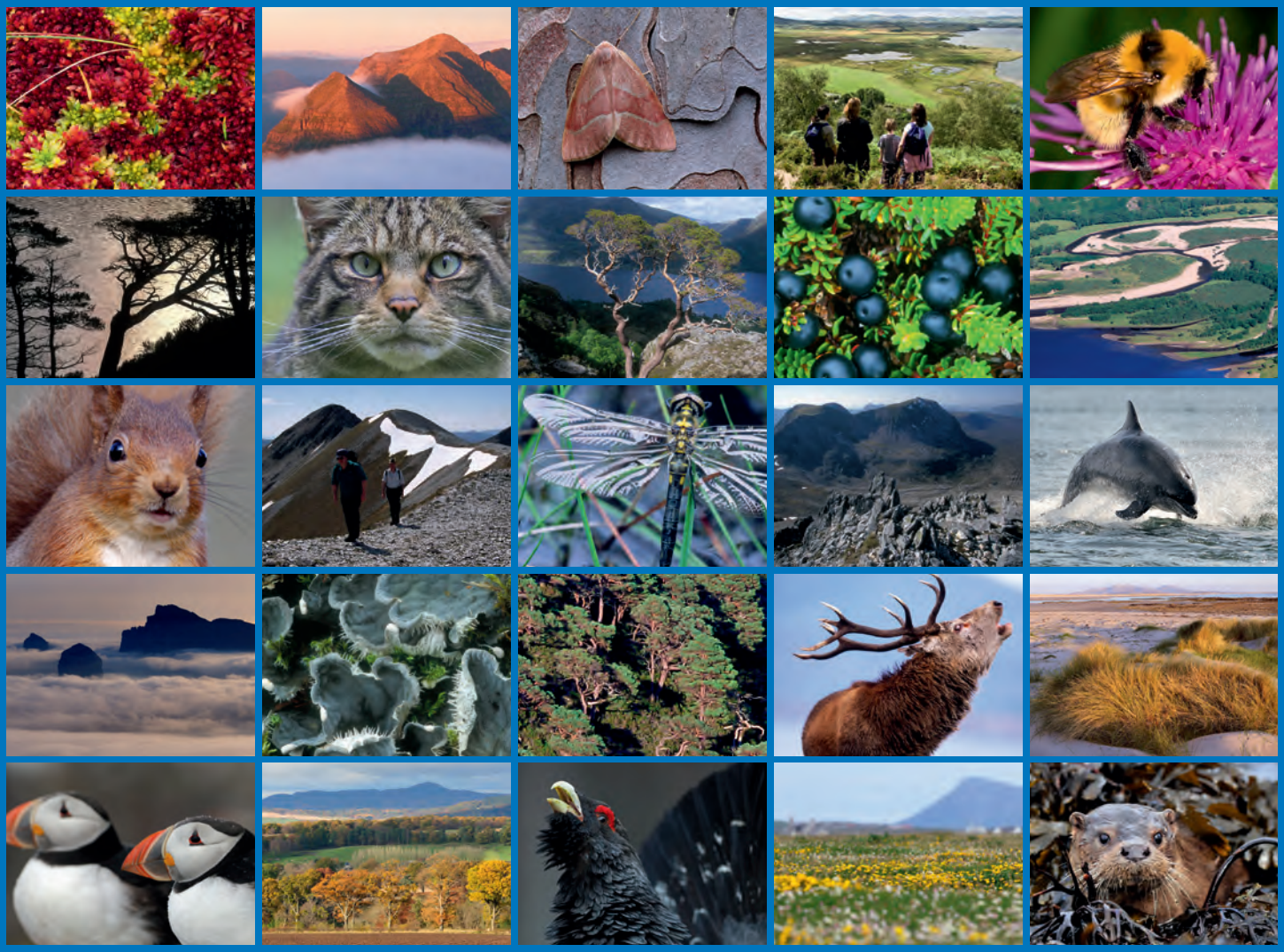
Scottish Natural Heritage
Commissioned Report No. 721

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Danskine Loch



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COMMISSIONED REPORT

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Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Danskine Loch

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Danskine Loch

Commissioned Report No. 721
Project No: 13700
Contractor: EnviroCentre Ltd.
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Keywords

Diffuse pollution; SSSIs; wetland; water; soil; samples; recommendation.

Background

SNH contracted EnviroCentre to look at a number of Sites of Special Scientific Interest across Scotland thought to be adversely affected by diffuse pollution. EnviroCentre was asked to carry out a number of tasks to help SNH understand better whether sites are being affected by diffuse pollution and if so, what activities might be contributing to this pressure and how SNH could improve the condition of the sites.

If sites are identified as being affected by diffuse pollution, SNH hope that the results of this report will inform their work with managers of the sites to improve their condition.

Main findings

The desk study and site walkover identified a trend of elevated nutrients within the site. This could be a consequence of nutrient input from agricultural activities in the site surrounds and the wider catchment. Although very limited data is available, results for the loch indicate likely eutrophic conditions.

Site walkover revealed potential existing and historical land use practices within the catchment that could adversely affect water quality and loch dynamics. This included long-term changes to the nutrient status resulting from diffuse agricultural sources, management practices and potential variations to the flow regime in the loch which could affect groundwater levels in the fen woodland.

- A series of recommendations are proposed to aid the understanding of the loch flow regime and understand the impact of land management practices. It is considered that this additional information will help further the understanding of the observed changes taking place at the site.

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Acknowledgements

EnviroCentre Ltd would like to thank the SNH Operations staff for their time and assistance in providing access to the site files held at the local office, providing landowner contact details, and in aiding the preliminary understanding of the site to assist with the health and safety evaluation prior to the initial visit.

Thanks are also extended to the site landowners for affording access to the site to enable the agreed scope of work to be undertaken.

1. INTRODUCTION

EnviroCentre Ltd was contracted by Scottish Natural Heritage (SNH) in August 2012 to deliver the 'Investigation of Standing Water and Wetland SSSIs under diffuse pollution pressure' project. The data collected from the project will be used to inform management decisions on standing water and wetland Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Danskine Loch SSSI is located approximately 3 kilometres east of Gifford, East Lothian.

The site is accessed off the B6355, which passes by the southern side of the site, and an unnamed track travels north from this road, eventually bisecting the site. Refer to Figure 1.1 in Annex 1.

1.2 Site Description

Danskine Loch SSSI comprises an area of 29.79 hectares and has been designated for its fen woodland feature. It is the largest area of fen woodland and associated open freshwater in East Lothian. These habitats are rare in the region and this site contains several locally rare plant species including marsh valerian (*Valeriana dioica*), greater pond-sedge (*Carex riparia*), blunt-leaved pondweed (*Potamogeton obtusifolius*) and autumnal water starwort (*Callitriche hermaphroditica*). The nationally rare lichen (*Psilolechia clavulifera*) has also been recorded here (SNH, 2011a).

The fen woodland or 'carr' is dominated by willow species (*Carex spp.*) with some areas of regenerating birch (*Betula spp.*) alongside occasional ash (*Fraxinus spp.*) and beech (*Fagus spp.*). Mixed woodland covers the valley sides surrounding the loch and continues northwards on the western side of the site; it includes coniferous species such as Norway spruce (*Picea abies*) and European larch (*Larix decidua*) (SNH, 2011b).

The site includes a long (approximately 500 metres), narrow loch occupying a glacial meltwater channel cut into bedrock. The loch itself contains non-native carp, non-native toads and non-native frogs which are of cultural and historical interest because they are possible releases from a monastery previously located on the site. However, they are introduced species and so are deemed to be of low natural heritage interest (SNH, 2011b).

The bedrock geology in the southern and eastern portions of the site consists of interbedded sandstone from the Stratheden Group and Inverclyde Group. In the north of the site are rocks from the Ballagan Formation, including sandstone, siltstone and dolomitic limestone. The superficial geology consists of alluvium, with till present on the flatter highs out with the site. Superficial cover is absent from the steeper slopes within the catchment (British Geological Survey, n.d.).

1.3 Site Hydrology

There are no major streams within the site. Danskine Loch drains into the Danskine Burn (which flows due south from the southern tip of the site) and a small drainage channel located in the eastern arm of the site drains to the Donolly Reservoir which lies to the east of the site boundary.

A catchment area of 1.19km^2 drains to the site and receives an annual average rainfall of 788mm (Centre for Ecology and Hydrology, 2009). The main source of inflow to the site is via overland flow from the surrounding fields. Additional flow is sourced from springs to the north and south east of the site.

Danskine Loch is artificially dammed at the southern end, and drains to the Danskine Burn via an underground outflow (SNH, 2011b).

The Hydrogeological Map of Scotland (British Geological Survey, 1988) indicates that the site is underlain by a highly productive but not extensive aquifer in which flow is dominantly in fissures and other discontinuities. This indicates that groundwater can be a pathway for pollutants/nutrients at this site.

1.4 Site History

Part of the site (25.0 hectares) was sold by the Forestry Commission in 1981 to the present landowner. In 1961, 11.5 hectares of the sold area had been planted with exotic conifers such as Sitka spruce (*Picea sitchensis*) and Japanese larch (*Larix kaempferi*). Most of these were located in the lower areas of the site where drainage was poor. The trees on the east side of the road were removed in the 1990s as the crop was failing due to the poor drainage with the trees stunted and prone to windthrow. This area has recently been replanted with more suitable species, mainly alder (*Alnus spp.*) although some conifers remain on-site (SNH, 2011b).

1.5 Recent Site Management Practices

No agricultural land is included within the SSSI boundary and hence it remains ungrazed by sheep or cattle. However, Roe deer (*Capreolus capreolus*) are understood to graze the site.

The unsuitability of the low areas within the SSSI for plantation forestry has resulted in the coniferous crops failing. However, commercial forestry continues on the better drained, higher ground around the loch and at the far eastern end of the site. The Site Management Statement (SNH, 2011b) suggests that as long as these are not shading the loch or the associated marsh habitats then the scientific interest of Danskine Loch SSSI will not be compromised.

2. METHODOLOGY

The following sections outline the approach undertaken to fulfil the scope of works established by SNH in the Statement of Requirements (SOR).

2.1 Pre-site Attendance Desk Study

Before the initial site visit was undertaken the local SNH officer was contacted and a meeting held at the corresponding local office to discuss the local understanding of the site and review SNH records.

The meeting was also used to provide an insight into any health and safety constraints not readily apparent from the site maps.

Landowners of the site were notified of the planned site visit a week before the proposed attendance date. This allowed landowners the opportunity to ask any questions and also gave EnviroCentre staff a chance to gain a greater understanding to the workings of the site and the site surrounds. Landowner details are provided in Annex 2.

2.2 Site Attendance

The site was accessed and samples collected over two days. Visit 1 to the site was aborted due to gun shots being heard within the site boundary whilst sampling. A follow up visit to the wider catchment was undertaken and appraised in context with the information obtained from the desk based exercise – Visit 2. A return visit was made to supplement the sampling exercise where designated samples were obtained – Visit 3. Table 2.1 below shows site conditions on the day of each visit.

Table 2.1: Site Conditions

Danskine Loch	Date of Visit	Weather Conditions	Grid References
Visit 1	30 November 2012	Clear, cold and sunny with ground frost	NT 567683
Visit 2	18 February 2013	Clear, mild and sunny	NT 567683
Visit 3	22 March 2013	Clear, dry and sunny with a covering of snow on the ground	NT 567683

2.3 Sampling Approach

SNH had determined the preferred locations for the collection of soil and water samples – as detailed in Figure 2.1 in Annex 1. EnviroCentre was not involved in determining these locations and had not assessed the suitability to access such in advance of Visit 1. Due to certain access restrictions the locations of samples that EnviroCentre collected had to be changed and are as detailed in Figure 2.2 in Annex 1. Changes to locations were kept to a minimum and are generally not deemed to have a significant impact on the sampling or conclusions.

All sampling methods were carried out by trained personnel. Photographs of each sampling location were taken (see Figure 2.3 in Annex 1) and grid references for each location recorded.

2.4 Sample Equipment

The following sample kit was used to undertake site field work:

- Handheld Global Positioning System (GPS) unit to record specific grid references;
- Handheld soil augers;

- Plastic bailers;
- Sample bottles (all sample bottles were written on to record locations, date and time); and
- Personal Protection Equipment (PPE - in line with the requirements of the site specific health & safety risk assessment).

All samples were given unique identification names and packaged in cool boxes with ice packs so as to keep samples at appropriate temperatures prior to being despatched to a United Kingdom Accreditation Service (UKAS) accredited laboratory for analysis.

2.5 Health and Safety

Site specific risk assessments were carried out before attending site. The assessment was based on information obtained from the meeting with the local officer and from EnviroCentre's extensive experience of undertaking previous work of this nature.

The risk assessment, which was completed by staff attending the site visit, included details of the landowner, nearest emergency services, and identified risks and proposed means of mitigation. Field operatives notified EnviroCentre head office when accessing and leaving site and wore the following appropriate PPE at all times:

- Warm and waterproof clothing;
- Waders;
- Waterproof footwear; and
- Hi-vis vest.

Biosecurity measures were rigorously implemented when entering and leaving site. Boots and equipment were washed when leaving site so as not to cross contaminate subsequent sites.

2.6 Water Samples

Surface water samples were collected from strategic locations within the surface watercourses on site. Collections were made from standing (open) water and outflows, to provide an understanding for the whole site.

Groundwater samples were collected using plastic bailers from slotted pipes installed with hand augered holes where soil samples were originally collected. The sampling methodology employed a geosock membrane for coarse filtration in an attempt to minimise samples being heavily loaded with suspended solids and organic material.

Samples underwent initial on-site field tests using an OTT Quanta Handheld probe for the following parameters:

- pH;
- Temperature;
- Electrical Conductivity (EC);
- Dissolved Oxygen (DO);
- Oxidation-Reduction Potential (ORP); and
- Salinity.

The water samples were submitted for the following analyses to a UKAS accredited laboratory:

- Total calcium (Ca), magnesium (Mg) and sodium (Na);

- Nitrogen species – total nitrogen (N), nitrate (NO_3) and ammonium (NH_3);
- Phosphate species – orthophosphate (PO_4^{-3})and total phosphorus (PO_4); and
- Total iron (Fe).

Dissolved and ferrous iron analyses were scheduled in but could not be undertaken by the laboratory due to insufficient sample. This data would have supported interpretation of results if available but is not considered critical for determining the presence or potential sources of diffuse pollution.

2.7 Soil Samples

Soil samples were collected from specific locations on site by hand augering holes into the ground. The soil samples were collected at two depths:

- The rooting zone; and
- A depth of approximately one metre below the rooting zone.

  NB - In the corresponding results tables the samples are differentiated by the suffix 'A' for the rooting zone; and 'B' for below the rooting zone.

Soil samples were analysed for the following suite:

- Moisture content;
- Extractable nitrogen and phosphorus;
- Total nitrogen and phosphorus; and
- Total calcium (Ca); magnesium (Mg) and potassium (K).

Bulk density analysis was scheduled in but could not be undertaken by the laboratory due to insufficient sample. Total sodium (Na) and total organic carbon (TOC) were not scheduled in properly and analyses were not undertaken. The lack of this data is not considered to affect interpretation of results in terms of determining the presence and potential sources of diffuse pollution.

2.8 Field Observations

On accessing the site for the first visit, and the wider catchment for the second visit, the following field observations were noted:

- Geo-referenced photograph locations of surrounding land use (refer to Figure 2.4 in Annex 1);
- Adjacent land use;
- Identified and potential pollution sources; and
- Atypical or unusual site features (*e.g.* fly tipping, vandalism, *etc.*).

In addition, mapping of the immediate surrounding catchment was completed following the second site visit (see Figure 2.5 in Annex 1). This process utilised the Flood Estimation Handbook (Centre for Ecology and Hydrology, 2009) catchments and Land Cover data (Land Cover Map 2007) to populate GIS mapping. The output was used to aid the interpretation of results and further inform the study conclusions.

3. STUDY LIMITATIONS

The scope of the commissioned study presented a series of limitations which should be borne in mind when reviewing this report. These are outlined below:

- The reported sampling was undertaken on two visits due to access constraints. Only one sample was taken at each location in total. This may have led to some inconsistencies in terms of weather conditions before and during the sampling
- For the same reasons outlined above, access to certain parts of the site may have been restricted and limited access to the predetermined sampling location.
- Sampling comprised a single set of samples from each of the pre-determined locations. Repeat or continuous sampling over an extended (seasonal) period would be preferred to enable a greater dataset to be collected. This would present a more representative assessment of the site and allow for seasonal/climatic variations.
- The dataset provides a 'snapshot' of the site condition. Due to the lack of historical data there is no scope for comparisons to be made with previous records or allowance for assessment of seasonal or climatic factors.
- The scope of work did not include the assessment of rainfall within the catchment, or measurement of water levels or of the outflows of associated watercourses.
- The limited dataset does not allow for any statistical analysis of the results to be undertaken. No adjustment has been made for anomalous results or to determine trends over time.
- The sampling methodology used to obtain groundwater samples (obtained from a circa. 1m depth coupled with geosock membrane for coarse filtration) typically results in these samples being heavily loaded with suspended solids and organic material meaning that the samples appear 'dirty' to the naked eye. To avoid interference with the laboratory analytical instrumentation and erroneous results, on receipt at the laboratory these are processed on a x10 dilution. It is this dilution process which explains why some of the results are reported as a less than value rather than the equivalent level of detection of 'clean' samples. The same dilution approach is applied to heavy silted surface water samples.
- The weather conditions prior to and during the site visit should be taken into consideration when reviewing the results. According to the Met Office (n.d.) the seasonal rainfall totals for summer, autumn and winter 2012 in eastern Scotland were 161%, 89% and 82% respectively of the annual average rainfall levels for the period 1981-2010. This should be taken into consideration when reviewing the results as it could result in bias when compared with years where average rainfall levels were recorded. The higher rainfall will directly influence runoff, dilution and catchment water levels/throughput which have not been assessed.
- Due to limitations in the mapping data used to compile the Flood Estimation Handbook (FEH) catchment boundary, the area defined in the Annex 1 maps does not necessarily present a fully accurate reflection of the hydrological catchment for the site. The groundwater catchment area was not determined as part of this study.

4. ANALYTICAL DATA

The following tables show the results obtained from Visit 1 and Visit 3 in which samples from the pre-determined locations (or as close to as practically possible) were collected. Where the pre-determined locations were not accessible comparable alternative locations with the same habitat features were sampled. Water samples DK1-DK5 and all soil samples were taken during Visit 1 on 30th November 2012 and water samples DK07-DK09 were taken during Visit 3 on 22nd March 2013.

Table figures in red indicate relative atypical (*e.g.* high or low values) or anomalous results or observations relative to the collected dataset or which would typically be expected from a site of this nature. These are discussed further in section 6.2.

4.1 Water Quality Field Data

The following data was collected by a suitably qualified operative using the methods outlined in section 2.

Table 4.1: Water Quality Field Data and Observations

Sample ID	Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	General Field Observations
DK01	3.75	6.09	0.18	76.4	10.14	108	0.347	Surface water - clear with large suspended solids; no odour
DK02	3.34	6.07	0.15	30.3	4.59	30	0.320	Groundwater - dark brown with mix of large and fine suspended solids; strong sulphur odour
DK03	3.47	6.09	0.14	96.8	12.42	51	0.310	Surface water - clear with very fine suspended solids; no odour
DK04	3.56	6.05	0.22	81.1	10.81	35	0.460	Surface water - light brown with fine suspended solids; no odour
DK05	3.04	6.19	0.11	78.20	10.5	68	0.230	Surface water - clear with few fine suspended solids; slight sulphur odour
DK07	4.75	6.38	0.10	55.5	7.94	-57.0	0.212	Groundwater – dark, cloudy, brown with large suspended solids; no odour
DK08	4.73	6.66	0.09	64.4	6.73	-56.7	0.190	Groundwater – dark, cloudy, brown with thick sludge suspended solids; strong petrol odour
DK09	4.51	7.45	0.15	105.9	13.83	-53.7	0.331	Surface water – clear with very fine suspended solids; no odour

4.2 Analytical Results

The data in the following tables was collected by a suitably qualified operative using the methods outlined in section 2.

Table 4.2: Water Samples - Laboratory Analysis

Sample ID	Nat. Grid Reference		Flow Type+	Total Ca (mg/ l)	Total Mg (mg/ l)	Total Na (mg/ l)	Total Fe (mg/ l)	Amm N (mg/ l)	Nitrate as N (mg/ l)	Phosphate as P (mg/ l)	Total P (mg/ l)	Total N as N (mg/ l)
DK01	NT 56629	NT 67429	SW(O)	35	10	11	0.98	0.11	2.2	0.07	0.9	3
DK02	NT 57084	NT 68014	GW	29	6	9	5.06	1.10	<0.2	0.08	0.2	3
DK03	NT 57168	NT 68052	SW(I)*	30	9	6	0.06	0.02	7.2	0.07	<0.1	7
DK04	NT 56781	NT 68490	SW(I)*	44	14	15	<0.01	0.02	0.9	0.07	<0.1	1
DK05	NT 56764	NT 68363	SW(I)*	16	5	7	0.32	0.03	<0.2	0.06	<0.1	<1
DK07	NT 56671	NT 68268	GW	93	14	16	355	1.60	<0.2	0.98	4.2	N/A
DK08	NT 56620	NT 68076	GW	79	20	14	240	3.70	<0.2	0.88	4.2	N/A
DK09	NT 56571	NT 67988	SW(I)	25	8	11	0.52	0.30	3.4	0.63	<0.1	N/A

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW).
** Classified as a surface water although spring derived.*
Red text denotes samples that are above typical ranges for the observed dataset.
DK08 – groundwater sample but no soil sample

Table 4.3: Soil Samples – Laboratory Analysis

Sample ID	Nat. Grid Reference		Extractable N (mg/Kg)	Total Ca (mg/Kg)	Total Mg (mg/Kg)	Total P (mg/Kg)	Total K (mg/Kg)	Tot Moisture* 105°C (%)	Total N (mg/Kg)	Nitrate (mg/l)	Nitrogen (%)	Extractable P (mg/l)
DK02A	NT 57000	NT 68000	11	16200	2800	3240	1420	82.1	<11.2	<0.2	1.22	4.89
DK02B	NT 57000	NT 68000	58	7150	1910	953	1250	58.8	<58.2	<0.2	0.88	<2
DK06A	NT 56700	NT 68300	4	23900	2090	951	941	90.6	<4.2	<0.2	2.48	2.6
DK06B	NT 56700	NT 68300	2.4	23600	2030	584	436	89.7	<2.6	<0.2	2.19	<2
DK07A	NT 56600	NT 68200	5.5	10700	1920	907	708	87.2	<5.7	<0.2	2.08	<2
DK07B	NT 56600	NT 68200	1.6	13700	1900	523	440	89.9	<1.8	<0.2	1.75	<2

** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*
Red text denotes samples that are above typical ranges for the observed dataset.

5. SITE OBSERVATIONS

To enhance the understanding of Danskine Loch and the surrounding area, preliminary research was undertaken and complemented with a site walkover to further understand the landforms, drainage configurations, potential environmental sensitivities and possible diffuse pollution sources influencing the site.

5.1 Desk Study

The Site Management Statement (SNH, 2011b) records 'Objective for management' of controlling the naturally regenerating birch and beech; controlling and eventually eliminating the non native dogwood; controlling silt and nutrient inputs from adjacent farmland and the fishery; and in the long term to restore the plantation woodland areas to native woodland.

The 2009 Site Condition Monitoring (SCM) assessment of the fen woodland feature (SNH, 2009b) found it to be in unfavourable condition due to the presence of dogwood (*Cornus spp.*), an invasive non-native species, and the presence of localised patches of birch (*Betula spp.*), ash (*Fraxinus spp.*) and beech (*Fagus spp.*) which indicate drier areas of the site.

The SCM form for the Fen woodland feature (SNH, 2009b) listed the following site pressures:

1. Silt and nutrients from agriculture;
2. Nutrients from fishery and damage to margins (of more relevance to the open water than the fen);
3. Non-native shrub species; and
4. Birch colonisation.

There is a file reference (SNH, 2007) to Danskine Loch being classified as eutrophic. A single water sample with a total phosphorus concentration of 112.6µg/l is recorded as having been taken during the 2004 Site Condition Monitoring exercise. The corresponding reporting states this as being 'extremely high' and 'indicative of hypertrophic, rather than eutrophic conditions'. As this is a single sample, the location of which is not confirmed, confidence in this value is low. However, it is comparable with the value for the open water result obtained for DK01 in this study. This is discussed further in section 6.

SNH (2008; 2009a) highlight that the loch has been stocked with non-native carp species for recreational angling. A requirement of the agreement in 2009 to re-stock (non-native) carp in the loch (SNH, 2009a) was monitoring of water quality and cover and distribution of aquatic macrophytes. No data was available for review for the purposes of this project and it is not known whether this monitoring was carried out.

SNH (2009b) highlighted that there was no indication of active management being undertaken at the site despite a management agreement being in place.

5.2 Catchment Walkover

The following observations of the surrounding catchment were made:

- The site was free of litter. No visible pollution sources were observed within the site boundary.

- Arable land surrounds the site along the eastern and northern boundaries.

- The loch is situated within woodland comprising a mixture of broadleaved and conifer trees.

- Several springs observed at the site and in the surrounding area.

- No discernible algal blooms were observed however, this is not atypical given the time of year the site visits were undertaken.

- A sluice at the southern end of Danskine Loch controls the loch outflow and levels.

- Public access is available throughout the woodland. A path can be followed from the gate by the fields on the eastern boundary through the woodland directly to the loch edge.

- The north eastern part of the site drains to the Donolly Reservoir.

- No evidence of accelerated sediment transport into the loch or fen woodland was observed from any of the catchment locations/features assessed.

- Pheasant pens and feed hoppers are present throughout the wooded area.

5.3 Summary

Table 5.1 provides a summary of the key site features which were observed during both site visits or identified in the desk study undertaken as part of the initial works**.**

Table 5.1: Summary of key observations

Activities	Observations
Fencing	Entire boundary of site is fenced, however, the condition of such to limit access to cattle and sheep was not appraised as part of the scope of works. A section of damaged fence was observed in the south west,
Fishing	The loch has historically been stocked with non-native carp and is understood to be fished recreationally. A small boat is located on the bank of the loch for this purpose.
Grazing	The site is not grazed. The fields adjacent to the northern boundary of the site are on occasion grazed by both cattle and sheep. Access by Roe deer will mean that a low level of grazing within the site boundary does occur.
Monitoring	A loch survey was undertaken by SNH in 1996 and condition monitoring was carried out in 2004 and 2009. Limited water data records exist. No known soil data records were reviewed as part of the desk study exercise.
Public Access	Site has public footpath access around the loch. This is accessed from the gate by the fields on the eastern boundary through the woodland directly to the loch edge.
Shooting	Pheasant and wild fowl shooting are understood to take place on site. Pheasant pens and feed hoppers are present throughout the wooded areas. This could lead to some inflow of nutrient enriched runoff to the loch but is not considered to be significant.
Point Pollution Sources	None observed within the SSSI boundary. However, the fields surrounding the site are used for arable production and are located up gradient from the loch hence the steep catchment would afford access for runoff containing fertiliser to enter the loch.
Properties in the catchment	There are no properties located within the site boundary or within the wider catchment.
Unusual, Distinctive or Atypical Features	Several springs are noted within and in close proximity of the site. Managed conifer and broadleaved woodland plantations present within the site.

A mapped summary of the perceived catchment pressures is detailed in Figure 5.1 (see Annex 1).

6. INTERPRETATION OF RESULTS

The following assessment is based on the field tests and laboratory analytical results only.

6.1 General Summary

The surface water samples indicated variable concentrations of bioavailable nutrients at the site. Elevated levels of total phosphorus were noted at the outlet (DK01) with elevated levels of total nitrogen and nitrate recorded in the eastern arm at DK03. Samples DK01-DK06 were taken during Visit 1 and samples DK07-DK09 were taken during Visit 3 (see section 2 for further detail).

pH and electrical conductivity were fairly uniform between monitoring locations, reflecting acidic conditions and moderate mineral enrichment across soil, water and groundwater samples. A basic pH (7.45) was observed at DK09, the inflow to the loch.

Relatively high levels of nitrate were recorded in the sample DK03, a surface water sample derived from a nearby groundwater source. Moderate nitrate levels were observed at the inflow (DK09) and outflow (DK01) from the loch. The elevated nitrate may be attributed to runoff and infiltration from the surrounding farmland. The highest ammonia was recorded in the groundwater sample (DK08) and reflects typical hydro-geochemical conditions in this media (more rich in reduced species).

Phosphate levels within water samples were fairly uniform between water monitoring locations DK01-DK05 and DK09. However, the total phosphorus result in the outflow sample (DK01) was notably higher than all other results at the site and is indicative of highly eutrophic conditions. This figure is also a notable increase on the only historic data held on file, a 2004 value of 0.112mg/l albeit that the location of this sampling point was not confirmed. This indicates potential accumulation of nutrients within the loch from the contributing catchment. Phosphate and phosphorus levels recorded in groundwater at DK07-DK08 during Visit 3 were significantly higher than the other water sampling locations which could be indicating higher levels and long term accumulation of phosphorus compounds in this area of the site, potentially associated with input from the regional aquifer.

Calcium, magnesium and sodium were all fairly uniform across the site with DK07 and DK08 recording highest levels. These slightly higher values may just be natural variation or attributed to influence from a groundwater source. The highest iron levels were recorded in the groundwater sample as would be expected, reflecting natural processes.

Extractable nitrogen was below the limit of detection (LOD) in all soil samples, although it is noted that the LOD was variable between samples. The highest values were recorded in the DK02 samples (both sample horizons) with all of the nitrogen recorded as ammonia suggesting reducing conditions (likely linked with poor drainage). No nitrate was recorded in the soil samples.

Total phosphorus was fairly uniform in soil samples across the site with the highest recorded in the root zone sample at DK02. Available phosphorus was generally low with the highest also recorded in the root zone sample at DK02. No obvious trends of inputs of phosphorus were noted.

Calcium, magnesium and potassium were fairly uniform across all the soil samples reflecting natural geochemical conditions.

6.2 Atypical Results

The monitoring data from the Danskine Loch site was fairly uniform across all monitoring locations with the key atypical results as detailed below:

- Total nitrogen, present as nitrate in the spring derived sample (DK03) is significantly higher than all other water samples indicating the likely influence of agricultural pressures on groundwater within the catchment.

- The strong sulphur odour in DK02 correlates directly with the corresponding low dissolved oxygen values. This is likely to be attributed to natural organic degradation and is supported by the presence of an elevated ammonia value. Depending on the volume of flow from this source this could place a direct oxygen demand on the loch.

- A strong petrol odour was observed in groundwater at DK08. No evidence of pollution was observed in the area and the source is unknown. The sampling location is beside a track and there is a potential for a fuel leak from a vehicle.

- Elevated iron values were recorded in groundwater samples DK07 and DK08 with a maximum value of 355mg/l recorded. This is typical for groundwater due to reducing conditions in this media resulting in greater presence of soluble iron species.

- The root zone soil sample DK02A recorded the highest levels of total and extractable phosphorus at 3240mg/kg and 4.89mg/l respectively. The deeper sample (DK02B) recorded the highest total nitrogen value of all the samples taken. This is likely linked to nutrient enrichment of the groundwater at the site.

6.3 Additional Considerations

The 2004 water quality data (SNH, 2007) is considered not atypical given the value obtained from this study. Whilst the details as to the location, depth and method of sampling for the historical record are not known, the value is significantly lower than that observed from the loch outflow sample in this study – namely 0.9mg/l (900.0µg/l) for DK01. Whilst reservations should be made of direct comparisons given the reasons stated, it is considered that the total phosphorus values within the loch are elevated and could have increased over the intervening years.

No records or reports (anecdotal or otherwise) of algal blooms or fishing records were identified or reviewed during this study. Information of this nature could be of value in understanding long-term trends and changes within the site.

7. CONCLUSIONS

The analytical results indicate there to be elevated nutrients in the soil, surface and groundwater samples consistent with eutrophic loch conditions. In conjunction with the desk study and site walkovers, there are observations that indicate an intensification in agricultural practices (likely in the last 60 years) and a commercial plantation (since 1961) within the immediate catchment which will have directly influenced water quality.

Due to the surrounding topography, low lying position of the fen woodland and loch, and underlying productive aquifer, it is expected that the site will be heavily influenced by the quality and quantity of groundwater which flows to the site. The extent of the groundwater catchment is not known but it could extend beyond the surface water catchment. These flows, which will vary seasonally, will leach nutrients from the surrounding catchment to the loch which in turn acts as a sink for the surrounding landform. The nutrients encourage plant growth which over time decay and, coupled with the inflow of suspended solids from the wider catchment, would tend to create a nutrient rich substrate. It is this continued infilling and accumulation which furthers successional change that is deemed to be presently observed at the fen woodland and is to the detriment of the designated site condition.

The historical information on the site is limited. With the exception of variations in land management resulting from developments in agricultural and forestry practices, it is assumed that the surrounding catchment is largely unchanged. It is therefore deemed that the changes in the former practices have influenced the SSSI in recent years. Fish stocking in the loch could have had an impact on aquatic vegetation and nutrient re-suspension.

The highly productive nature of the underlying geology is expected to aid migration of nutrients to groundwater from the intensively managed arable land. This will be enhanced through losses of vegetation during the harvesting cycle, increased runoff from ploughed land and the seasonal application of soil conditioners, artificial fertilisers and herbicides – the extent and volumes of which are unknown.

A sluice at the southern end of Danskine Loch controls the loch outflow and levels. It is possible that variations in operation of the sluice over time could influence the nutrient inputs and flushing in the loch and its associated margins.

It is probable that there are significant sediment accumulations within the loch. These will afford a plentiful supply of nutrients through disturbance by, and variations in, seasonal inflows. The loch depth is unknown and therefore it is unclear whether there could be any release of nutrients resulting from stratification. How water quality is seasonally influenced will directly influence the composition of the woodland fen. The limited information of algal blooms and lack of historic water quality data restricts the conclusions which can be drawn in proving the loch has changed in its trophic status.

Consideration should also be given to the potential for additional nutrient input from wildfowl. Whilst current numbers are not known, a significant population descending on the loch could potentially add a notable nutrient load to the loch sediments.

There appears to be limited understanding of the current and historical land management practices, in both the surrounding arable land and the fen woodland. From the observations made during the study, land management practices present a major potential impact to the site.

8. RECOMMENDATIONS

Based on the limited understanding gained from the sampling exercise and catchment visits, the following recommendations are proposed:

8.1 Monitoring

i. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to include orthophosphate and bioavailable (extractable) nitrogen. Ideally this would be undertaken over the course of several seasons (e.g. for one year). The data from such should be compared alongside surface water and groundwater levels, rainfall data and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site. In conjunction with this, the seasonal flow and nutrient loads of spring/groundwater inflow should be assessed and compared with those of the outflow from the south-east end of the loch. This data would be of direct value in being able to assess the hydrological and hydrogeological regime at the site and season variations in throughput.

8.2 Other Commissioned Studies

ii. Undertake hydrological and hydrogeological assessment of the spring and groundwater sources within the boundary of the site in order to determine the background water quality and quantity. This should also include an assessment of recent and historical changes in surface water and groundwater levels and management of the loch outflow sluice.

iii. Assess the link between the observed tree encroachment in the woodland fen and nutrient enrichment and potential changes in water levels.

iv. Undertake core sampling and detailed analysis of loch and fen sediments to understand historic source pollution and retained nutrients.

v. Undertake an outline assessment into the potential effect of wildfowl on water quality in the loch.

8.3 Policy

vi. SNH to review the existing site management agreement (as identified in SNH, 2009b) and seek to address the management issues as identified in this study and corresponding SNH reports.

vii. Review the fish stocks and associated policies at the site. It is considered that the fishing activities will predominantly be ‘catch and release’ orientated, hence the number and size of fish within the loch should be in a state of equilibrium. By understanding the existing fish stocks, consideration can be made to the likely disturbance of sediments with regards nutrient release.

viii. Review the tree planting approach, as outlined in the Site Management Statement (SNH, 2011). It is not known where new native tree planting has been undertaken at the site and how this may affect the hydrology and specifically the inflow of nutrients to the site.

8.4 Landowners

ix. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment including field usage,

crop type and fertiliser/soil conditioning approaches. Consider appropriate management strategies accordingly - for example, nutrient management planning, treatment of outflows *e.g.* constructed wetlands, buffer strips, exclusion zones, routine spot monitoring, improved/repaired fencing, improved use of fertilizers, *etc*.

8.5 External consultations

x. Engage with SEPA to further the understanding of the site in terms of the sluice management/operation at the site.

From the stated conclusions and identified pressures (Figure 5.1) the key actions to seek to reverse the present declining status of the site are to:

1. Address the inputs to the site from the agricultural catchment including the groundwater contribution (i, ii, ix); and
2. Assessment of factors contributing to tree encroachment within the woodland fen (i,ii, iii); and
3. Assessment of the water levels/loch throughput (ii, x).

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ANNEX 1: FIGURES

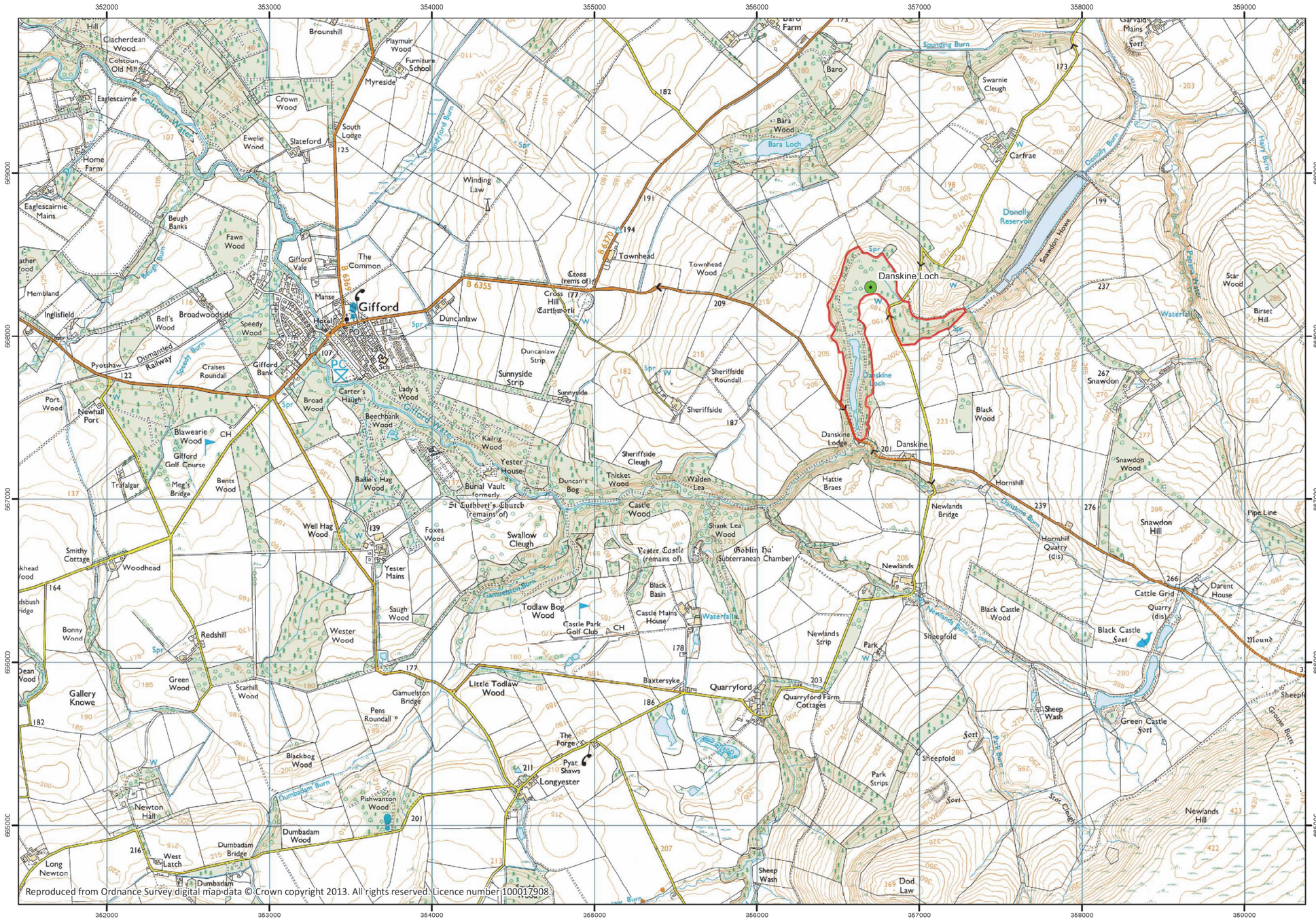
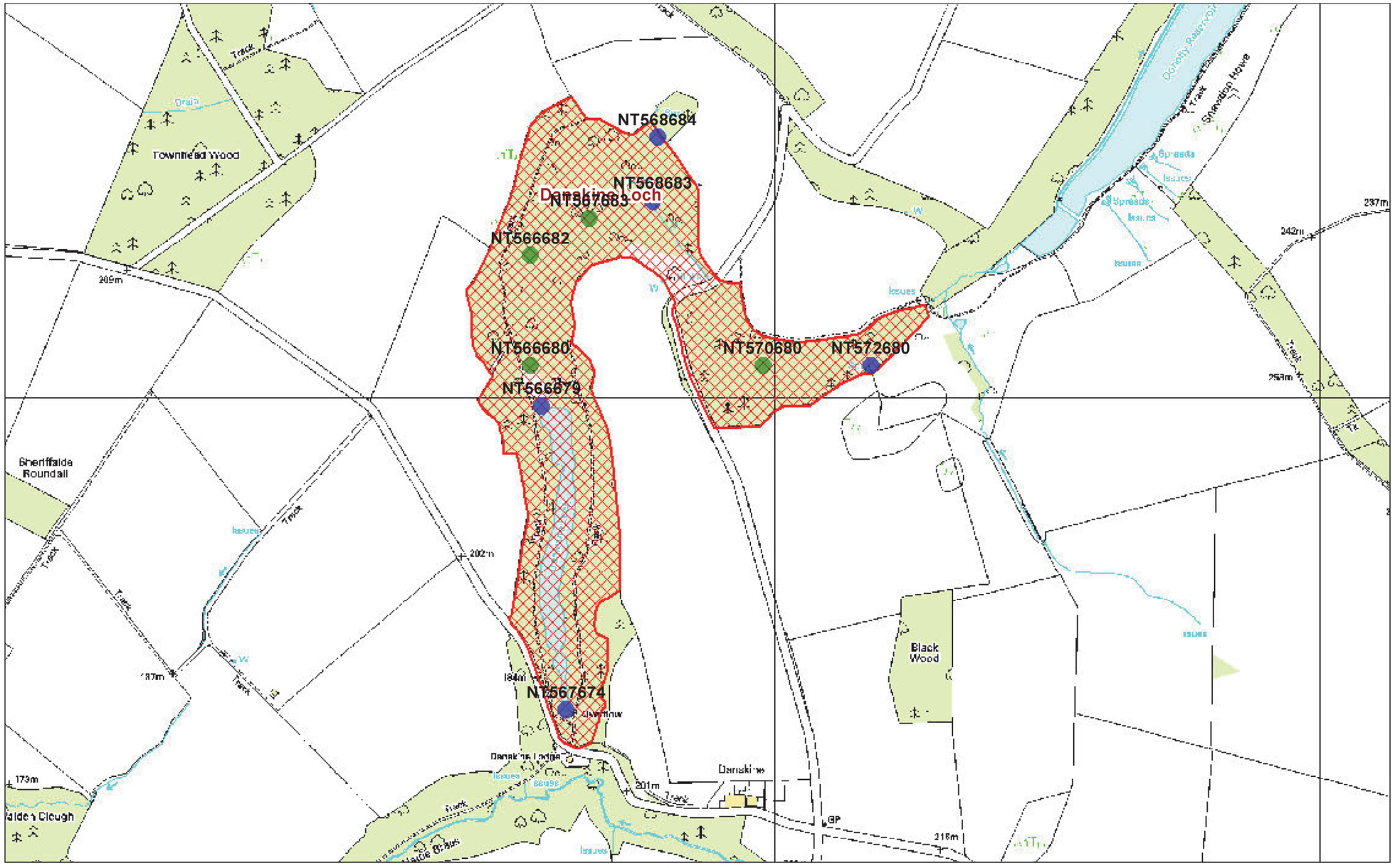


Figure 1.1: Site Location Map

Danskine Loch



Notes:

0 0.05 0.1 0.2 0.3 0.4 km

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Map produced using geo.View 3.0
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Figure 2.1: SNH Proposed Sampling Location Plan

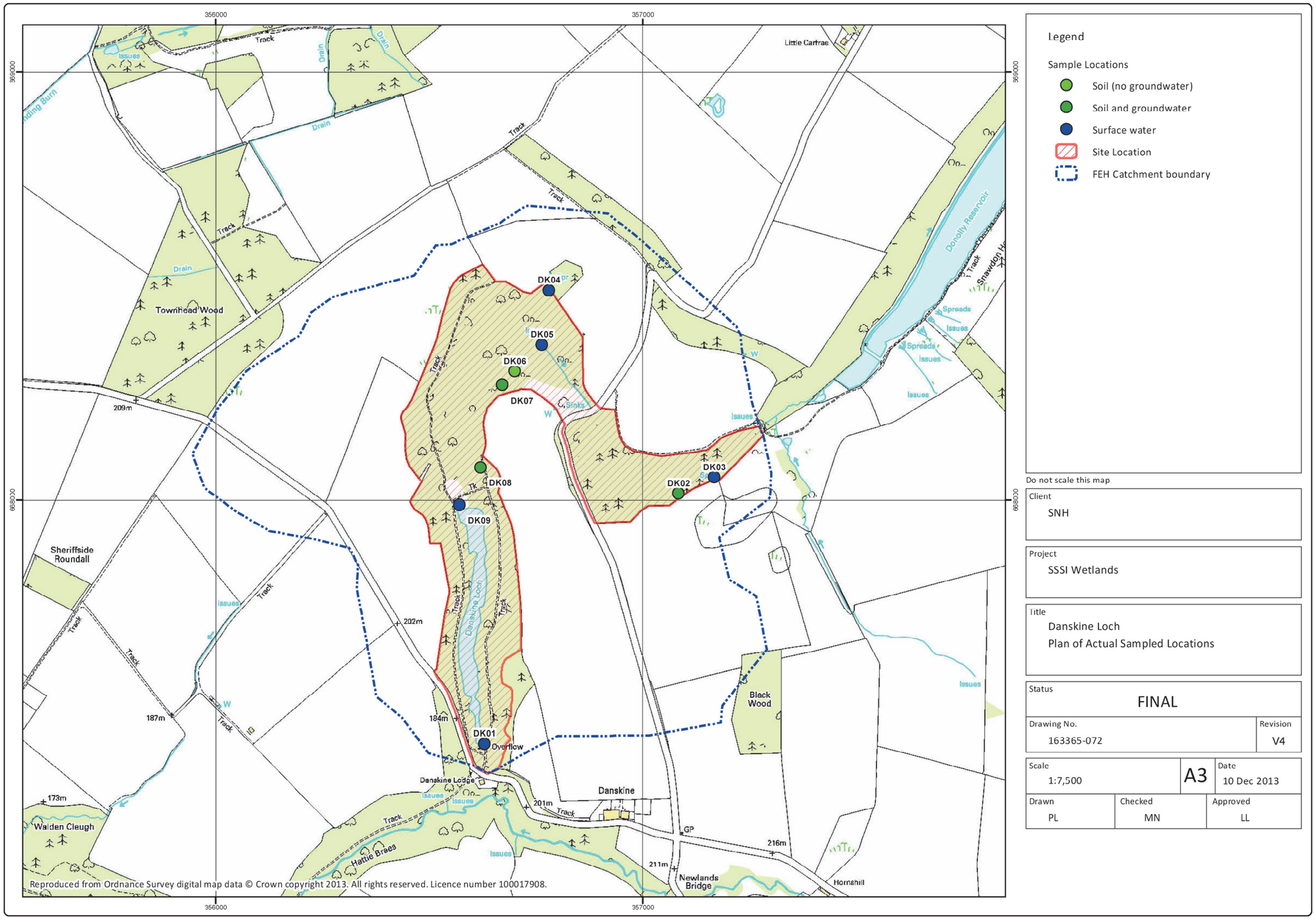

Figure 2.2: Plan of Actual Sampled Locations

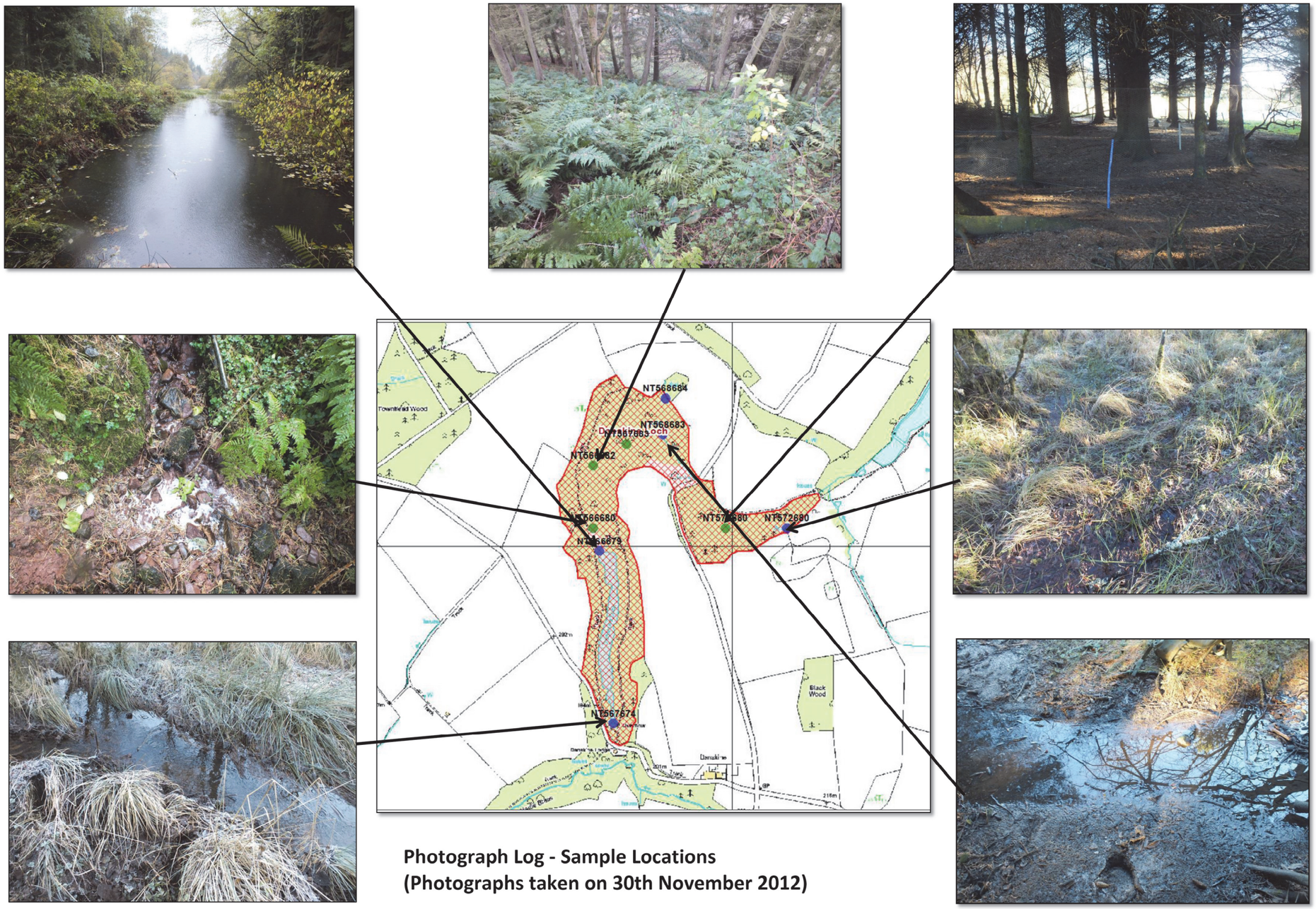

Figure 2.3: Sample Location Photographs

Photograph Log- Surrounding Catchment
Photographs taken on 18th February 2013

Figure 2.4: Surrounding Land Use Photographs

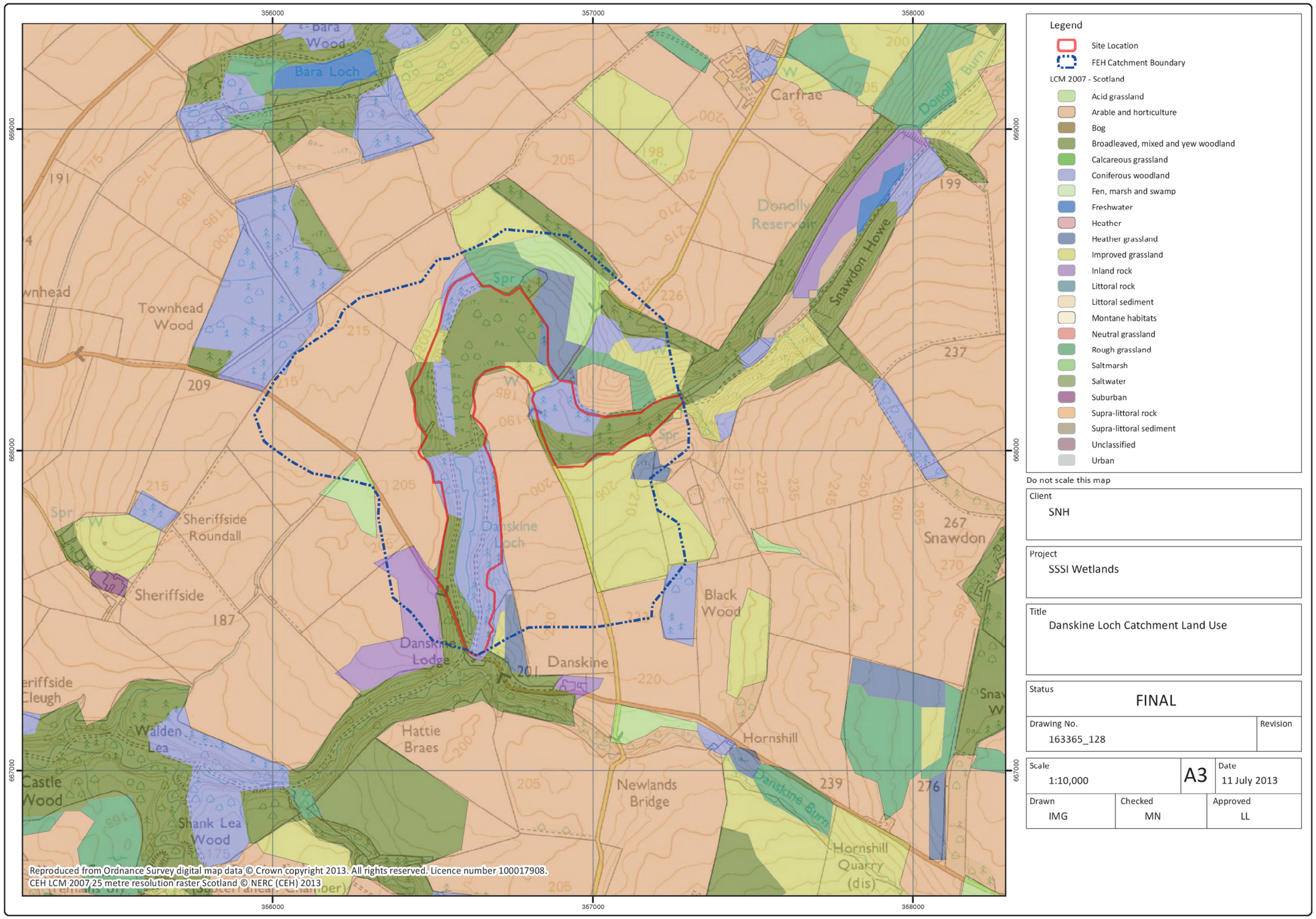

Figure 2.5: Land Use Characteristics Map

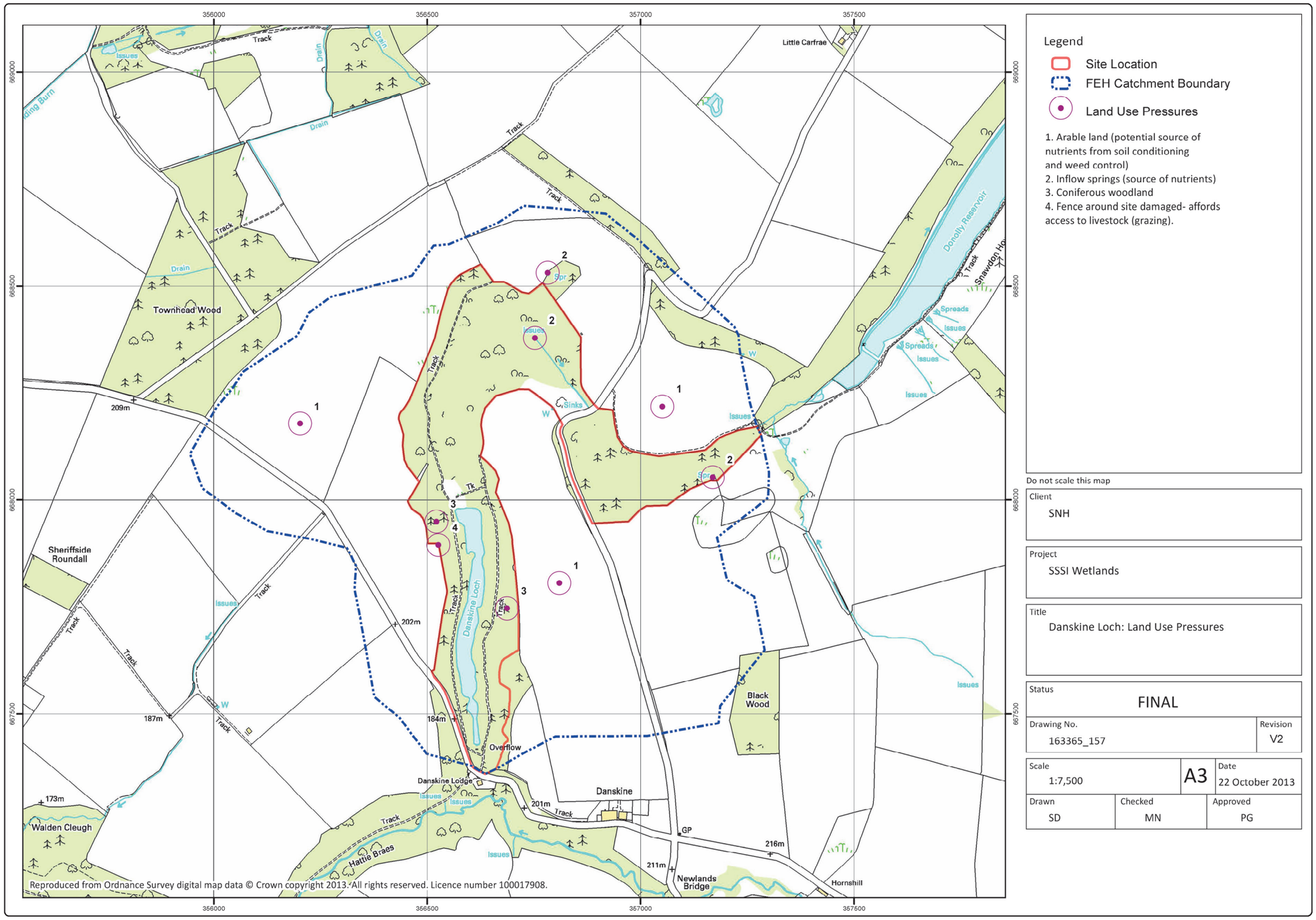

Figure 5.1: Catchment Pressures Land Use Summary

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