek to protect soils from damage such as erosion or compaction' and that 'Local nature conservation sites designated for their geodiversity should be selected for their value for scientific study and education, their historical significance and cultural and aesthetic value, and for their potential to promote public awareness and enjoyment'.

8.1.1.2 Local

Under the Aberdeenshire Local Development Plan (Aberdeenshire Council, 2017) there are a number of policies which are relevant to the land use topic.

- Policy PR1 relates to, 'Protecting Important Resources, which covers mineral resources, prime agricultural land."
- Policy P1, 'Layout, siting and design of new development', particular requirements are imposed on new developments on land that is contaminated or suspected of contamination.
- Policy P4, 'Hazardous and potentially polluting developments and contaminated land', developments which pose and unacceptable danger to the public or the environment will be refused development under this policy.
- Policy E1 relates to 'Natural Heritage', stated that the Council will *'not allow new development where it may have an adverse effect on a nature conservation site designated for its biodiversity or geodiversity importance,'* exceptions to this are identified.
- Policy C3 sets out requirements to protect any peat rich soils as Carbon sinks and stores.

Additionally, the Scottish Executive has issued advice to planning authorities on the development of contaminated land, in the form of Planning Advice Note 33 Scottish Executive, 2000 (Scottish Government 2000). Part of the PAN 33 discusses the need for land to be "suitable for use", particularly:

"ensuring that land is made suitable for any new use, as planning permission is given for that new use"; and

"limiting requirement for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to the current use of the land for which planning permission is being sought".

8.1.2 Guidance and Reports

The following sources of information were utilised:

- Ground Investigation method:
    - BS EN 1997-1:2004+A1:2013: Eurocode 7: Geotechnical Design. General rules. British Standards Institution;
    - BS EN 1997-2:2007 Eurocode 7. Geotechnical design. Ground investigation and testing. British Standards Institution;
    - BS EN ISO 14688-1:2002+A1:2013. Geotechnical investigation and testing – Identification and classification of soil: Part 1: Identification and description. British Standards Institution;
    - BS EN ISO 14688-2:2004 +A1:2013. Geotechnical investigation and testing – Identification and classification of soil: Part 2: Principles for a classification. British Standards Institution;
    - BS 5930: 2015: Code of practice for ground investigations. British Standards Institution;
    - BS EN ISO 14689-1:2003. Geotechnical investigation and testing – Identification and classification of rock: Part 1: Identification and description. British Standards Institution;
    - BS 1377-1:2016: Methods of test for soils for civil engineering purposes. General requirements and sample preparation. British Standards Institution;
    - BS 10175 :2011+A2:2017 *Investigation of potentially contaminated sites. Code of practice.* (British Standards Institute, 2017); and
    - BS EN ISO 22475-1:2006. Geotechnical investigation and testing. Sampling methods and groundwater measurements. Technical principles for execution. British Standards Institution.

- Key References:
    - Scottish Geodiversity Forum (Scottish Geodiversity Forum 2018);
    - SNH Sitelink website (SNH 2017);
    - Environmental Reclamation Services Ltd: *"North Collielaw & Denend, Peterhead, Desk Study"*, REP01-REV02, November 2013;
    - LQM: The LQM/CIEH S4ULs for human health risk assessment 2015. Land Quality Press (S4UL3283);
    - Environment Agency: UK soil and herbage pollutant survey 2007;
    - The James Hutton Institute. The National Soil Inventory of Scotland (NSIS 1978-88);

- The Macaulay Institute for Soil Research (now the James Hutton Institute), *"Land Capability for Agriculture (LCA) in Scotland"*, Aberdeen, 1981; and
- Structural Soils Ltd. Peterhead, Scotland - Factual Report on Ground Investigation (Project No: 541286), May 2018.

8.2 Assessment Methodology

8.2.1 Baseline Data collection

Detailed Ground Investigation (GI) studies have been undertaken in line with the general requirements set out in the British Standards detailed in Section 8.1.2. The GI was carried out by Structural Soils Ltd under the instruction and supervision of consulting engineers Gutteridge Haskins and Davey Ltd (GHD) and covered the routes of HVDC cabling as well as the Convertor Station site. Superficial deposits encountered across the site were broadly consistent in terms of soil type although thickness varied. Therefore, for the purposes of this EIAR, all soils tested for contaminants are considered relevant to the HVDC cabling and so are included as part of this assessment. The ground investigations took place between 6th November 2017 and 7th March 2018 (Structural Soils Ltd, 2018).

8.2.1.1 Trial pits

Trial pit excavations were carried out using a tracked excavator to depths of between 0.7 and 4.0 metres below ground level (mbgl). Soil was removed in layers by the excavator driver, under instruction from the geotechnical engineers, so that relevant observations and measurements could be made at various depths, and at any visible changes in ground characteristics. The physical soil characteristics were documented from site observation, and several samples were taken and sent for analysis in order to gain detailed understanding of physical and chemical characteristics of soils for cable installation. The location of the pits is shown in Appendix C.1 and a summary of their locations is in Table 8.1. Those with environmental sample analysis are marked *.

Table 8.1 Trial Pit Locations.

Trial Pit	Location (Easting, Northing)	Summary location information
TP101*	E412002:N841241	Located within Fourfields Site.
TP102	E411989:N841178	Located within Fourfields Site.
TP103	E411842:N841187	Located within Fourfields Site.
TP104*	E411871:N841262	Located within Fourfields Site.
TP105	E411844:N841317	Located within Fourfields Site.
TP106	E411875:N841336	Located within Fourfields Site.
TP107	E411836:N841404	Located within Fourfields Site.
TP108	E411880:N841411	Located within Fourfields Site.
TP109	E411940:N841451	Located within Fourfields Site.
TP109SA	E411943:N841452	Located within Fourfields Site.
TP110*	E412060:N841323	Located within Fourfields Site.
TP111	E412063:N841265	Located within Fourfields Site.
TP112	E412020:N841472	Located within Fourfields Site.
TP113	E411805:N841477	Located within Fourfields Site.
TP114	E411786:N841366	Located within Fourfields Site.
TP115	E411784:N841240	Located within Fourfields Site.
TP116	E411866:N841127	Located within Fourfields Site.
TP117	E412065:N841119	Located within Fourfields Site.
TP201	E412102:N839976	Located by the Land Fall site.

Trial Pit	Location (Easting, Northing)	Summary location information
TP202	E412031:N840038	Located by the Land Fall site.
TP301	E411938:N840082	On route from HDD site up to disused railway line.
TP302	E411851:N840133	On route from HDD site up to disused railway line.
TP303	E411823:N840213	On route from HDD site up to disused railway line.
TP304	E411800:N840280	Southside of disused railway line.
TP305*	E411724:N840501	North of A90 in field adjacent to Mains of Longhaven.
TP306	E411704:N840580	On route north to Fourfields.
TP308*	E411702:N840787	On route north to Fourfields.
TP309	E411710:N840875	On route north to Fourfields.
TP310	E411719:N840970	On route north to Fourfields.
TP311	E411727:N841060	On route north to Fourfields.

8.2.1.2 Boreholes

Boreholes were sunk within the Fourfields site and along the HVDC cable corridor at specific locations to inform the design of the HDD works both at the A90 crossing and the landfall. The principle aim was to establish rock depth and groundwater characteristics, but also to gain further understanding on soil and rock characteristics. Both vertical and directional drilling were undertaken to maximum depths of (or vertical equivalent depth for inclined boreholes) of 26.4 and 64.2mbgl respectively.

The boreholes were sunk vertically and at an incline at some locations by rotary open hole and core drilling using Hycat Low Pressure Tracked rig, a Massenza M-I-4 rig, Comacchio GEO 601. Competent bedrock was proven in each borehole by coring at least 5m of rock. A conventional double tube core barrel was employed for the maximum recovery of rock core in conjunction with either an air, air-mist or water flushing medium. Core samples were packed carefully and placed within core boxes labelled to indicate the depth below ground surface of each core run. Each box was labelled with the site name, contract number, borehole number and depth of core runs.

Upon completion, selected boreholes within Fourfields were installed with a 50mm high-density polyethylene (HDPE) pipe for future monitoring of groundwater level. This comprises 2-5mm washed gravel surrounding the slotted section of the pipe, which allows groundwater to enter the pipe whilst keeping it clear from blockages. Bentonite seals were placed above and below the response zone and concrete installed around the plain section at the top of the pipe to prevent surface infiltration. Each installation was capped with a bolted metal raised headworks and marked with a triangular timber post arrangement so that agricultural vehicles are aware of their locations.

On completion, the remaining exploratory holes were backfilled with arisings / bentonite pellets as required. The borehole locations are shown in Appendix C.1, and their locations are summarised in Table 8.2.

Table 8.2 Borehole locations.

Borehole	Location (Easting, Northing)	Summary location information
BH101	E412046:N841211	Located within Fourfields Site.
BH102	E411969:N841229	Located within Fourfields Site.
BH102A	E411964:N841224	Located within Fourfields Site.
BH103	E411811:N841233	Located within Fourfields Site.
BH103A	E411877:N841234	Located within Fourfields Site.
BH104	E411866:N841313	Located within Fourfields Site.
BH105	E411891:N841382	Located within Fourfields Site.
BH105A	E411886:N841387	Located within Fourfields Site.
BH106	E411888:N841449	Located within Fourfields Site.
BH107	E411961:N841444	Located within Fourfields Site.
BH108	E412045:N841378	Located within Fourfields Site.
BH109	E411928:N841262	Located within Fourfields Site.
BH110	E411933:N841332	Located within Fourfields Site.
BH111	E411937:N841400	Located within Fourfields Site.
BH112	E412007:N841266	Located within Fourfields Site.
BH113	E411990:N841381	Located within Fourfields Site.
BH114	E411963:N841303	Located within Fourfields Site.
BH201	E412143:N839952	Located by the Landfall site. To determine the ground conditions for the landfall HDD.
BH202	E412197:N840022	Located by the Landfall site. To determine the ground conditions for the Landfall HDD.
BH301	E411782:N840331	Immediately north of the disused railway line. To determine the ground conditions for the Road Crossing HDD.
BH302	E411758:N840402	Immediately north of the A90. To determine the ground conditions for the Road Crossing HDD.

8.2.1.3 Logging, sampling and *in-situ* testing

In all trial pits and boreholes, the stratigraphy and depths in mbgl of soil, rock and groundwater conditions were logged on standard log sheets. An initial soil/rock description was also recorded of each soil/rock type, including the observed density description. Descriptions and properties were to be later confirmed during core logging and refined by further laboratory testing of disturbed and undisturbed samples. The following samples and measurements were undertaken where possible at each trial pit or borehole sample depth:

For physical soil and rock characteristics or index properties:

- Bulk disturbed samples
- Small disturbed samples (1l Plastic tub)
- Undisturbed rock core

For various chemical (contamination) soil and water testing:

- 1l plastic tub
- Glass jar
- Glass vial
- Plastic and glass containers for water samples

A soakaway test was attempted in P109SA however the infiltration rate was not able to be calculated due to rise in water level.

Groundwater depth monitoring in borehole installations was undertaken regularly between 15 December 2017 and 3 April 2018 on 26 separate occasions.

A geophysical survey was undertaken to seek to determine the depth to bedrock and the possible presence of a potential fault at the cable landing site. The geophysical techniques employed were that of Electrical Resistivity Imaging, Seismic refraction, and Surface Wave Ground Stiffness (SWGS). In addition, electrical resistivity tests have been undertaken at the converter station site and thermal resistivity tests have been undertaken along the HVDC and HVAC cable alignment, in order that adequate earthing and heat dissipation can be designed for electrical equipment.

8.2.1.4 Laboratory testing

Samples for potential geotechnical testing were returned to MATtest, a UKAS accredited laboratory, and those for potential geo-environmental testing were sent to Envirolab Limited, a MCERTS and UKAS accredited testing laboratory. The following tests were carried out in accordance with MCERTS/UKAS standards where noted in Appendices D and E of the Structural Soils Factual Report:

Physical Testing / Index Properties:

- Geotechnical laboratory testing was generally carried out in accordance with the relevant part of BS1377: 1990, Methods of Test for Soils for Civil Engineering Purposes, or, where superseded, by the relevant part of BS EN ISO 17892:2014 Geotechnical investigation and testing – Laboratory Testing of Soil;
- Soil classification. (Bs 5930 “Code of Practice for Site Investigations”, 1999; BS EN, “Eurocode 7: Geotechnical design”, 1997);
- Particle size distribution;
- Moisture content;
- Organic matter content;
- Water absorption and particle density;
- Liquid and plastic limits;
- Particle density;
- Compaction tests;
- Consolidation tests;
- Undrained shear strength of cohesive soils;
- Resistance to fragmentation;
- Magnesium sulphate soundness;
- pH, chloride, sulphate, sulphur, magnesium;
- Cercher abrasivity; and
- Uniaxial compression and point load strength of rock.

Contamination Testing Suites:

- Total metals (dissolved metals in waters);
- Inorganics;
- Aromatic compounds;
- Polycyclic aromatic hydrocarbons (PAH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX) and Methyl Tert-butyl ether (MTBE);
- Total petroleum hydrocarbons (TPH); and
- Asbestos.

The contamination tests each measured either the *Detected Concentration* level of a particular chemical or compound, or defaulted to the limit of detection, i.e. the lowest concentration at which a contaminant can be detected by the testing method. The limits of detection used by the laboratory were fit for purpose.

The results of the soils chemical analysis were compared to appropriate generic human health risk assessment criteria in line with UK policy. LQM/CIEH S4ULs have been used as a basis for a generic quantitative risk assessment. These generic assessment criteria (GAC) are based on the Contaminated Land Exposure Assessment (CLEA) exposure model and represent, for a particular land-use, the average concentration of a substance in soil at or below which human exposure can be considered to represent a minimal or tolerable level of risk. Non-exceedance indicates that soil contaminant levels are such as not to compromise human health. Exceedance can indicate that further assessment or remedial action may be needed.

The proposed use of the site is industrial although the CLEA standard commercial/industrial exposure model may not be sufficiently protective in this instance as there are likely to be areas of the Site, such as along the cable routes, which will be accessible to the public following development. Therefore, the GAC for public open space has been used as a conservative screen. The results for metals analysis have also been benchmarked against Scotland's Soil Inventory for rural soils. Soil analysis results from the previous investigation were also included in the assessment as they provide further evidence of the general ground conditions encountered. As well as the determinants listed above, the previous investigation scheduled analysis for suites of pesticides and insecticides, Volatile Organic Compounds (VOCs) and Semi-volatile organic Compounds (SVOCs).

8.2.2 Impact Assessment Methodology

This assessment has been undertaken primarily using a qualitative assessment based on analysis of baseline data, statutory and general guidance, combined with professional judgment. The assessment follows the methodology provided within Chapter 3: Methodology with the significance of effect being determined through a combination of sensitivity / value of a receptor and the magnitude of impact. The sensitivity / value of the receptor under consideration are defined in accordance with the criteria set out in Table 8.3, while the magnitude of impact criteria is set out within Table 8.4. The significance of effect then follows the matrix set out in Table 8.5.

The Macaulay Institute for Soil Research maps show the LCA in Scotland (Macaulay Institute for Soil Research, 1981). The LCA classification is used to rank land on the basis of its potential productivity and cropping flexibility. This is determined by the extent to which the physical characteristics of the land (soil, climate and relief) impose long term restrictions on its use. The LCA is a seven class system. Class 1 represents land that has the highest potential flexibility of use whereas Class 7 land is of very limited agricultural value. These categories have been used in the characterisation of the different receptors sensitivity in Table 8.3.

Table 8.3 Environmental Value of Geology, Soils and Land Use Receptors

Value	Criteria	Example
Very high	Very high importance and rarity, international scale and very limited potential for substitution.	• SSSIs with geological / geomorphological qualifying interest. • Soils with a very high likelihood of readily transmitting contaminants to nearby sensitive receptors or over a large distance (e.g. granular deposits in saturated zone or in continuity with river systems etc.) H1 soils as defined by the Environment Agency groundwater vulnerability classification system. • Agricultural land use / soil quality of LCA Class 1, 2, and 3.1 (prime agricultural land).
High	High importance and rarity, national scale, and limited potential for substitution.	• Regionally Important Geological and geomorphological Sites (RIGS). • Local Geodiversity Sites (LGS). • Soil sensitivity to pollution: soils with a moderately high potential to transmit contaminants to other receptors or over a significant distance (e.g. mixed cohesive and granular deposits of alluvium). H2/H3 soils as defined by the Environment Agency groundwater vulnerability classification system. • Agricultural land use / soil quality of LCA class 3.2, 4.1 and 4.2 (moderate).
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.	• Soils with an intermediate potential to transmit contaminants (e.g. Glacial Clays with occasional sand bands). Soils of intermediate (I1 or I2) leaching potential as defined by the Environment Agency groundwater vulnerability classification system. • Sites of Interest to Natural Science (SINS: also referred to as Study of Environmentally Sensitive Areas(SESA). • Local Nature Conservation Sites (LNCS) • Agricultural land use / soil quality of LCA Class 5.1, 5.2 and 5.3 (poor).
Low (or Lower)	Low or medium importance and rarity, local scale.	• Soils with a low potential to transmit contaminants (e.g. competent clay). Soils of low (L) leaching potential as defined by the Environment Agency groundwater vulnerability classification system. • Agricultural land use/soil quality of LCA Class 6.1, 6.2, 6.3 and 7 (very poor).
Negligible	Very low importance and rarity, local scale.	• Land not agricultural – e.g. hardstanding cover.

Table 8.4 Magnitude of Impacts and Descriptors

Magnitude of Impact	Criteria	Example
Major	• Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse). • Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).	• Change in soil quality or ground gas regime for a large area (>20ha) of land, sufficient to alter land use (e.g. remediation of 20Ha of industrial land sufficient to enable mixed residential / commercial use). • Permanent loss of any area of agricultural land (LCA Class 1, 2 and 3.1). • Generation of large volumes of non-inert waste materials for disposal off-site to landfill.
Medium	• Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements (Adverse). • Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).	• Change in soil quality or ground gas regime for a moderate area of land (<20ha) to a degree sufficient to alter land use in localised portions of the site or to a degree requiring a change in management / mitigation measures for site use.
Low	• Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse). • Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial).	• Measurable but relatively small scale rock volume removed. • Measurable but relatively small scale change in an area of contaminated land or ground gas regime, but insufficient to alter end land use. • Comparatively small area of SINS / SESA sites affected. • Permanent loss of any area of agricultural land (LCA Class 3.2, 4.1 or 4.2).
Negligible	• Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse). • Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).	• Very limited mass of contamination mobilised – just detectable. • Very limited change in area of agricultural land. • Very limited volume of rock removed.
No change	• No loss or alteration of characteristics, features or elements; no observable impact in either direction.	• No change.

Table 8.5 Significance of Effects Categories

Magnitude of Impact	Value				
	Very High	**High**	**Medium**	**Low**	**Negligible**
Large	Major	Major	Moderate	Minor	Negligible
Medium	Major	Moderate	Moderate	Minor	Negligible
Low	Moderate	Minor	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible	Negligible

Key

	Significant Effect
	Non-Significant Effect

8.2.3 Identification of Mitigation

Mitigation measures have been identified in line with best practice to prevent, minimise and mitigate impacts.

8.2.4 Assessment of Residual Effects

Where mitigation has been identified, the magnitude of the impact will be reassessed as per Table 8.4 and the overall significance of effect reassessed in line with Table 8.5 to understand the resultant residual effect.

8.2.5 Limitations of the Assessment

Trial pits and boreholes provide sample data only of specific locations and sampling depths within the ground strata. From this, trends and extrapolations can be made to establish the level of risk associated with the assessment, but a residual risk will always remain that ground conditions between two points may differ greatly from those measured at the two points in question. However, given the extent of the coverage obtained by the exploratory positions and the general uniformity of soils encountered, this residual risk is estimated as being relatively low.

8.3 Baseline Information

The results informing this Baseline Information are drawn from a desk study of the information sources listed in 8.1.2, and also from the physical ground investigation findings.

8.3.1 Designated Sites

Table 8.6 details designated sites with a geological feature within the areas.

Table 8.6: Designated Sites

Site	**Approximate Distance from Cable Corridor**	**Relevant designated Interests**	**Feature's latest assessed condition**
Bullers of Buchan Coast SSSI	Crossed at HVDC cable landfall.	Coastal geomorphology of Scotland Maritime cliff	Favourable maintained
Skelmuir Hill, Stirling Hill, Dudwick Local Nature Conservation Site	Crosses the HVDC landfall and HVDC cable corridor.	Pre-glacial Buchan Graves Formation. Den of Boddam Glacial Meltwater Channel included in the nature conservation site.	N/A
Hill of Longhaven SSSI	3km west of HVDC cable corridor	Quaternary of Scotland	Unfavourable declining
Moss of Cruden SSSI	7km west of HVDC cable corridor.	Quaternary of Scotland	Favourable maintained
Collieston to Whinnyfold Coast SSSI	7km south of HVDC cable corridor.	Dalradian	Favourable maintained

8.3.2 Geology

The British Geological Survey (BGS) onshore digital map DiGMapGB-50 (BGS, 2017)) were consulted to gain a general understanding of the geological conditions in the area.

BGS mapping indicates that the superficial geology of the Site consists of Head 1 – Gravel, Flinty, polymict deposit of the Quaternary period comprising poorly sorted gravel, sand and clay depending on upslope source and distance from source. No superficial deposits are indicated in the south of the site.

The mapping for the general area indicates glacial drift of Pleistocene Age, fluvioglacial and glacial sand and gravel and glacio-lacustrine deposits. Recent drift overlay includes coastal deposits of a very thin to absent alluvium associated with watercourses on the coast resulting from erosion. Over much of the inland area, glacial deposit comprises diamicton (otherwise known as boulder clay) of mainly red Hatton Till formation. These Hatton Till formation deposits are frequently very variable and fissured in nature, with sediment type varying rapidly horizontally and vertically. In general, there appears to be an increase in thickness north and east of the site location.

The BGS records of the area also indicate that the underlying bedrock of the area is dominated by Peterhead Pluton granite which creates a ragged coastline, highly sculpted/fractured cliffs and sea stacks. In general, the granite, understood to belong to pre-Lower Old Red Sandstone Age, is a coarsely crystalline red rock, resting unconformably on the old platform of slates and schists. The strata consist mainly of conglomerates and sandstones, associated with lenticular bands of andesite indicating contemporaneous volcanic action.

Peterhead Pluton Granite is quarried at the Stirling Hill Quarry, located to the east of the Fourfields site. The granite here is blasted, graded and sold principally for use in road stone and other civil

engineering purposes (commonly referred to as Type 1 and Type 2 aggregates), but there are also concrete batching facilities at the quarry which uses the granite for concrete aggregate to supply local civil and structural engineering uses.

Through the exploratory hole observations, logging and the laboratory soil classification and PSD testing, the soil and rock types encountered across the two HDD sites can be identified and categorised into the approximate stratigraphy shown in Table 8.7. The sample descriptions are mapped to the appropriate BGS lithology description, and then also assigned a simplified geotechnical grouping for engineering purposes, and further interpretation within the project engineering studies and design. This is a summary table of the generalised encountered stratigraphy at the study site. The full details of soil depths, height and descriptions at each exploratory location are presented in Trial Pit and Borehole log sheets within the factual report (Structural Soils Ltd, 2018). The findings were inconsistent with the anticipated geology from BGS mapping for the area of investigation where superficial deposits were expected. There was no evidence of the Head 1 gravels nor the fluvioglacial and glacial sand and gravel and glacio-lacustrine deposits nor alluvium.

Table 8.7 Encountered Generalised Geology on the HVDC Cable Corridor (including the two Western Fields of Fourfields).

Sample Descriptions	BGS Area-Wide Lithology	Depth (mbgl)	Geotechnical Grouping
Firm (occasionally soft) dark brown slightly sandy gravelly CLAY with frequent rootlets. Gravel is angular to subrounded fine to coarse of granite, quartz, schist and flint.	N/A – Topsoil / ploughing layer	Typically 0-0.3m	Topsoil
Firm brownish red slightly sandy gravelly CLAY with lenses of sand, medium cobble content and low boulder content. Gravel is angular to subrounded fine to coarse of granite and quartz. Cobbles and boulders are subangular and subrounded of granite.	Hatton Till - Diamicton, Unsorted glacial deposits of clay, sandy clay, sand with pebbles and boulders	Typically from 0.3 to between 0.45 and 3.1m	Glacial till
Soft brown slightly sandy slightly gravelly CLAY with low cobble content. Gravel is angular to subrounded fine to coarse of granite, quartz and schist. Cobbles are subangular to subrounded of granite.		Typically from 0.3 to between 0.7 and 3.6m	
Brownish red clayey gravelly fine to coarse SAND with pockets of clay (20-200mm) with low cobble content. Gravel is angular to subrounded fine to coarse of granite, quartz, schist and flint. Cobbles are angular to subrounded of granite.		From 0 – 1.6m	
Weak pinkish brown distinctly weathered GRANITE.	Peterhead Pluton Granite: conglomerate, with subsidiary horizons of sandstone and clay.	From 0.5-64.2m at the landfall, 0.9 to 11.6m on cable route and 1.6 to 23.3m in western fields of Fourfields	Granite Bedrock
Medium strong to strong pinkish grey partially weathered GRANITE.			
Very strong to extremely stong partially unweathered greyish pink GRANITE fractures are subhorizontal (30° to 50°) closely to medium closely space tight to partially open with minor reddish brown clay infill and some orangish brown staining on surfaces.			

Note: Examples of Hatton Till and rock sample descriptions are given to show the range of soil and rock types encountered. Several other descriptions were logged which varied slightly or were different combinations of the above.

8.3.3 Topsoil

The topsoil was encountered extending to depths between of 0 and 0.7m but typically from surface to around 0.3m at all trial pit and borehole locations considered as part of the HVDC cabling works. There was a sharply defined change in all cases, presumably at ploughing depth, to the underlying undisturbed ground beneath.

The soil is a typical clayey topsoil medium of mixed lithologies.

8.3.4 Glacial Till

These were the predominant drift geology strata from the Hatton Till Formation (Diamicton) encountered across all test locations except at TP202 at the landfall where rock was shallow at 0.5m. The deposits were generally undifferentiated and ranged from slightly gravelly sand, to firm to stiff and very stiff, sandy, slightly gravelly clay. These strata covered the full depth from below the topsoil to the rock level at between 0.65 to 3.00 metres below ground level.

8.3.5 Granite Bedrock

The Peterhead Pluton Granite was encountered in the vast majority of trial pits and in all boreholes considered within the HDD areas and the HVDC cable corridor. The trial pits where rock was not encountered were all located within the western fields of Fourfields. Bedrock was recorded from 0.5mbgl and drilled to a maximum depth of 64.2mbgl at the landfall. Along the HDD cable route, rock was recorded from 0.9 and drilled to a maximum of 11.6mbgl. In western fields of Fourfields, bedrock was recorded from 1.6 to a maximum depth of 23.3mbgl. Rock varied in strength and weathering within and between boreholes.

8.3.6 Hydrogeology

The BGS classify the regional bedrock aquifer to be of low productivity (0.1-1 l/s) characterised by fracture flow processes within an unnamed igneous intrusion of late Silurian to early Devonian age. The interactive map of the 2008-2015 River Basin Management Plan (RBMP) published by SEPA indicted that the groundwater body in the area is part of the, *"Peterhead bedrock and localised sand and gravel aquifer"*. The groundwater body beneath the Site is classed as 2C by SEPA, being characterised as a low productivity aquifer where flow is virtually all through fractures and other discontinuities. These rocks have negligible intergranular porosity and, therefore, can store groundwater only within fractures. All groundwater flow is through fractures, along bedding planes, joints or fault lines. Small amounts of groundwater is however possible in the near surface weathered zones and secondary fractures, and there are also rare springs. This groundwater body was classified with an overall status of 'good' in 2016 and is also a Drinking Water Protected Area with a Pass status. The site is also located in a Nitrate Vulnerable Zone.

During the ground investigation, groundwater was encountered at depths between 1 to 2mbgl, mainly as seepages, in the HDD cable route trial pits coinciding with the boundary between glacial till and weathered rock. More shallow groundwater was encountered at the landfall site between 0.2 and 0.35mbgl either in weathered rock or perched on glacial till. Groundwater was only encountered in one trial pit in the western fields of Fourfields (TP104) with a moderate flow recorded in gravel of granite. It is possible therefore that limited groundwater could be encountered during the excavation works, particularly in the southern most stretches of the route.

Groundwater strikes were only recorded occasionally in boreholes although the method of drilling (and flushing) could have prevented such observations. Strikes were recorded within destructed granite in BH110 and BH111 at 6m and in till at 0.35m in BH302.

Post drilling groundwater level monitoring was undertaken in 16 boreholes installations (14no. from the current investigation and 2no. from the previous investigation). All borehole level monitoring data has been assessed to provide information on the likely local groundwater regime. Groundwater levels were monitored between 15/12/17 and 3/4/18 on between 9 and 25 occasions, depending on the borehole. Groundwater levels were recorded at between 0.25 and 3.78mbgl (except for BH109 which is discussed below). Taking into account existing ground levels, the response zone for the installations and the observations made during trial pitting, it would appear that there is a limited potential groundwater body within the near surface weathered rock zones and that groundwater flow in the Fourfields Site appear to be to the north east, generally following surface topography.

Groundwater levels in BH109 were consistently recorded slightly above ground level indicating artesian conditions. The response zone for the borehole was within extremely weak to weak weathered deconstructed granite from 4.5 to 18mbgl. Similar boreholes in this area did not show artesian conditions. This borehole had a confining layer of glacial till (4.2m thick) and it is considered that the borehole may have intercepted fracture flow.

The Hatton Till Formation deposits may have sand and gravel lenses of local importance to private water supplies. Three wells are located within a 1km radius of the Fourfields site. One is in the vicinity of the currently derelict Denend Farm buildings, one is beside the residential properties at Lendrum Terrace and the other is adjacent to the property Highfields. None are within 100m of the HVDC Cable or associated infrastructure.

A hydrological study was also carried out to understand any hydraulic continuity between the site and the Braeside Fishery Pond (currently non-operational) situated beyond the northern boundary of the site within the property of Highfields (Envirocentre 2015). The study concluded the pond is fed by the natural catchment draining to the pond from within Highfields property, potentially some springs within the base of the pond at around the level of the near surface weathered rock / glacial till interface zone referred to above, and augmented by a field ditch to the south west which is routed into the pond from the Fourfields site. The latter intake route would be lost due to the converter station development, but the study recommended that could be easily replaced by surface water routing from elsewhere on the site to the pond if required. However, in addition to this, there is also another piped intake from the larger field ditch to the south east of the pond which would not be affected by the project and, although not operational at present, it could simply be re-commissioned to supplement flow into the fishery pond.

Groundwater samples from 8no. boreholes (BHs 101, 103, 104, 105, 106, 108, 102 and 109) were analysed for general water quality. The results of the analyses (except total petroleum hydrocarbons (TPH)) were directly compared to relevant assessment limits which protect the resource potential of the water body (HMSO 2017). There are currently no assessment limits for TPH and therefore the results have been compared to WHO drinking water guidelines (WHO 2008). Groundwaters recovered from the selected boreholes were all found to have concentrations of analytes below the relevant assessment limit. This is consistent with the SEPA overall classification of the Peterhead bedrock aquifer as ‘good’.

8.3.7 Agricultural classification

According to the Land Capability for Agriculture (LCA) in Scotland maps (Macaulay Institute for Soil Research, 1981), the majority of the HVDC cable corridor belongs to the LCA Class 3.2, Land Capable of Supporting Mixed Agriculture as,

"land capable of producing a moderate range of crops with an increasing trend towards grass within the rotation".

The majority of the HVDC cable corridor and HDD cliffside activities therefore sits within current improved grassland fields.

From the LCA map there appears to be a small section of the HVDC corridor which passes through Class 3.1, Land Capable of Supporting Arable Agriculture as,

"land capable of producing a moderate range of crops with high yields of cereals and grass; potatoes and other vegetables are also grown".

Currently, the Fourfields are is utilised for crops with the remainder of the land that the HVDC corridor passes under being utilised for grazing of animals. The amount of land classified as 3.1 appears to be small from the LCA map in relation to the rest of the corridor. Furthermore, it should be noted that once the HVDC cables are installed, the fields will be returned back to agricultural use. The design of the cable route (see Chapter 2: Project Description) has been an iterative process and has ensured that the minimal amount of agricultural land will be affected, even temporarily, by the HVDC cabling.

8.3.8 Contamination

8.3.8.1 Historic Land Use

From historic maps of the area, the cliffside HDD is west of a disused quarry site. Therefore, there is a possibility that the development may encounter contaminated spoil and waste from quarrying operations. The cable route also crosses the line of a former railway with associated cuttings and embankments (running SW-NE just south of the A90) and therefore the development may encounter made ground associated with this feature, there are no surface signs of contamination associated with the railway line. However, made ground was not encountered in any of the exploratory positions during this investigation and therefore the risk of encountering such wastes is considered to be low. The only other previous known use of the Site is for agricultural use.

8.3.8.2 Contamination Testing

The results of the 12 soil samples from both investigations were compared to appropriate generic assessment criteria. No samples were found to contain concentrations above the GAC. Indeed, the vast majority of the results for inorganics, BTEX and MTBE, VOCs and SVOCs, PAH, TPH) and Pesticides/insecticides were found to be below the limit of detection for the method used.

Detectable concentrations of metals were recorded in all samples. Metals are generally naturally occurring in soil, and the detected concentrations of the metals were generally consistent with background concentrations recorded in rural soils in Scotland. Therefore, there is not considered to be a contamination source present which could present a risk during or on completion of the proposed installation works.

8.3.9 Valuation of receptors

Table 8.8 presents a summary of the valuation of the features relevant to assessing land quality.

Table 8.8: Valuation of Geological and Land-use Features.

Receptor	Evaluation Rationale	Site receptor Value
Designated Sites for Geological Features		
Bullers of Buchan Coast SSSI	The landfall crosses the SSSI. However, because the cables will run through the cliffs and under the designated coastal geomorphology and maritime cliff, the geological feautres of this designated site will not be affected by the installation. Nevertheless, due to the proximity of the designated features to the cliffside HDD, it will be included for further assessment.	Very high
Skelmuir Hill, Stirling Hill, Dudwick Local Nature Conservation Site	As this LNCS crosses the HDD sites, it will be included for further assessment.	Medium
Hill of Longhaven SSSI	This is 3km from the HDD and therefore no effects are expected on the designated features, as the HVDC cable effects will be localised in nature. It is therefore excluded from further assessment.	Excluded from further assessment.
Moss of Cruden SSSI	This is 7km from the HDD and therefore no effects are expected on the designated features, as the HVDC cable effects will be localised in nature. It is therefore excluded from further assessment.	Excluded from further assessment.
Collieston to Whinnyfold Coast SSSI.	This is 7km from the HDD and therefore no effects are expected on the designated features, as the HVDC cable effects will be localised in nature. It is therefore excluded from further assessment.	Excluded from further assessment.
Other Land Quality Features		
Groundwater	Groundwater of good quality was present in the boreholes and was encountered as seepages in a number of trial pits within the weathered rock strata. The presence of groundwater and surface water features mean that groundwater as a land asset will be considered for impact assessment in respect of its inherent quality and possible pollution pathways.	High.
Soil	LCA class 3.2 and 3.1 are present.	High.
Bedrock	Due to the fact the cliffside HDD will be drilling through bedrock, this should be considered as a receptor.	Medium.
Hydrogeology	Potentially important on a regional scale.	Medium

8.4 Impact Assessment

8.4.1 Construction

8.4.1.1 Change of Land-Use

The HDD site set up will involve setting up a 65m by 50m site with an additional 10m by 23m for parking. Topsoil will be removed which will then be stockpiled to the sides for reinstatement after completion of the works. The secure working area within the fields, where the HVDC cabling and HDD activities will be located, will not be able to be used as agricultural or grazing fields whilst the cable installation activities take place. The changes involved with the cable route and the HDD site set up will be temporary in nature, as the surface of the site will be restored to its former use on completion.

Jointing Pits 1 and 2 are expected to be 25m long by 6m wide. The jointing bays will have a protective concrete slab to avoid damage during future excavations but buried 1.0m below the surface. The ground over the joint pits will be reinstated following completion of the joints. Though the concrete slab and joint pit underneath the soil will mean a permanent effect on the soil environment, the land use can remain the same when the topsoil has been replaced. Therefore, grazing may continue as before.

The cable route construction corridor covers a total area of 10Ha. Within this, the topsoil strip for the haul road, drainage and cable trenches has an area of 0.4Ha and will remove approximately 2,200m^3 of topsoil. The cable trenches themselves at a further 1.3m deep will generate a further 5,500m^3 of glacial till and 1,000m^3 of rock. The topsoil and glacial till removed during construction will be stored and, once the cables have been installed, the ground will be reinstated, and the land returned to its former use.

The Buchan Ness to Collieston SSSI is designated for its coastal geomorphology and is **very high** value receptor. The Landfall HDD will pass under the SSSI having no or **negligible** impact on the coastal geomorphology leading to a **minor**, **non-significant** effect.

The Skelmuir Hill, Stirling Hill, Dudwick LNCS is a **medium** valued receptor and it will be temporarily affected by having the HVDC cabling and associated joint pits within the boundary of the LNCS, and also the temporary access road passing through it. However, the effects will be reversible. As such, the magnitude of impact is **low**, leading to an overall **minor**, **non-significant** effect.

The soil receptor, valued as a **high** receptor, will be temporarily affected by the HDD site set up works, cable and joint pit installation, and also the temporary access road. As the land will largely be returned to its former usage and as LCA classes 3.1 and 3.2 after the installation works, the magnitude of impact is **low**. The effects on the soil receptor is therefore defined as being a **minor**, **non-significant effect**.

8.4.1.2 Land Contamination Disturbance

From both observations and testing during the ground investigations, no evidence of old quarry workings, railway land or associated contaminated ground has been found. The concentrations observed in the soils tested are consistent with rural background concentrations. Therefore, the land is not considered to presents a material risk to human, plant or animal health. It is not recommended that any isolation or remediation measures would be required in relation to these, and the storage and reinstatement of the excavated materials during construction should not pose any increased risk of exposure for receptors.

On this basis, the magnitude of the impact from existing land contamination is deemed to be **no change**, making the significance of the effect on all receptors **no change**, **non-significant**.

8.4.1.3 Release of Hazardous Substances

As identified in Chapter 24: Resources Usage and Waste, there will be fuel, oils and chemicals stored on site which, if released, could be harmful to the environment. It is assumed that they will be appropriately stored and utilised, however, there is still a risk of loss of containment. The harm caused will be determined by the material and the volume reaching ground or groundwater. The relatively low permeability of the superficial deposits will limit migration of contaminants to some extent.

Table 10.4.1.1 in Chapter 10: Water Quality (Onshore) identifies potential pollution sources and scenario's the most significant scenario is catastrophic failure of the refuelling bowser which could be up to 5m^3 of diesel.

The Bullers of Buchan SSSI geological features will be highly unlikely to be affected by any pollution incident, due to the nearest part of the installations works, the landfall HDD site, being more than 125m from the SSSI. Therefore, the magnitude of effect of any pollution incident on this **very high** value receptor will have a **negligible** impact magnitude leading to a **negligible**, **non-significant** effect.

The Skelmuir Hill, Stirling Hill, Dudwick LNCS is a **medium** valued receptor. However, pollution incidents impact on the pre-glacial Buchan Gravels formation would be expected to be of **negligible** magnitude. This is because the quantities of any pollutant spills would be relatively small, localised and recoverable. The geological features of interest may not even be present in the HVDC cable installation area. Overall the effect on the LNCS is **negligible** and **non-significant**.

If a loss of containment of a hazardous substance was to reach the groundwater, a **high** valued receptor, became polluted this could lead to a **medium** magnitude impact leading to a **moderate**, **significant** effect.

The soil receptor, valued as a **high** receptor, would be temporarily affected if a pollution event were to occur. However, the impact would be localised in nature. Therefore, it is deemed to be of **low** magnitude of impact leading to a **minor**, **non-significant** effect.

The bedrock, a **medium** receptor, will be drilled through during the cliffside HDD drilling and is likely to be encountered along some of the cable route excavation. The only likely potential polluting substances to be in contact with the bedrock during these works would be hydraulic fluid or fuel leaks from plant and equipment. Such releases are likely to be low in volume but could locally contaminate the bedrock. Therefore, the impact magnitude would be **negligible** which results in a **negligible**, **non-significant** effect.

8.4.1.4 Hydrogeological Effects

Due to the presence of groundwater within weathered rock at the base of glacial deposits and possible more extensive aquifer through fractures in deeper bedrock as well as the artesian conditions locally in Fourfields, there is the potential that excavations will interact with groundwater. The cable trenches for the majority of the route are relatively shallow but, groundwater may seep into them. Where small volumes seep into the trenches they will be managed with surface water arisings in excavations as discussed in Chapter 10 - Water Quality (Onshore) and, as such, groundwater seepage into cable trenches will not be considered further within this Chapter.

The deeper excavation required to install the cable ducting into the Fourfields site has the potential to pass into the water table and, as such, groundwater will be a much more significant element requiring management at this location. It is likely that groundwater will need to be actively managed (dewatering pumps) to facilitate construction works. With regard to the duct installation in isolation,

the requirement to actively manage groundwater will be temporary and hence any effects on hydrogeology will be temporary and localised giving rise to a **low** magnitude of impact on a **high** value receptor, leading to a **minor, non-significant** effect.

The abstraction of groundwater falls under the Water Environment (Controlled Activities) (Scotland) Regulations (as amended) (CAR), compliance with the regulations for the cable installation is discussed in Chapter 10.

8.4.2 Operations

8.4.2.1 Change of Land Use

Part of the bedrock will be permanently affected once the HDD's have been completed. The drilled holes are expected to be in the region of 800mm in diameter. There will be three Landfall HDD boreholes and three Road Crossing HDD boreholes. The bedrock, a **medium** receptor, will be affected during the landfall HDD drilling and along some lengths of the cable route, although excavation in rock is anticipated to be limited. As such there will be a minor loss of bedrock. This leads to a **low** magnitude of impact which results in a **minor, non-significant effect.**

The soil receptor, valued as a **high** receptor, will be permanently affected by the installed infrastructure including cables, ducts and joint pits. The total area taken up by the infrastructure installed in relation to the overall area of the surrounding land will be small the magnitude of impact is **low**. The effects on the soil receptor is therefore defined as being a **minor, non-significant effect**.

8.4.2.2 Hydrogeological Effects

The presence of the HVDC cable infrastructure in the ground is highly unlikely to change the levels or flows of groundwater, due to the small volume that the infrastructure will take up, the reuse of existing soils during reinstatement and the fact ducts will be sealed once cables are in place to prevent groundwater ingress. Impacts on hydrogeology **high** value receptor, are deemed to have a **negligible** magnitude of impact, leading to a **negligible**, **non -significant** effect.

8.5 Mitigation Measures

Significant effects, specifically on groundwater, could occur in event of a release of hazardous substances without appropriate mitigation. Mitigation identified in Chapter 24: Resource Usage and Waste and in Chapter 10: Water Quality (Onshore), with regard to the appropriate storage and handling of materials including refuelling activities, will aid in the reduction of the chance of a release of a hazardous substance and limit the volumes released. Furthermore, the spill response plans, spill kits and operator trained in their use identified in Chapter 10, will minimise the spread of contamination and facilitate prompt recovery. This will reduce the risk of hazardous substances reaching groundwater.

8.6 Residual Effects

Taking account of the proposed spill prevention and response mitigation the magnitude of impact on groundwater is reduced to **low** giving rise to a **minor, non-significant effect.**

8.7 Cumulative Effects

There is the potential to have cumulative effects with the NorthConnect Converter Station and HVAC cabling. The previous ES relating to the Interconnector Converter Station and HVAC Cable Route (NorthConnect 2015), was based on initial ground investigations. The surveys completed in 2017 and 2018 have augmented the understanding of geology and hydrogeology at the Fourfields site. The additional information discussed in this chapter, supplemented by further pumping tests to ascertain

the location, levels and flow rates of groundwater at the site, will be utilised to inform detailed design for the Converter Station site earthworks and any associated groundwater management.

The 2017 CAR amendments mean that a construction site licence will be required for the Converter Station site and, as such, a Pollution Prevention Plan will be developed.

The installation of the HVDC cable ducts and cables on the Fourfields site is a small element in comparison to the earthworks associated with the Converter Station, and will not significantly change the scale of any effects on geology or hydrogeology, or any associated management requirements. The HVDC cables will, however, be considered within the CAR Construction Licence for the Fourfields site. The cumulative effect of the HVDC cables on the Converter Station is deemed to be **minor, non-significant**.

8.8 Summary of effects

The effects on land quality were considered and no significant effects are expected due to the cable installation taking account of mitigation. The mitigation identified has been incorporated into the Schedule of Mitigation. Table 8.9 provides a summary of the possible effects on land use.

Table 8.9: Summary of Geology and Hydrogeology Effects

Receptor	Nature of Impact	Receptor Sensitivity	Impact Magnitude	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Impact Magnitude	Significance of Residual Effect
Construction							
The Buchan Ness to Collieston SSSI	Change of Land Use	Very High	Negligible	Minor: Non-significant		Negligible	Minor: non-significant
Skelmuir Hill, Stirling Hill, Dudwick LNCS	Change of Land Use	Medium	Temporary Low	Minor: Non-significant	Reinstatement of land with existing soil, after cable installation has been completed.	Low	Minor: non-significant
Soil	Change of Land Use	High	Temporary Low	Minor: non-significant	Reinstatement of land with existing soil, after cable installation has been completed.	Low	Minor: non-significant
The Buchan Ness to Collieston SSSI	Release of Hazardous Substances	Very High	Negligible	Negligible: Non-significant	Appropriate storage and handling of materials and wastes as defined in Chapter 24. Spill response plans, spill kits and trained operators as per Chapter 10.	Negligible	Negligible: Non-significant
Skelmuir Hill, Stirling Hill, Dudwick LNCS	Release of Hazardous Substances	Medium	Negligible	Negligible: Non-significant		Negligible	Negligible: Non-significant
Ground Water	Release of Hazardous Substances	High	Medium	**Moderate: Significant**		Low	Minor: Non-significant
Soil	Release of Hazardous Substances	High	Low	Minor: Non-significant		Negligible	Negligible: Non-significant
Bedrock	Release of Hazardous Substance	Medium	Negligible	Negligible: Non-significant		Negligible	Negligible: Non-significant

Receptor	Nature of Impact	Receptor Sensitivity	Impact Magnitude	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Impact Magnitude	Significance of Residual Effect
Hydrogeology	Hydrogeological Effects	High	Low	Minor: Non-significant			
Operations							
Bedrock	Change of Land Use	Medium	Permenant Low	Minor: Non-significant		Low	Minor: Non-significant
Soil	Change of Land Use	Permanen High	Low	Minor: Non-significant		Low	Minor: Non-significant
Hydrogeology	Hydrogeological Effects	High	Negligible	Negligible: Non-significant		Negligible	Negligible: Non-significant

Key

	Significant Effect

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