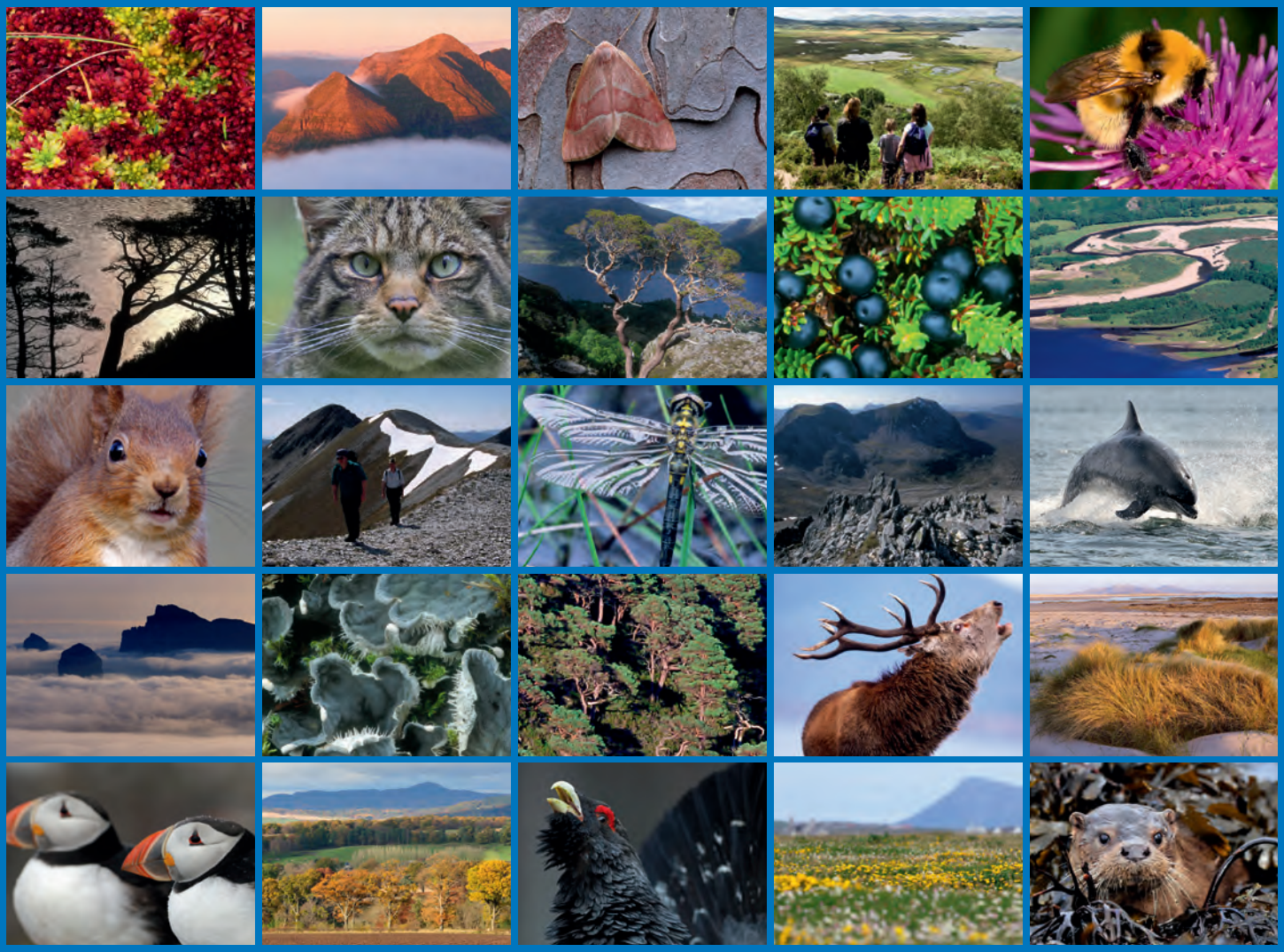
Scottish Natural Heritage
Commissioned Report No. 730

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Mill Dam



Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

COMMISSIONED REPORT

Commissioned Report No. 730

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Mill Dam

For further information on this report please contact:

Sarah Hutcheon
Scottish Natural Heritage
Silvan House, 3rd Floor East
231 Corstorphine Road
EDINBURGH
EH12 7AT
Telephone: 0131 316 2617
E-mail: sarah.hutcheon_edinburgh@snh.gov.uk

This report should be quoted as:

EnviroCentre Ltd. Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Mill Dam. *Scottish Natural Heritage Commissioned Report No. 730.*

COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Mill Dam

Commissioned Report No. 730
Project No: 13700
Contractor: EnviroCentre Ltd.
Year of publication: 2015

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 conditions.

Main findings

- Analytical data recorded high levels of inorganic nutrients within the site. The observations are typical of eutrophication and are supported by evidence of nutrient enrichment within the catchment from land management and drainage practices. The sampling assessment was undertaken as a single visit and limitations of the dataset constrain the ability to draw accurate conclusions on current site conditions.
- The site walkover revealed potential existing and historical land use practices within the catchment that could adversely affect water quality and loch dynamics.
- A series of recommendations are proposed to aid the understanding of the site, the loch flow regime and the impact of variation of water levels and land management practices. It is considered that this additional information will help further the understanding of the observed changes taking place at the site.

For further information on this project contact:
Sarah Hutcheon, Scottish Natural Heritage, Silvan House, 3rd Floor East, 231 Corstorphine Road, Edinburgh, EH12 7AT.
Tel: 0131 316 2617 or sarah.hutcheon_edinburgh@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

Table of Contents **Page**

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 wetland and standing water Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Mill Dam loch is located approximately 3.5 kilometres (2 miles) north west of Bankfoot and 4.5 kilometres (3 miles) west of Murthly, Perthshire. The site is accessed off an unnamed road off the B867 (Birnam Quarry to Bankfoot). See Figure 1.1 in Annex 1.

1.2 Site Description

Mill Dam is an 8.83 hectare site designated as a Site of Special Scientific Interest (SSSI) in 1984 for its species rich basin fen (SNH, 2010a). It is also important as it supports a number of plant species which are locally uncommon. This type of habitat is rare particularly in the lowlands (SNH, 2010b).

The site consists of a small area of open water which was artificially impounded by an earth dam and sluice to serve the mills at Murthly. The water levels were lowered following the mills' conversion to electricity in the 1950's. The lowered water table encouraged the development of a fen around the remaining open water body.

The site consists of undisturbed species-rich basin fen. The fen, or mire, is contained within a depression (a kettle hole) where the local landform gives rise to a permanently high water table. This type of feature is also known as a topogenous or basin mire.

The most important features of the site are the small areas of fen on the west side of the dam, which are influenced by the groundwater merging into more acid areas, and the surrounding reed swamp (SNH, 2010b)

The immediate surrounding catchment comprises improved pasture beyond which is managed woodland.

The bedrock geology on site comprises of the Craighall Conglomerate Formation, this is overlain by alluvium in the lower lying areas and glaciofluvial ice contact deposits (gravel, sand, and silt) elsewhere (British Geological Survey, n d).

1.3 Site Hydrology

A catchment area of 2km^2 drains to the Mill Dam site, with an annual average rainfall of 916mm (Centre for Ecology and Hydrology, 2009). The main inflow to the site is the Birnam Burn which flows under the B867 from Stare Dam to enter the site in the south western corner. Two further watercourses enter the site, both unnamed. One of the unnamed burns flows to the site from the north west, this is associated with the local water supply system. The other watercourse enters the loch in the east through an established treeline. There is also a contribution from road drainage along the B867 to the west, and from overland runoff and field drainage on neighbouring agricultural land. The Birnam Burn forms the loch outflow to the north east, this passes over an earth dam with a central sluice which functions as a control to water levels.

1.4 Site History

A review of the SNH site files coupled with internet research revealed limited additional information above that within the Site Management Statement (SNH, 2010b). This document is therefore considered to be the main source of historical information for the site and is that from which the following information is taken.

Although the site has limited agricultural value it has been subject to drainage with ditches present within the site boundary. It is considered that these serve an important purpose in protecting agricultural interest outwith the site (SNH, 2010b).

The earth dam is known to have failed in the past and the central sluice has a history of vandalism. In addition, the blocking of the outflow below the sluice has occurred in the past due to the collapse of wet woodland trees in this area (SNH, 2010b). No further details on these events were made available during the desk study.

In 2007 two sinkholes to the west of the site were in-filled and an unconsented drainage pipe installed into the SSSI towards the Birnam Burn (SNH, 2010b).

A review of historical mapping (National Library of Scotland, n.d.) indicates there to have been notable changes in the size of the loch within the site and to the inflow watercourses/waterbodies. Up to as recently as 1958 the loch comprised a substantial part of the designated site and is assumed to have retracted since. The inflow from Stare Dam is an addition since 1927 which resulted from the Birnam and Aldinny Burns having been diverted through Stare Dam which itself was constructed between 1868 and 1898. The reasons for the dam are not known but speculated at either aiding the draining of the upstream catchment for the purposes of timber production and/or to feed the Mill Dam loch with the outflow being required by the neighbouring saw mill.

1.5 Recent Site Management Practices

The estate presently uses the loch as a flight loch for Mallard (*Anas platyrhynchos*) and a flight pen is present within the SSSI (SNH, 2010b).

The southern and western ends of the site are reported to silt up and become vegetated. Maintenance dredging is an option being considered as part of the future management of the site (SNH, 2010b).

The spread of certain plant species (nettles, reed-mace and docks) 4-5 metres into the SSSI boundary suggests increased nutrient enrichment. A field immediately to the west of the site is used as part of a tenanted dairy farm and slurry is spread onto the field. The soil in this field is free draining and slopes down to the SSSI on all sides (SNH, 2010b).

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 visiting 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 a one day period – termed Visit 1. A follow up visit to the wider catchment was undertaken once the analytical data was available and appraised in context with the information obtained from the desk based exercise. Table 2.1 below shows site conditions on the day of each visit.

Table 2.1: Site Conditions

Mill Dam	Date of Visit	Weather Conditions	Grid References
Visit 1	12 November 2012	Cold, overcast with light rain	NO 055385
Visit 2	20 February 2013	Cold, overcast, snow on the ground	NO 055385

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 before 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 inflows, 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 so as 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);
- N Species – total nitrogen, nitrate and ammonium;
- P Species – orthophosphate and total phosphorus; 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 (CEH), 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:

- Sampling was undertaken on a single visit. Whilst this afforded consistency for the samples collected, the weather conditions preceding and at the time of the visit may have directly influenced the observations made and the analytical results obtained.

- 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 limited availability of historical data (see section 1.4) there is very limited 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, measure loch levels or the inflow(s)/outflow(s) 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 an accurate reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

The following tables show the results obtained from the initial site visit (Visit 1) 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.

Table figures in red indicate relative atypical (e.g. high or low values) or anomalous results relative to the remaining dataset or which would typically have been expected to be observed 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	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	Comments
MD01	NO 05188	38354	9.19	7.46	0.1	93.3	10.25	290	0.281	Surface water - clear with only very few fine suspended solids; no odour
MD02	NO 05248	38326	8.05	6.96	0.1	28.6	3.42	289	0.151	Groundwater - cloudy brown with fine brown suspended solids; very mild organic (sulphur) odour
MD03	NO 05447	38491	7.41	6.39	0.0	28.4	3.39	295	0.122	Groundwater - cloudy brown with fine brown suspended solids; very mild organic (sulphur) odour
MD04	NO 05517	38536	7.41	7.02	0.1	79.9	9.25	303	0.186	Surface water - clear with only few very minor suspended solids; no odour
MD05	NO 05515	38611	8.04	7.13	0.0	87.1	10.14	298	0.09	Surface water - clear with only few very minor suspended solids; no odour
MD06	NO 05578	38771	7.63	7.13	0.1	71.8	8.59	296	0.108	Surface water - clear with very fine suspended solids; no odour
MD07	NO 05253	38712	8.26	6.87	0.1	49.2	5.89	324	0.205	Surface water - clear with a few minor suspended solids; no odour
MD08	NO 05261	38714	7.95	6.58	0.1	18.7	2.36	290	0.147	Groundwater - dark cloudy brown suspended solids, very mild organic (sulphur) odour
MD09	NO 05468	38590	8.34	5.71	0.0	27.5	2.9	337	0.081	Groundwater - light cloudy brown, with fine brown suspended solids; very mild organic (sulphur) odour

4.2 Laboratory 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		Sample 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)
MD01	NO 05188	38354	SW (I)	6	2	4	0.4	<0.01	<0.2	<0.01	<0.1	<1
MD02	NO 05248	38326	GW	19	7	10	12.7	0.60	<0.2	<0.01	0.7	9
MD03	NO 05447	38491	GW	18	5	7	57.0	1.10	<0.2	<0.01	1.0	3
MD04	NO 05517	38536	SW (I)	24	5	6	0.04	0.01	<0.2	<0.01	<0.1	<1
MD05	NO 05515	38611	SW (OW)	8	3	5	0.49	<0.01	0.2	<0.01	<0.1	<1
MD06	NO 05578	38771	SW (O)	10	3	6	0.36	<0.01	0.7	<0.01	<0.1	1
MD07	NO 05253	38712	SW (I)	26	7	8	<0.01	<0.01	3.3	<0.01	<0.1	4
MD08	NO 05261	38714	GW	52	10	10	105.0	0.40	<0.2	<0.01	1.2	4
MD09	NO 05468	38590	GW	10	2	5	8.79	0.28	<0.2	<0.01	0.4	6

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)
Red text denotes samples that are above typical ranges for the observed dataset.

Table 4.3: Soil Samples - Laboratory Analysis

Sample ID	Nat. Grid Reference		Soil Type*	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)
MD02A	NO 05248	38326	Dark organic, wet sludge	1.2	16300	3010	873	1230	75.0	1.9	0.7	2.11	6.23
MD02B	NO 05248	38326	Brown soil with gravels	1.6	2680	1800	278	596	70.2	<1.8	<0.2	0.72	3.44
MD03A	NO 05447	38491	Low organic brown soil	0.7	11700	2300	821	2310	78.6	<0.9	<0.2	1.33	5.51
MD03B	NO 05447	38491	Brown soil with gravels	6.9	5570	1470	773	637	78.5	<7.1	<0.2	1.92	5.23
MD08A	NO 05261	38714	High organic, wet sludge	<0.5	10000	1490	797	816	89.5	<0.7	<0.2	2.36	7.85
MD08B	NO 05261	38714	Brown soil with gravels	<0.5	4070	1820	325	487	65.5	<0.7	<0.2	0.82	<2.0
MD09A	NO 05468	38590	High organic, wet sludge	1.4	4050	708	501	389	91.3	<1.6	<0.2	1.75	7.91
MD09B	NO 05468	38590	High organic, wet sludge	1.4	6540	1120	614	319	76	1.7	0.3	2.16	5.79

** Soil types are field observations*
*** 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 Mill Dam and the surrounding area, preliminary research was undertaken and complemented with a second 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, 2010b) records an 'Objective for Management' of maintaining and improving the botanical interest of the basin fen communities. This is to be achieved through maintaining water levels to acceptable limits; maintaining water quality through ensuring that nutrient enrichment/eutrophication is reduced where possible; and maintenance dredging, particularly in the south and west of the site where silting and vegetation is encroaching.

The Site Condition Monitoring Form for the Basin fen feature (SNH, 2010c) states that the current condition of the site is unfavourable declining. This is attributable to a loss of some fen vegetation in the north western corner of the site; changes in vegetation in the vicinity of the dam indicative of nutrient enrichment; increase to the willow scrub and presence of birch seedlings attributed to a lack of grazing which previously occurred; and change to positive indicator species reflecting nutrient enrichment as a result of increased phosphates and nitrates.

Changes to the site took place in 2007 with the infilling of two kettle holes and an unconsented fence line was erected along with site boundary in 2003 (SNH, 2010c).

The site lies within the Strathmore and Fife Nitrate Vulnerable Zone (NVZ), which was designated in 2002.

No water quality or soil sample data was made available during the desk study stage, and EnviroCentre has not been made aware of any work in regards to addressing the identified issues.

5.2 Catchment Walkover

From the second site visit post-receipt of the analytical results, 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. There was however evidence of the dumping of waste materials in the layby area immediately west of Birnam Burn.

- No discernible algal blooms were observed in the loch (or neighbouring lochs) however, this is not unexpected given the time of year the site visit was undertaken.

- Newly ploughed land was observed within the immediate site catchment.

- Manure heaps were present to the west of the site.

- Observations indicated the recent application/spreading of animal slurry on field bordering the site.

- Evidence of drainage works having recently been undertaken in the southern areas of the SSSI boundary.

- Roads abound the north and western perimeter of the site. There was evidence of minor runoff from the roads into the adjoining parts of the site.

- Potential water abstraction to west of the site consisting of a concrete covered channel with manholes present. Water is leaking from the eastern end of this structure into the site.

- There is understood to be a connection between Stare Dam and the site loch, via an assumed high level overflow. This could not be confirmed at the time of the site visit due to high water levels. For the same reason it was not possible to confirm whether a connection exists between Rohallion Loch and Stare Dam, although it is suspected that such is likely to exist to enable the levels in Stare Dam to be as observed.

- The area of standing water as detailed on OS mapping does not appear to reflect the area present, particularly in the south. It may be that the level of vegetation cover is deceptive but it would potentially indicate that encroachment from vegetation is reducing the area of open water over time. This view is consistent with the areas as depicted on historical mapping.

5.3 Summary

The following table provides a summary of the key site features which were observed during the 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	Fence erected around site boundary after 2003 - the standard and completeness of which was not assessed as part of the site visit.
Grazing	Site not grazed at present although is known to have been previously (dates not confirmed). Fields adjacent to the site are used for the grazing of dairy cattle.
Monitoring	Condition monitoring was carried out by SNH in 2003 and 2010.
Public Access	Site has footpath access around north, east and west parts of the site. There is no formal access along the southern perimeter of the site.
Shooting	Seasonal shooting of wildfowl (duck) and pheasant takes place within the site boundary.
Properties in catchment	One residential property, Staredam Cottage, is confirmed within the catchment (to the south west of the SSSI site boundary). In addition, the site walkover indicated that the multiple properties along the unnamed road on the northern boundary of the site may have septic tanks which drain into the site.
Point Pollution Sources	Silage and manure stockpiles were observed in a field to the west of the site. Unconfirmed road drains on B867 and unnamed 'Murthly saw mill' road likely to enter the site/catchment.
Unusual, Distinctive or Atypical Features	There are residential properties on the northern boundary of the site and these are potentially served by septic tanks; unconfirmed spring sources in the northwestern part of the site; two sink holes on west of site have been infilled (2007); an unconsented drainage pipe installed towards the Birnam Burn (2008); tenant farmer grazes land to the west of the site either side of the B867 – it is understood from SNH records that this was previously grazed by cattle but is now intensive arable (no buffer strips evident); commercial forestry and a quarry activities are evident within the wider catchment.

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 dataset indicates nutrient enrichment within the site most notably on the western and southern boundaries where there is considered to be an increased nitrogen and phosphorus load entering the site. Given the nature of the catchment, the loch is considered to act as a sink for the surrounding landform with nutrients being largely retained and used within, rather than being 'flushed' from, the site. This is evidenced by the infilled site drains and may be a seasonal observation which requires a more detailed understanding of the flow dynamics of the site in order to be fully evaluated.

The most notable observation from the results is the elevated total nitrogen values across the entire water sample dataset. With the exception of MD07 (a surface inflow), the highest values are in the groundwater samples which are elevated throughout the site. The distribution of the phosphorus results is less distinct although the highest total phosphorus values are again groundwater derived. The corresponding low phosphate values indicate the phosphorus content to be predominantly derived from artificial fertilisers.

Of the surface water dataset there are only two values with elevated total nitrogen and total phosphorus - namely MD07 and MD08 – both are located in the western part of the site. MD07 was impacted with a low dissolved oxygen value, high nitrate and elevated total nitrogen. It is considered that this location is likely to be influenced by the spring sources (possible groundwater connection with Rohallion Loch as represented by the lower dissolved oxygen values) in the north west corner of the site and the adjacent intensively managed land upstream (elevated nitrogen values). MD08 is likely to be influenced by the activities and runoff from the field immediately to the south and east of the sampling location which is reported to have been both grazed by cattle and used for arable crops. As a result it is expected to have been subject to soil conditioning (with the elevated ammonia result being from slurry or faeces) and the application of artificial fertilisers.

In contrast to MD07, the inflow sample from Birnam Burn indicates no elevated values and is deemed to be of favourable quality. It is speculated that this is likely to have been different had sampling taken place in wet weather conditions due to the influence of flows from the B867, contributions from Stare Dam and runoff from the upstream catchment.

The presence of elevated total nitrogen and ammonia in MD09, coupled with low nitrate and low dissolved oxygen results, is indicative of anoxic conditions and nitrification. Whilst this is most notable at MD09, this is potentially replicated to some degree in all the groundwater samples and is corroborated by the corresponding sulphurous odours detected.

When compared with the surface water samples, the inorganic concentrations of bioavailable nutrients were highest in the groundwater samples. With the exception of iron concentrations in the latter, none of the analysed metals were recorded as being elevated or above expected concentrations. Excluding MD07 elevated iron results were observed across the site as a whole. It is considered that this is a result of conditions resulting in dissolution and corresponds with the orange-brown visual observations in samples MD06 and MD08.

Total phosphorus levels were elevated in the upper (root zone) of all the collected soil samples. Higher extractable phosphorus recorded within the groundwater may reflect either natural ground conditions or input from fertilisers.

6.2 Atypical Results

No consistent atypical results were recorded from the soil or water samples at Mill Dam. Of the limited data set the only observations of note are as discussed below:

- Elevated iron values of 8.79-105mg/l were recorded in all four groundwater samples. As these are groundwater samples where conditions are such that dissolution of iron is likely to occur this is not unexpected. The high value of 105mg/l in MD08 may warrant further investigation to confirm whether this is naturally occurring or is the result of current/past contamination.

- Faint organic (sulphur) odours were observed for all four groundwater samples (namely MD02, MD03, MD08 and MD09). As this corresponds with low dissolved oxygen, slightly acidic pH and elevated iron concentrations, this is indicative of organic degradation. This observation is consistent with the visual observations of decaying organic matter in the corresponding soil samples.

- In addition to the aforementioned odour, MD02 and MD09 also have elevated total nitrogen values in water (of 9mg/l and 6mg/l respectively). It is considered that coupled to the low dissolved oxygen level, this may be attributable to nitrification processes.

- Elevated ammonia and total phosphorus in MD03 are potentially associated with soil conditioning (slurry application) having been undertaken in the fields adjacent to the eastern boundary of the site.

- Elevated nitrate, total nitrogen and low dissolved oxygen levels were detected in sample MD07. Although this is a surface water sample it is located very close to a spring source (not confirmed during the site visits). Whilst further sampling would be advised to confirm such, it is possibly influenced by the groundwater but also to runoff from the B687, neighbouring properties and/or the adjacent land use.

6.3 Additional Considerations

See study limitations presented in section 3.

No records of previous water or soil samples were obtained through the desk study exercise to enable an assessment to be made with the data collected. No records or reports (anecdotal or otherwise) of algal blooms were reviewed during this study. Information of this nature could be of value in understanding long-term trends and changes within the site.

It is understood that this site is outwith the SEPA priority catchment operational area and that farms will not be visited as part of this scope of work.

7. CONCLUSIONS

Despite the limitations outlined in section 3, the analytical results show a definitive trend of elevated nutrients in the soil, surface and groundwater samples across the site. The desk study and observations from the site walkover survey indicate that there have been changes in land use management within the immediate catchment which have had a direct impact on nutrient levels within the site. These are primarily the inputs to the loch from the agricultural activities and the connections with Rohallion Loch and Stare Dam (and their respective catchment).

Due to the surrounding topography, low lying position of the loch, and underlying permeable geology, it is expected that the site will be heavily influenced by the quality and quantity of water which flows to the site. These flows, which vary seasonally, will leach nutrients from the surrounding catchment to the loch which 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, create a nutrient rich substrate. It is this continued infilling and accumulation furthering successional change that is presently observed as likely to be to the detriment of the designated site condition.

The historical information on the site is limited. With the exception of the potential for variations in effluent from the residential properties (notably phosphates) and in land management resulting from developments in agricultural practices, it is assumed that the surrounding catchment is largely unchanged. It is therefore the changes in the aforementioned practices which have influenced the SSSI in recent years.

The potential for runoff and nutrient enrichment affecting the inflow of nutrients to the SSSI and loch from the immediate catchment 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. The presence of nettles within the site (SNH, 2010b) may indicate nutrient enrichment. The residential properties along the northern boundary, as well as Staredam Cottage outwith the south western boundary are close to inlet feeds to the site. Given the remote location of the site, it is expected that these dwellings will be on a septic tanks and hence the foul water flows have the potential to drain to the site. Water quality and soil data in the fields outwith the site boundary would be needed to qualify such.

The most notable observation which does not appear to have been previously fully assessed is the limited understanding of the site hydrology. This includes the variations to water levels in the loch and associated function of the sluice; the contribution from the spring sources in the north western part of the site; the demands for and controls on the abstraction of water for the purposes of potable supply from the western boundary; the connectivity with Rohallion Loch and Stare Dam; and the need and function of the land drains across the site and the responsibility for their management and maintenance.

The field drains within the site and inflow watercourses will be directly affected by runoff. This will include suspended solid loads from ploughed fields, infilling the channels with nutrient rich silts which would in turn be flushed into the loch. The desk study revealed no records of any maintenance having taken place in this regard. The unconfirmed (and possibly unconsented) changes to the drainage configuration of the site and the connectivity with Stare Dam are likely to have had a notable effect on the site hydrology. It is understood from liaison with the local SNH Officer that there have been considerations made to installing an open culvert and sluice/spillway as an alternative to the existing pipework. Whilst this would afford greater control of flows entering the site, it may lead to an increase in the level of nutrients entering the site due to the inflow of road drainage. This decision therefore

requires initial consultation with SEPA and Perth & Kinross Council Roads Department prior to being advanced.

It is expected that there are significant sediment accumulations within the loch. These will afford a plentiful supply of nutrients through disturbance by variations in seasonal inflows. The shallow depth of the loch means it is unlikely to release nutrients through stratification, however, quantification of the volumes of sediment and concentration of nutrients therein would help to establish a more complete picture of the loch and how water quality is seasonally influenced.

According to the observed vegetative changes there is a clear need to reduce the nutrient inputs to the site. It is therefore of concern that there appears to be a very limited understanding and exercise of control on the current land practices in both the surrounding arable land and the woodland immediately adjacent to the SSSI. Arguably the greatest potential impact to the site from the observations made during the study is the known use of soil conditioners (namely slurry) employed on the adjacent agricultural land. It is considered that this can be improved through engagement with the tenant farmer, including reminding the farmer of the minimum ten metre no spreading zone to all adjacent fields, and auditing the seasonal applications.

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 monitoring study of the seasonal changes in open water and fen extent. The 2010 SNH Condition Monitoring Report makes no reference to the extent of open water habitat. If such were routinely quantified over time this would aid the understanding of loch and fen dynamics, and would also be directly beneficial to aiding the function of, and potential operation of, the loch sluice.

ii. It would be of value to the long-term status of the SSSI to understand whether the loch is classified as eutrophic. For this to be determined, a more extensive seasonal monitoring programme is necessary.

iii. 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 (ideally for a minimum of one year). The data from such should be compared alongside rainfall data, loch levels and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site.

iv. In conjunction with ii, assess the seasonal flow and nutrient loads of the three inflow burns and compare these with those of the loch outflow. This data would be of direct value in being able to assess the flow dynamics of the loch and to understand retention times and seasonal variations in throughput. It would also allow for a greater understanding of nutrient input to the site.

8.2 Other Commissioned Studies

v. Review the historical changes to the area of standing water within the loch and determine the extent of vegetation encroachment over time. This will allow a greater understanding of the dynamics between the open water area and fen extent, to inform future management.

vi. Undertake hydrological and hydrogeological assessment of the catchment to determine the source water of the loch. This should include the connection with Rohallion Loch (possible groundwater), Stare Dam (possible direct connection), spring sources on the north western boundary, and the various field drains.

vii. Undertake core sampling of loch sediments to understand historic source pollution and retained nutrients, and determine the suitability for dredging and corresponding disposal options. Although the loch is understood to be shallow, and therefore unlikely to stratify, artificial disturbance of the sediments could result in extensive nutrient release and significantly alter the nutrient availability within the loch and margins. It is considered likely that there will be a significant volume of nutrients bound up in the loch sediments this may be being released into the water column and aiding successional change.

viii. Consideration should be made to understand the functioning and management of the sluice on the outlet flow from the loch, and how this has influenced the fen and open water extents. This may be subject to regulatory control from SEPA and variations to such would therefore be likely to require consultation and approval.

ix. Undertake further study to understand the quality and quantity of inputs from the road drainage from the B867 – a main thoroughfare for local access. The analysis should appraise the likely contaminant sources from the road as well as the potential to deoxygenate the Birnam Burn and main waterbody.

x. If conditions within the loch are found to be eutrophic then consideration should be given to a review of the biomass of marginal vegetation within the loch, and to suitable techniques to manage the nutrient balance within the site going forward.

xi. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to loch use, size and depth. Where this is not available, commission a bathymetry survey of the loch to confirm depth and sediment profiles. This would aid the understanding of inflow and retained sediment volume.

8.3 Management

xii. Review the policy for the management of site vegetation with the aim of focussing these on the net reduction of nutrients within the site.

8.4 Landowners

xiii. Engage with landowners to convey the action programme rules (Scot.Gov, n.d.) for landowners/agriculture within a Nitrate Vulnerable Zone (NVZ). The implementation of these guidelines should result in a net reduction of Nitrate entering the site over time.

xiv. Proactively engage with catchment landowners to understand the historical land use practices to determine changes which are likely to have influenced the site. It is speculated that the catchment was more densely wooded than it is at present and particularly the area immediately surrounding the loch. Consideration should be made to appraise how this may have led to changes at the site and the corresponding nutrient status of the loch.

xv. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment including field usage, crop type and soil conditioning approaches. This should include access of livestock to the site. Consider appropriate management strategies accordingly - for example, nutrient management planning, no spreading zones, buffer strips, exclusion zones, routine spot monitoring, removal of fencing *etc*.

xvi. Review of the ownership of the identified land drains and the future management and maintenance of such.

xvii. Review the potential impact of any proposed future developments within the catchment. This should focus on the hydrological impacts, and notably wastewater discharge and use of septic tanks.

8.5 External Consultations

xviii. Engage with SEPA to understand:

a. the sewage disposal methods in place for the identified properties within the catchment and where applicable, the corresponding controls in place to limit nutrient enrichment to the SSSI;

b. the regulatory provision governing the possible water abstraction on the western boundary of the site (near the bus stop);
c. Sluice management/operation (see vii above); and
d. Identified/reported pollution incidents at the site.

Given that SEPA do not plan to attend the farms in the catchment as it lies out with the priority catchment operational area, it would be of value to understand the process that SEPA would undertake if it were and for SNH to seek to replicate such to highlight any regulatory or managerial concerns at these facilities.

xix. Engage with Perth and Kinross Council to understand the water quality of the potable supply from the western boundary of the site - which they are required to monitor under the Private Water Supplies (Scotland) Act 1996 and which should be available on the public records.

From the stated conclusions and identified pressures (Figure 5.1) the key actions to reverse the present declining status of the site are to address the inputs to the loch from the agricultural catchment and understand the flows from the catchment notably the connections with Rohallion Loch and Stare Dam. The former should focus on the landowners (xiii, xiv & xvi) along with the inflow burns (iv), the potential contribution from domestic sewage (xviii a & xvii) and the accumulated sediments (vii), and the latter, the catchment hydrology (vi) and water level/loch throughput (viii) including sluice operation (viii).

9. REFERENCES

British Geological Survey, n.d. DiGMapGB-625 Data download. Available at: http://www.bgs.ac.uk/products/digitalmaps/dataInfo.html

Centre for Ecology and Hydrology. 2009. *Flood Estimation Handbook (FEH).* CD-Rom Version 3.0. Wallingford, Oxfordshire.

Met Office, n.d. 2012 Weather summaries – Regional values. [Online] Available at: http://www.metoffice.gov.uk/climate/uk/2012

National Library of Scotland, n.d. Geo-referenced map images [Online] Available at: http://maps.nls.uk/

Scottish Government, n.d. Nitrate Vulnerable Zone: Action Programme. Available at: http://www.scotland.gov.uk/Topics/farmingrural/Agriculture/Environment/NVZintro

Scottish Natural Heritage. 2010a. *Mill Dam Site of Special Scientifc Interest - Citation.* Inverness, Scottish Natural Heritage.

Scottish Natural Heritage. 2010b. *Mill Dam - Site Management Statement.* Inverness, Scottish Natural Heritage.

Scottish Natural Heritage. 2010c. *Mill Dam - Basin fen - Site Condition Monitoring Form.* Inverness, Scottish Natural Heritage.

ANNEX 1: FIGURES

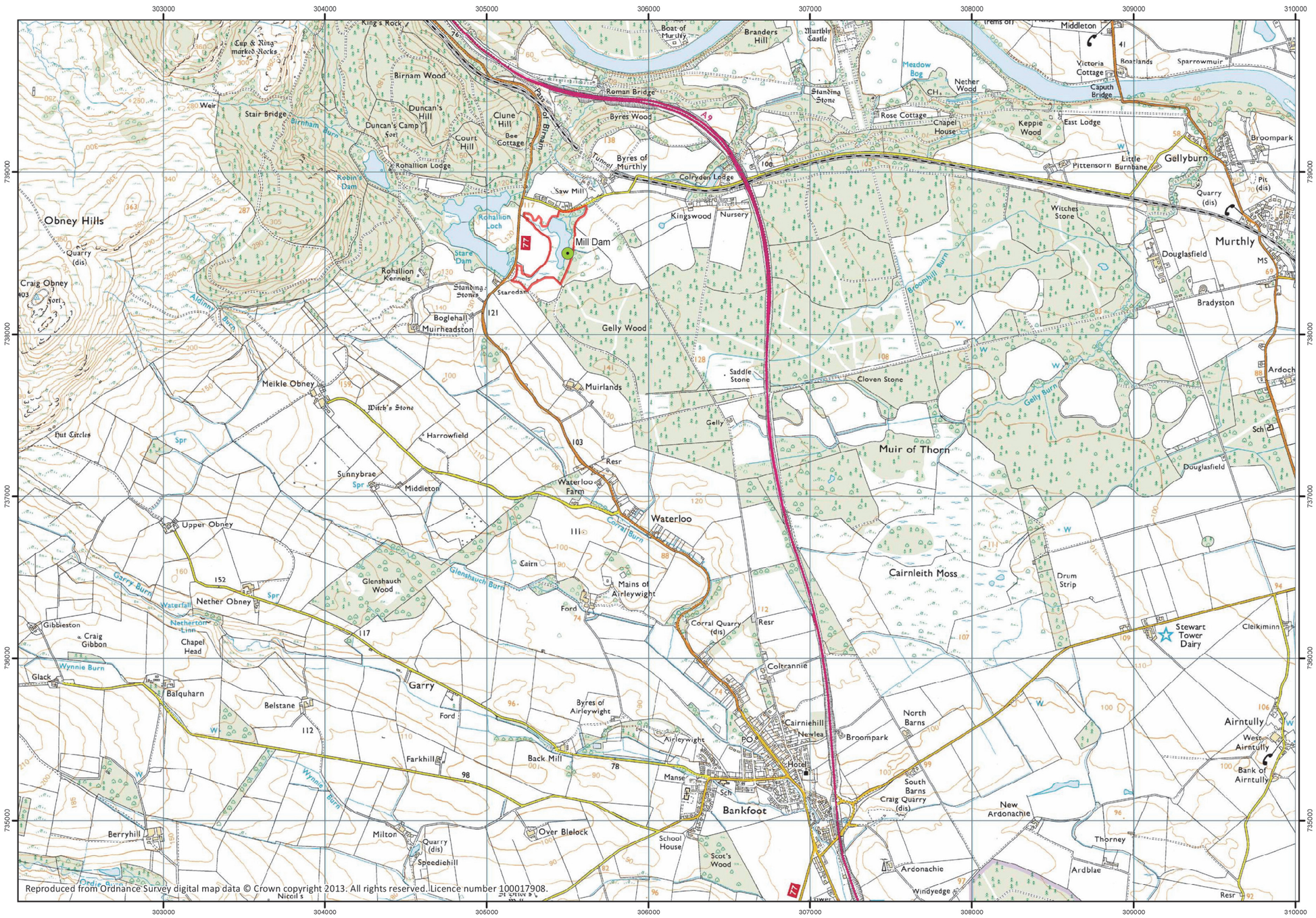
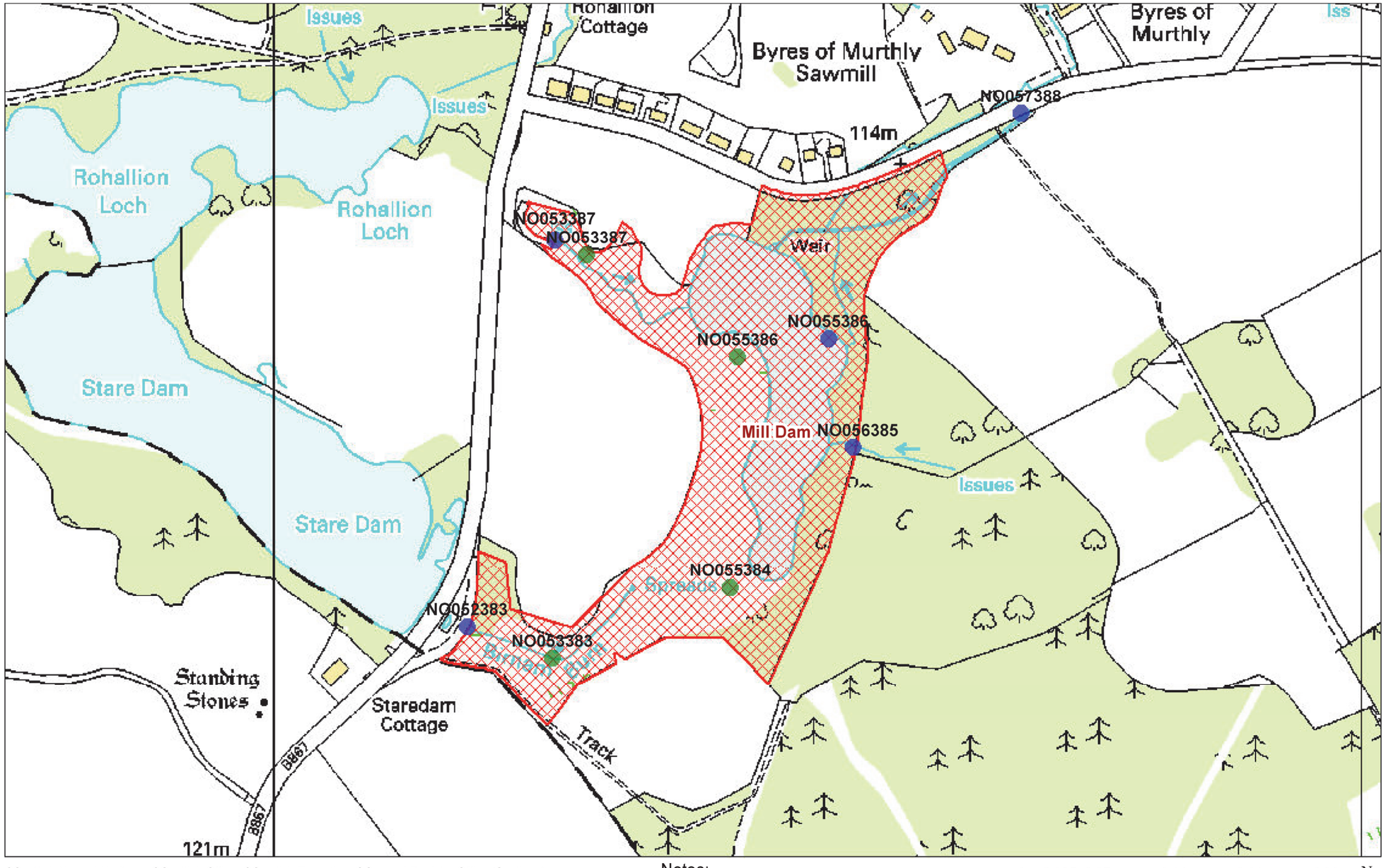


Figure 1.1: Site Location Map

Mill Dam



Notes:

0 0.035 0.07 0.14 0.21 0.28 km

N

Map produced using geo.View 3.0
Printed: Sep 20, 2012 16:09:10

Figure 2.1: SNH Proposed Sampling Location Plan

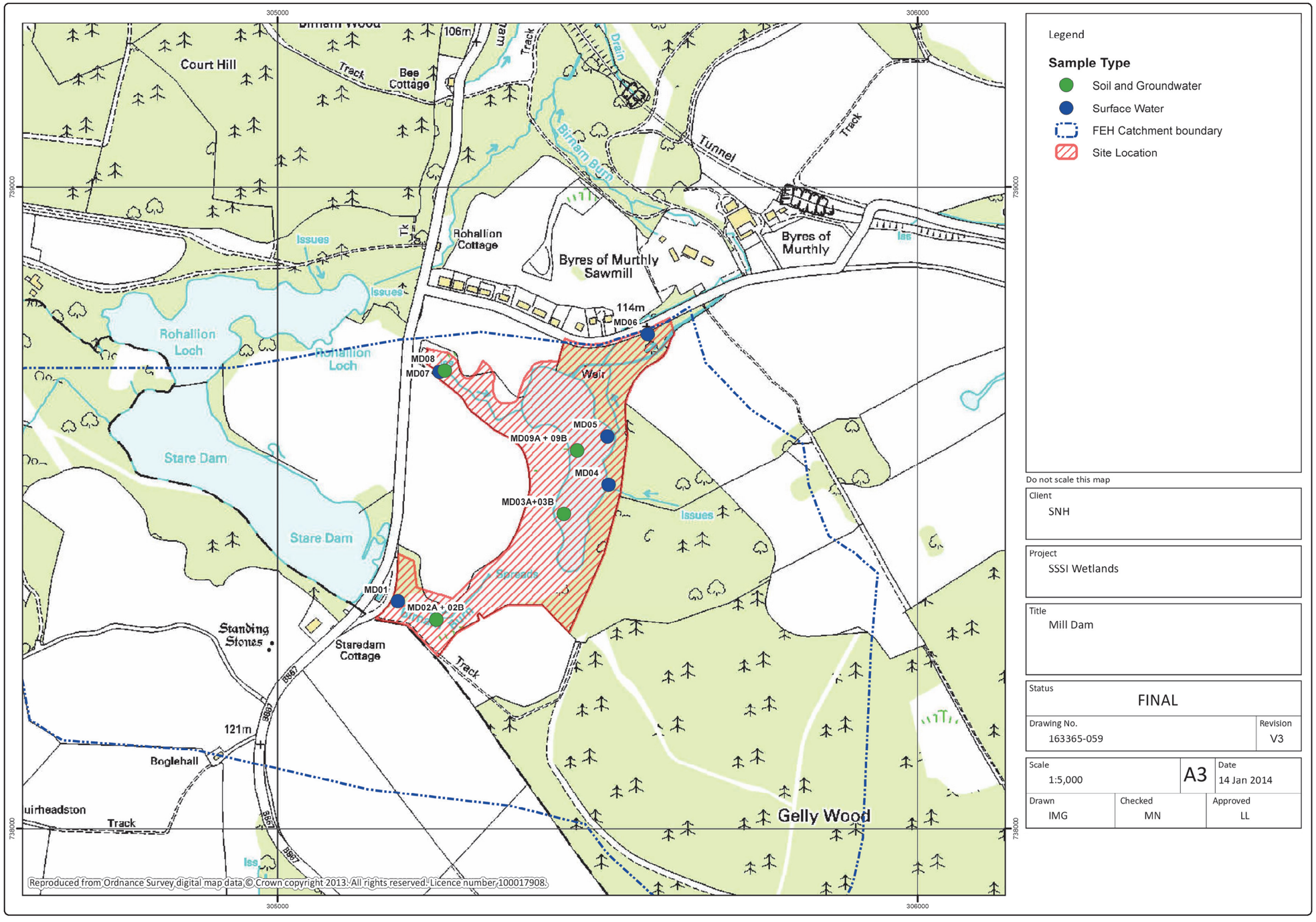
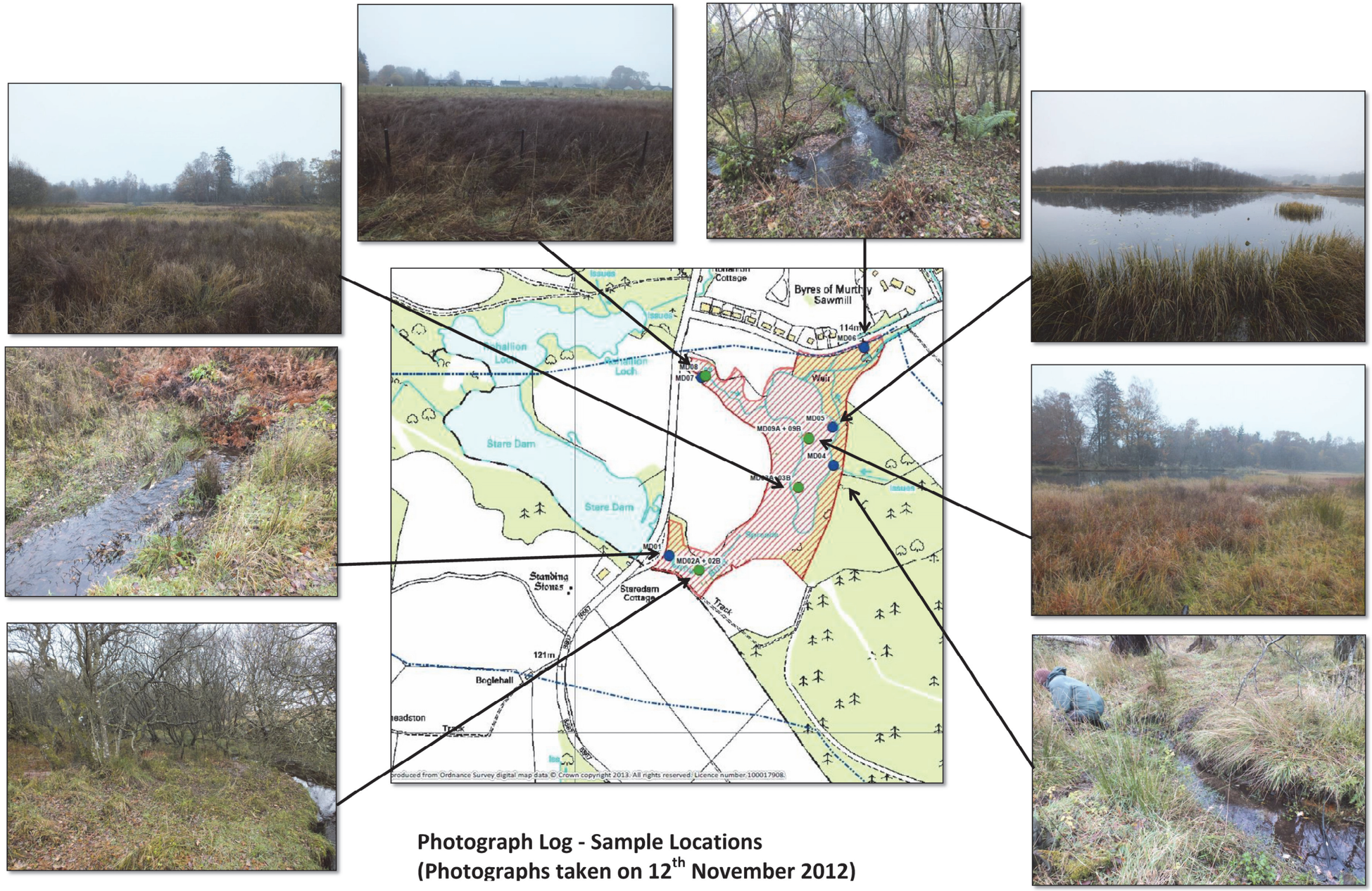


Figure 2.2: Plan of Actual Sampled Locations



Photograph Log - Sample Locations
(Photographs taken on 12th November 2012)

Figure 2.3: Sampling Location Photographs

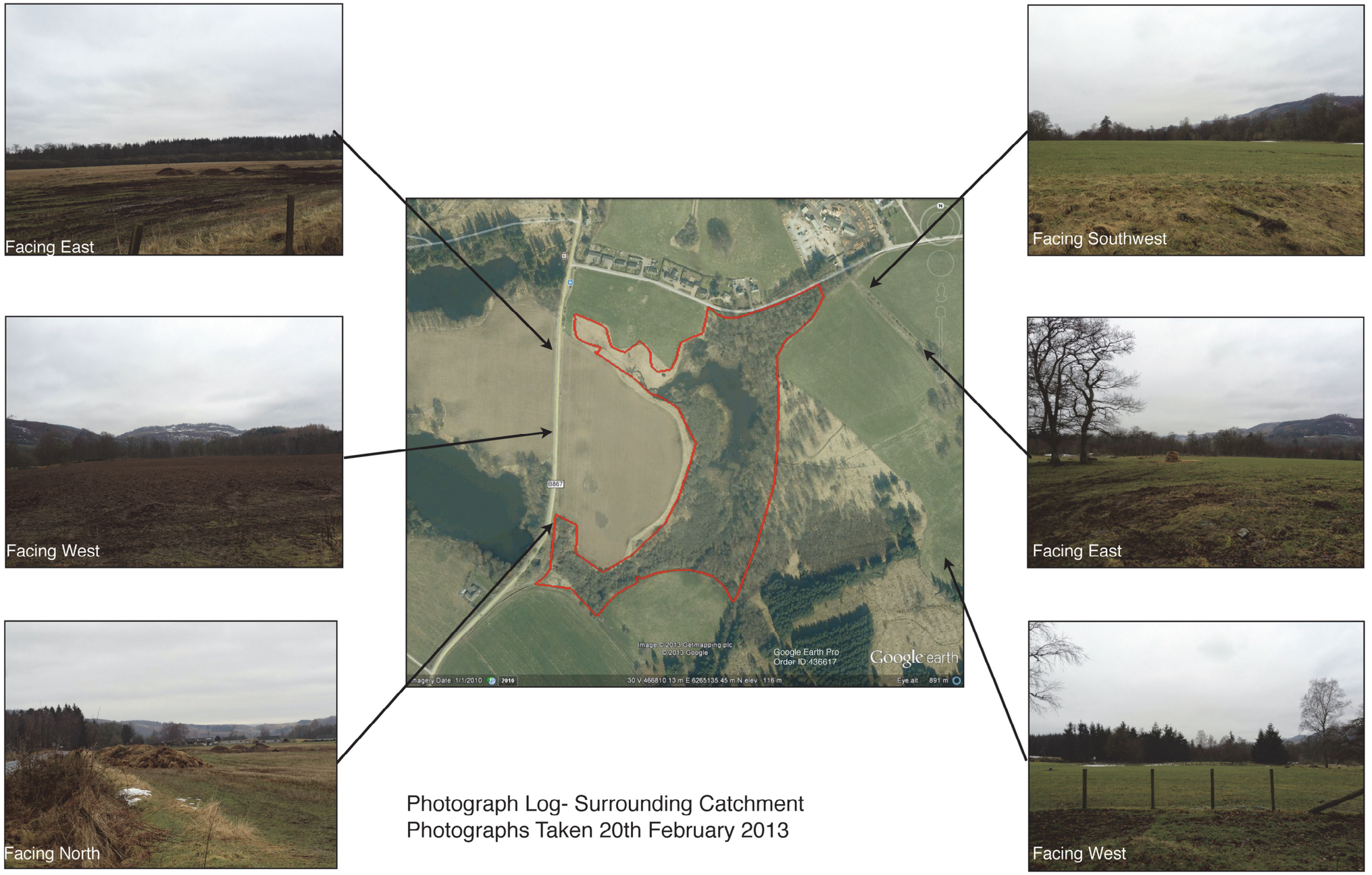
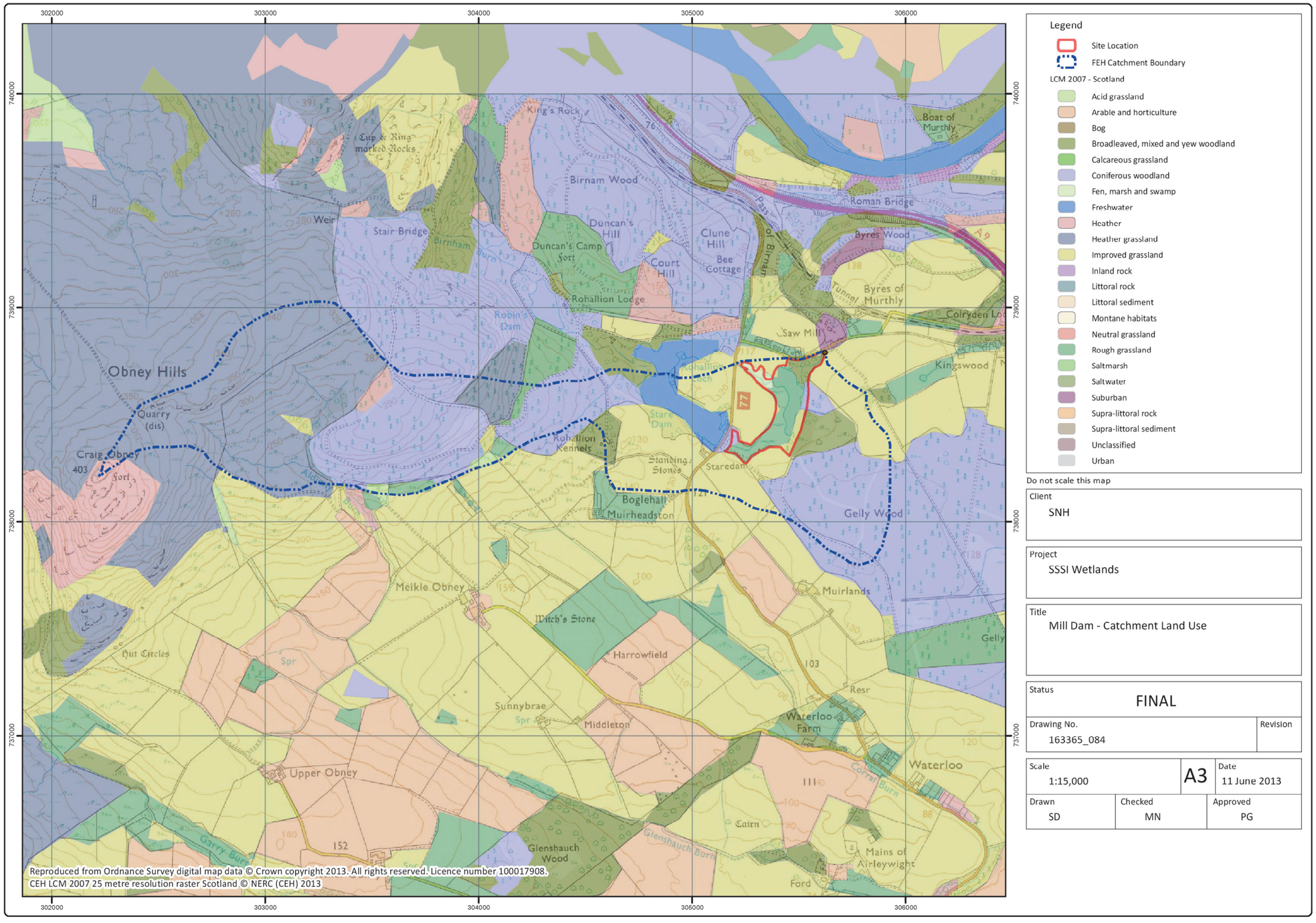


Figure 2.4: Surrounding Land Use Photographs



Legend

- Site Location
- FEH Catchment Boundary

LCM 2007 - Scotland

- Acid grassland
- Arable and horticulture
- Bog
- Broadleaved, mixed and yew woodland
- Calcareous grassland
- Coniferous woodland
- Fen, marsh and swamp
- Freshwater
- Heather
- Heather grassland
- Improved grassland
- Inland rock
- Littoral rock
- Littoral sediment
- Montane habitats
- Neutral grassland
- Rough grassland
- Saltmarsh
- Saltwater
- Suburban
- Supra-littoral rock
- Supra-littoral sediment
- Unclassified
- Urban

Do not scale this map

Client: SNH

Project: SSSI Wetlands

Title: Mill Dam - Catchment Land Use

Status: FINAL

Drawing No.: 163365_084

Revision:

Scale: 1:15,000

A3

Date: 11 June 2013

Drawn: SD

Checked: MN

Approved: PG

Figure 2.5: Catchment Land Use Characteristics

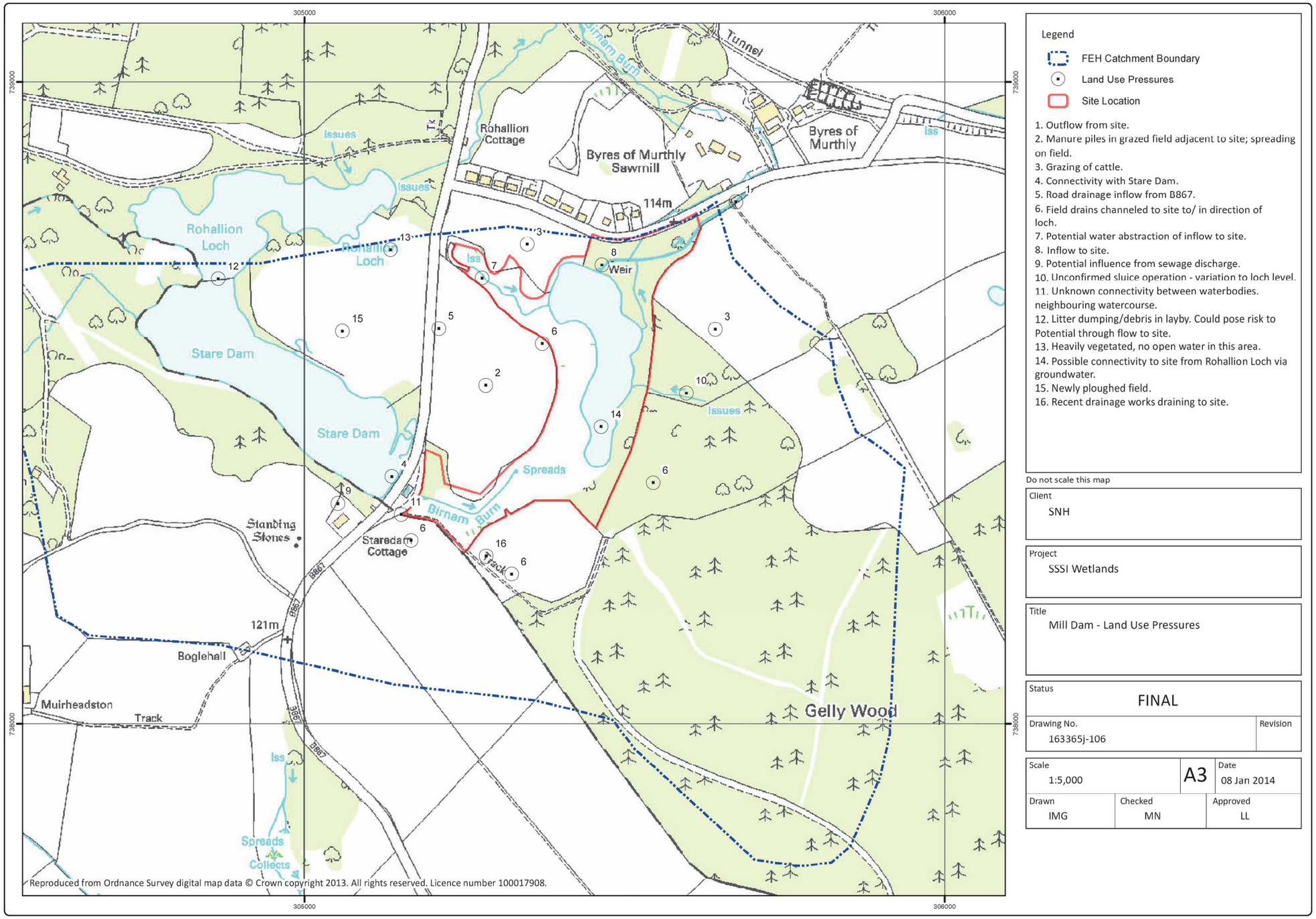


Figure 5.1: Catchment Pressures Summary

www.snh.gov.uk

ISBN: 978-1-78391-126-4

Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

You can download a copy of this publication from the SNH website.

recycle

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad