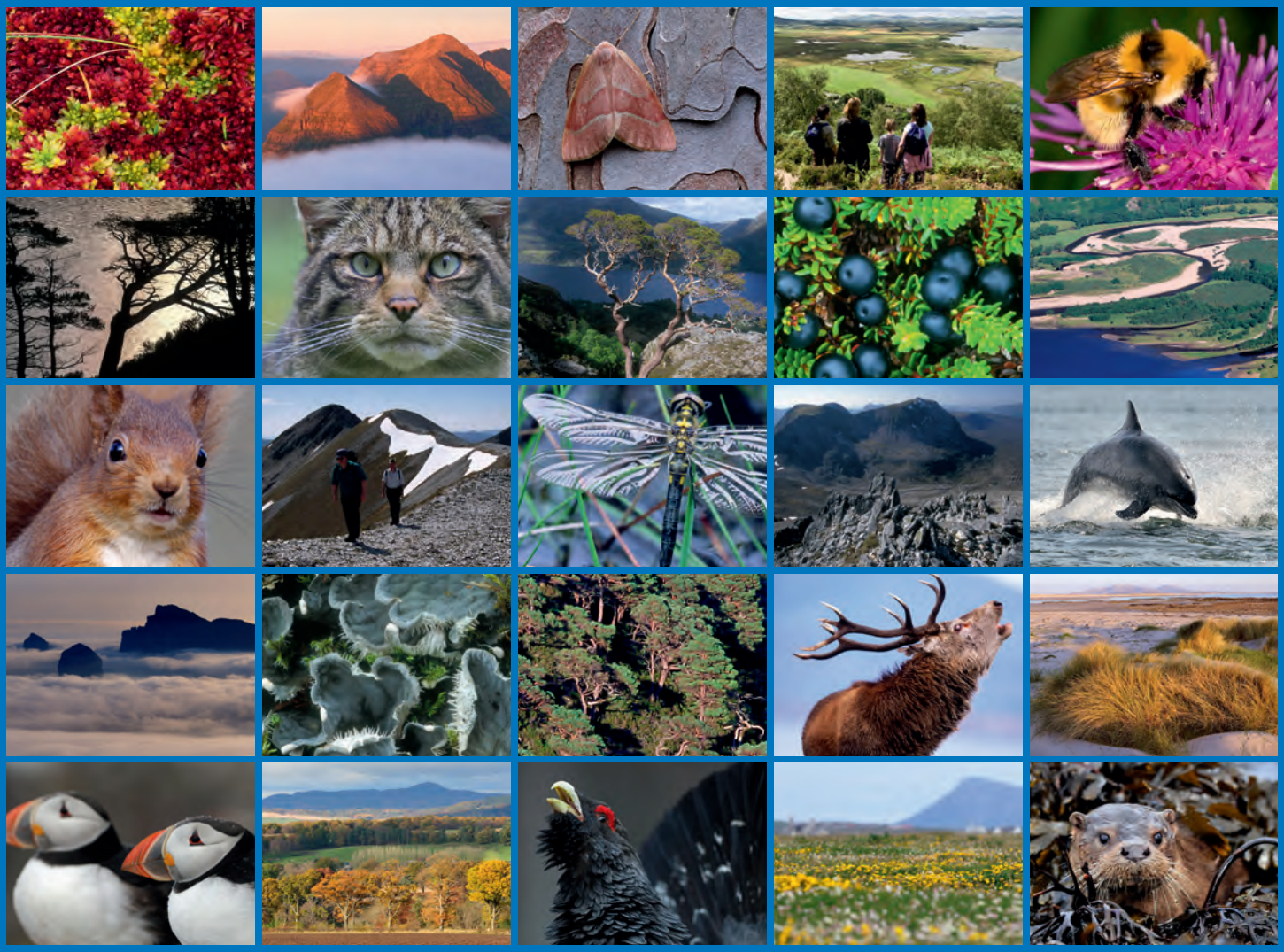
Scottish Natural Heritage
Commissioned Report No. 725

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



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. 725

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

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: Loch Libo. *Scottish Natural Heritage Commissioned Report No. 725.*

COMMISSIONED REPORT

Summary

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

Commissioned Report No. 725
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 condition.

Main findings

- Analytical data was inconclusive in determining nutrient levels that would be typically expected of a eutrophic waterbody. The sampling assessment was undertaken as a single visit which was limited by access to parts of the site on health and safety grounds. The limited dataset constrains the ability to draw accurate conclusions on current site conditions.
- Site walkover revealed additional inflows not previously identified and 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 loch flow regime and understand the impact of newly identified inflow sources. It is considered that 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

Loch Libo is located adjacent to the village of Uplawmoor, approximately 4.5 miles south-west of Barrhead, Glasgow (see Figure 1.1 in Annex 1).

Loch Libo is bordered by the Glasgow-Kilmarnock railway line. Access to the site is by crossing the single track railway line at a dedicated (unmanned) gated crossing point for which extreme care is required with regards to oncoming trains which pass every fifteen minutes on weekdays (datum 2012).

1.2 Site Description

Loch Libo is a Site of Special Scientific Interest (SSSI) comprising a long, shallow, natural lowland (freshwater) loch with extensive aquatic, emergent and semi-aquatic plant communities (SNH, 2007a). The site is notified a SSSI for its eutrophic loch feature and comprises an area of 18.16 hectares (SNH, 2007b).

The loch and part of Caldwell-Lawside Wood have been a SSSI since 1972 for being the best example of a eutrophic loch in East Renfrewshire with aquatic and emergent vegetation. Significant plants include the nationally scarce cowbane and the locally uncommon greater tussock sedge and lesser pond sedge. The nationally uncommon species lesser tussock sedge, water sedge, slender tufted sedge and water parsnip are also present (SNH, 2007a).

The loch occurs at an altitude of 118m, has a surface area of 8.6ha and a perimeter of 1.5km (SNH, 2004) and lies in a glen, with Caldwell Law to the north and Uplawmoor Wood to the south. The eastern and western boundaries of the site are bordered by rough grazing farmland; the north boundary by mature deciduous woodland; and the southern boundary by the railway line. The area to the north and west of the loch is underlain by glacial till while there are no recorded drift deposits to the north-east of the loch. Alluvial deposits are recorded along the valley in which the loch is located. The underlying solid geology consists of lavas and tuffs of the Clyde Plateau Volcanic Formation to the north-west of the loch and sedimentary rock cycles of the Clackmannan Group to the south-east (British Geological Survey, n.d).

Loch Libo forms part of a Scottish Wildlife Trust (SWT) Reserve and is currently managed as a wildlife reserve.

1.3 Site Hydrology

The SWT Management Plan 2008-2018 (Stewart and Smart, n.d.) states that the loch is no deeper than two metres apart from a deeper area in the south-east part of the loch. The Plan also details the presence of multiple springs (qv.10) within the catchment which supply water to the loch, and the presence of inflow from an old mine shaft (the detailed location of which is unconfirmed).

Two surface watercourses convey flow to the loch. The first of these watercourses flows in a south-westerly direction into the eastern part of the loch while the second drains the steep topography to the north of the loch. Surface water runoff, particularly from the steeper

topography to the north of the loch, also provides an inflow. The outflow from the loch flows in a south-westerly direction and forms the Lugton Water.

The catchment area draining to the site is 2.56km^2 and the annual average rainfall for this catchment is 1520mm (Centre for Ecology and Hydrology, 2009).

Unsupported reference is made in the SWT Management Plan to the fact that the loch has probably changed shape by shortening and widening with the water level in the locality now higher than in the past as a historic access track (medieval cart track) is now submerged at the western end. It is subsequently speculated that this is probably due to the construction of the railway line altering the natural spread of the loch and diversion of the Thorter Burn to the loch. This has led to an assessment (by SWT) that the loch is now 30-40cm above its level of the 19th century although levels remain fairly constant through the year with minor fluctuations in summer and winter.

1.4 Site History

From the desk based research, the 'History and Topography of Loch Libo' (Grant, 1975) was the main source of historical information on the site. This document describes the ownership history from the earliest written record in 1294 through to land use up until 1948.

The following sub-sections are primarily a direct extract from the SWT Management Plan 2008-2018 (Stewart and Smart, n.d.) which summarises the key activities of mining, recreation, reed cutting and woodland management which have taken place at the site.

History of Mining

It is possible that the coal mining is the principal reason for Uplawmoor village being where it is. There are old mine shafts in the hills over Loch Libo. Coal was found at the south end of the loch around 1780. In 1793 the mine was flooded drowning seven men. Grant (1975) refers to the waters of the loch bursting into the mine workings however, it is now considered more likely to have been a subterranean inflow. The mine was reopened around 1830 and was deepened to exploit two seams – Carw Coal (an inferior thin seam) and Ell Coal (an 'ell' being 37 inches).

Coal was mined in the south east corner of the site until the late 18th century. When entering the reserve the area to the east has brick foundations from where the area was mined. The birch woodland at this location is slightly higher than surrounding land and could be growing on shale waste.

History of Recreation

The 1895 Ordnance Survey map shows a boat house on the northern side near where a burn feeds into the loch. From the 1930s through to the 1950s small scale stocking of brown trout was carried out. The loch was periodically dragged to remove weed to improve the trout fishing; this was done by employing two Clydesdale horses pulling the drag through the loch along the loch side bordering the woodland.

In 1973 the Post Office angling club were using the site and introduced carp. When the SWT purchased the reserve the original sales papers stated that fishing rights may not continue. The SWT was not keen for fishing to continue as 'lines' were being cut through the vegetation by fishermen to aid access to the water. By 1979 it was clear that it would be impossible to stop fishing without a warden so fishing was permitted albeit only in certain areas.

Several interested parties have been in contact regarding the use of the loch as a fishery. In 1998 the Scottish federation for Coarse Angling contacted SWT. A lease was eventually agreed with the West of Scotland Specimen Group, now known as the Scottish Carp Group. The SWT Management Plan refers to eleven species present within the loch comprising both salmonid and cyprinid species.

Curling matches began at Loch Libo in 1885 and continued through the beginning of the 20th century when colder winters were recorded than present.

Fox hunting occurred prior to the reserve being established and was forbidden thereafter.

History of Reed Harvesting

There is an old cart road running around the north side of the loch which was used by the estate and neighbouring farmers for transporting reeds for thatching. The cart tracks may have connected to tracks to Beith. The old cart roads are overgrown and swampy in places although the upper track is quite distinct in winter when vegetation is low. They all require drainage, and under traffic in these conditions, these fine old medieval roads of broken stone on boulder and pebble, just break down whenever the drainage water cannot get away. Old stone drains on the site are remarkably well constructed.

Woodland History

The first estate plantings on record are 1730-1740. It is possible that one or two isolated beeches of this planting survived although it is more likely that the old ones are from 1770 with ring dating providing dates between 1760 and 1800. Thereafter there was little (known) planting until the middle of the 19th century and the remaining large deciduous trees would have been planted between 1850 and 1870.

The last organised planting was in 1910-1917 when considerable areas were planted with coniferous trees, including a few isolated stands at the loch side. These were felled during World War 2. The estate was sold in 1919 and since then there have been two major fellings and several minor ones, which effectively removed all the valuable and accessible trees.

The origin of the vehicular access across the railway relates to the woodland being owned by a timber merchant. According to archived records, title deeds allow access from Cadwell Law.

Other activities

Mapping from 1895 onwards shows a large sand quarry off the lane leading to Westhead of Side Farm.

1.5 Recent Site Management Practices

SWT acquired Loch Libo in November 1973. A summary of recent management activities is recorded in the SWT management plan 2008-2016 and includes fencing, drainage, public access works and tree planting. Woodland management has involved the felling of sycamores (*Acer pseudoplatanus)* on two occasions and the successive planting of native ash (*Fraxinus excelsior*), oak (*Quercus spp.)* and hazel (*Corylus avellana*).

It is noted in the Plan that Italian alder (*Alnus cordata*) was planted north west of the loch in 1977.

Network Rail has improved the pedestrian railway crossing providing access into the SWT reserve and they have provided whistle boards at the crossing to alert pedestrians to the passing trains – an important improvement in aiding safe access to the site.

The SWT report also references that the Scottish Carp Group has exclusive fishing rights to the loch through a yearly agreement with SWT. Attempts by the Scottish Carp Group to remove the Canadian pondweed (*Elodea canadensis*) were unsuccessful. It is not confirmed what practice was employed or that this was approved by SNH (or its predecessors).

The Plan also provides a list of past nature conservation management practice between 1975 and 2006. This is summarised in the following table.

Table 1.1: Past Nature Conservation Management Practices

Past Management for Nature Conservation (known work between 1975-2006)	
1975	Greenside march fence (west fence) of 482m along boundary erected by contractors to exclude animals from loch. Two trailing gates, over stream and Lugton Water, included in this.
1976	Sleeper bridge over inlet burn constructed by volunteers.
1977	“No fishing” signs and SWT reserve signs erected.
1977	Tree planting by Conservation Corps and volunteers. Willows and Italian alders planted at west below Greedside.
1978	Conservation Corps cleared north and track. Channels cut across the track where drains existed on hillside. Grant from NCC contributed to 50% cost.
1981	Repairs to northwest boundary fence and ground strengthening posts and struts on south west boundary fence.
1981	50 spiral tree guards (second hand) purchased. Removal of wind-blown trees from march fence (north) and consequent repairs to fence. Drainage works. Repairs to water gates and SWT signs.
1982	Contractors erect 247m of fencing and two stiles at east boundary.
1983	Scottish Tree Trust removed litter.
1983	Drainage work and silt trap dug by Clyde Regional Environmental Workers at the inlet/ new drain across the northern path.
1988	Crude sluice constructed at outlet.
1988	Railway fencing undertaken by Manpower Services Commission team.
1993	5 Year Management Plan written by Dennis Garratt, reserve manager.
1992	Boundary fencing (NE edge) erected by contractors.
1993	3 small stands of sycamore felled. 200 native broadleaves planted (120 Ash, 65 Oak, 15 Holly) – staked and tubed.
1993	Negotiations begin with British Rail to find alternative access arrangements to allow for closure/ down grading of the level crossing.
1995	Fishing platforms constructed by the Carp Group to reduce erosion of the loch side.
2000	Forestry Commission contacted about the possibility of a Woodland Grant Scheme for monitoring/ surveying non-native trees/ regeneration; selective felling of non-native and control of regeneration; selective coppicing of elms to prevent further spread of Dutch Elm disease; planting of native species and maintenance of fence; public access encouraged by paths. This was put on hold until access across railway could be resolved.
2000	5 Years Management Plan by Dean Heward, Reserve Manager, and Caroline Harrison.
2005	Drains reinstated and bridge inserted across spring at top cart track. Fallen trees removed from track and branches cut back.
2006	Rail track installed new gates and stiles with whistle boards at crossing.
2006	Dangerous tree survey and removal and path maintenance.
2007	Dangerous tree survey and removal, path/ drain maintenance and Rosebay Willowherb strimming. Removal of Beech samplings from compartment 4.

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. Access to non-publically available data held by other regulators, including SEPA, was not available.

The meetings were 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 a gain a greater understanding of the workings of the site and the site surrounds.

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

Loch Libo	Date of Visit	Weather Conditions	Grid References
Visit 1	01 November 2012	Clear, cold and sunny	NS 435557
Visit 2	18 February 2013	Clear, mild and sunny	NS 435557

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 suitably to access such before Visit 1. Due to certain access restrictions the locations of samples that EnviroCentre collected are 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. Samples were taken from the shore which can introduce a bias as it may not reflect average conditions in the water body.

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 planned but could not be undertaken by the laboratory due to insufficient sample. This data would have supported interpretation of other 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.

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 planned 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 locations.

- 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.

- Due to health and safety constraints posed by the railway line and the Lugton Water, field operatives were unable to access two of the pre-determined sample points along the southern boundary. This resulted in a shortfall of two groundwater and two soil (upper and below root zone) samples not being collected (at locations NS432554 and NS434556). Assessment of an adjacent comparable site within this part of the site was undertaken but again access was not feasible, and a sample taken on the northern side of the Lugton Water was deemed to have been comparable with NS431554 (Libo6).

- 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 western Scotland were 144%, 104% and 128% 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.

4. ANALYTICAL DATA

The following tables show the results obtained from the initial site visit (Site 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 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 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	Sal (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	Comments
Libo 1	NS 43765	55870	5.32	6.2	0.07	59.3	7.12	-67.3	0.149	Surface water - clear with very fine suspended solids (s/s); no odour
Libo 2	NS 43732	55909	7.75	5.82	0.09	16.8	1.75	-69.5	0.179	Groundwater - dark, cloudy brown with fine s/s; no odour
Libo 3	NS 43414	55804	7.64	6.22	0.09	63.0	7.11	-73.4	0.98	Surface water - clear with very fine s/s; no odour
Libo 4	NS 43245	55724	8.04	6.33	0.04	69.8	7.84	-76.7	0.79	Surface water - light brown with fine s/s; no odour
Libo 5	NS 43232	55688	8.07	6.26	0.05	66.3	7.42	-76.4	0.96	Surface water - clear with some s/s; no odour
Libo 6	NS 43190	55450	7.84	5.37	0.04	9.0	0.98	-75.1	0.95	Groundwater - cloudy brown with fine s/s; strong organic (sulphur) odour
Libo 7	NS 43176	55416	8.74	9.5	0.07	62.4	6.87	-75.9	0.151	Surface water - light brown with fine s/s; no 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	National 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)
Libo 1	NS 43765	55870	SW (I)	20	5	13	0.31	<0.01	0.3	<0.01	<0.1	<1
Libo 2	NS 43732	55909	GW	64	16	<10	82.9	0.4	<0.2	<0.01	<1.0	2
Libo 3	NS 43414	55804	SW (OW)	10	5	6	0.41	0.01	*	<0.01	<0.1	1
Libo 4	NS 43245	55724	SW (I)	6	3	5	0.22	0.01	0.5	<0.01	<0.1	<1
Libo 5	NS 43232	55688	SW (I)	8	3	6	0.05	0.01	0.2	0.02	<0.1	<1
Libo 6	NS 43190	55450	GW	36	<10	<10	90.1	1.0	<0.2	0.02	<0.1	<1
Libo 7	NS 43176	55416	SW (O)	20	4	12	0.67	0.01	<0.2	0.02	<0.1	<1

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)
Red figures denote samples that are above typical ranges for the observed dataset.
**not known*

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)	Total Moisture** 105°C (%)	Total N (mg/Kg)	Nitrate (mg/l)	Nitrogen (%)	Extractable P (mg/l)
LIBO02A	NS 43700	55900	High organic, wet black sludge	0.9	15100	3080	1600	1260	81.4	<1.1	<0.2	2.38	<2.0
LIBO02B	NS 43700	55900	High organic, wet black sludge	0.7	3110	2580	184	510	60.2	<0.9	<0..2	0.24	<2.0
LIB06A	NS 43100	55400	High organic, wet black sludge	0.5	6830	2430	1020	1530	89.9	<0.7	<0.2	1.43	5.51
LIBO06B	NS 43100	55400	High organic, wet black sludge	1.4	10700	3710	582	918	82.4	<1.6	<0.2	1.56	2.04

** Soil types are field observations*
*** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*
Red figures denote samples that are above typical ranges for the observed dataset.

5. SITE OBSERVATIONS

To enhance understanding of Loch Libo 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 from the catchment.

5.1 Desk Study

The eutrophic loch feature has been assessed as Unfavourable declining in two Site Condition Monitoring visits in 2004 and 2010.

The Site Management Statement (SNH, 2007a) records an 'Objective for management' of enhancing the conditions of the site by 'ensuring the loch and associated habitats continue to receive a supply of relatively unpolluted water, especially the presently high levels of water from the springs; to reduce the percentage of *Elodea canadensis* without the use of chemicals; and ensure access to the site follows the Scottish Outdoor Access Code'. An SNH memo in file 'SIT/SSSI/210/MON' (SNH, 2008) on the recovering status of Loch Libo dated 20 August 2008 further stated that the feature failed due to 'presence of *Elodea canadensis*; lack of detail on macrophyte community structures; lack of detail on water chemistry; and loss of local distinctive species (*Elatine hexandra* recorded in 1979)'. With the exception that SNH have commissioned work in August 2011 to investigate the effectiveness of shading as a control measure for *Elodea canadensis* for which Loch Libo was the trial site (Bell, 2012) and those recorded in the SWT Management Plan 2008-18, EnviroCentre has not been made aware of any work undertaken in regards to addressing the above issues.

The desk study identified that historical water quality samples have been taken – albeit that the records are not particularly detailed in terms of location, depth *etc*.

The SNH Condition Monitoring Form (SNH, 2004) – visit date of 4 June 2004 - states a single sample of Total Phosphorus of 39.5µg/l and that the target for eutrophic loch deep water is <35µg/l. No other parameters were recorded but a comment is included that 'moderate levels of filamentous algae were recorded' (pg.4). It is further stated that 'low confidence should be attached to this datum as it was based on a single sample. Water clarity was very turbid due to suspended sediment in the water column – it was very windy on day of survey' (pg.9). The Thorter Burn, which flows into the site from the east (Shilford village catchment), has a known history of pollution.

Hennessy (2007) states that additional water quality analysis was undertaken in 1996 during the SNH Loch Survey in which pH, alkalinity and conductivity of the loch was measured. The results of which were 6.6, 1.16m/eql and 386μScm respectively. No information is given as to the location of these measurements although it is concluded that the results were 'indicative of eutrophic conditions' (pg.1).

The SNH Condition Monitoring Form (SNH, 2010) – visit date 5 June 2010 - states a single sample of Total Dissolved Phosphorus (TDP) of 21μg/l and alkalinity of 45.8mg/l. No other parameters were recorded but a comment is included that 'moderate levels of filamentous algae were recorded' (pg.4). It is again stated that 'low confidence should be attached to these data as they are based only on a single sample' (pg.9). The phosphorus analysis is not consistent with the 2007 data which assessed 'total' and not 'total dissolved' phosphorus.

Email correspondence from S.Bell (2012) indicates that the use of jute bed applications have been used to seek to control *Elodea* and algal growth. No further information was made available to EnviroCentre on the evaluation of the success, or otherwise, of this study.

Given the limited information on the location, depth and weather conditions at the time of the monitoring, and any repeat or consistency of data, confidence in the water quality data is low.

When reviewing the British Geology Survey (n.d.) Solid Geology mapping for the site it can be seen that the soils at the site comprise a mixture of peaty soils and thin poor acidic soils. Layers of boulder clay are present on the lower flanks of the hills having been deposited by glacial ice age activity.

5.2 Catchment Walkover

From the second site visit post-receipt of the analytical results, the following observations of the surrounding catchment were made:

- With the exception of the area adjacent to the A736 and railway line, the site was free of litter. No visible pollution sources were observed within the site boundary.

- Dog walkers were observed using the site at the time of the second visit. No angling was observed.

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

- The area abutting the northern part of the catchment comprises improved pasture and mature woodland with small areas of recent tree felling observed. The eastern and western boundaries comprised improved pasture grazed by sheep. No buffer zones were observed to be in place. The southern boundary of the site was contained by a railway line and road (A736) from which drainage routes were observed to enter the site perimeter.

- Along the southern boundary within the railway track fence line lies a drainage ditch into which a series of road gullies pass from the A736 (see Figure 2.4). These gullies have the potential to carry pollutants accumulated from the roadside into the ditch which flowed (slowly) in an easterly direction and was understood to pass under the railway line and into the site (although the location of this was not readily ascertained). To understand the full extent of pollutant linkages from this drain a detailed investigation would be required as access to the drainage ditch was not possible at the time of the visit due to the health and safety restrictions posed by the railway.

  At the time of the site visit it was observed that the water in the drainage ditch was an orange colour. Whilst no direct analysis of this was made, it is considered likely to be a result of iron leaching from the railway substructure or potentially associated with the aforementioned historical mine workings.

- Along either side of the railway track it was observed that there is a lack of vegetation. It is considered that this is a result of treatments undertaken by the line operator (Network Rail) to limit growth in order to protect the railway line. It is likely that this is a chemical application, most probably glyphosate, which could potentially runoff or leach from the railway into the loch.

- No visible signs of water pollution (including debris from sewage discharges in adjacent vegetation/high water line) were observed in the Thorter Burn at the time of the site visit.

- To the northeast of the catchment area it was observed that the tree line on the steep side of the hill has been reduced and heavily thinned out. This could potentially increase the amount of runoff from the surrounding agricultural land discharging into the loch.

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

- The site history references a large sand quarry and coal workings in the area. These activities are likely to have altered the hydrology and potentially the water quality entering the catchment over time. No direct observations were made of these activities. See section 2 for further details.

5.3 Summary

The following table 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 (condition variable/not fully assessed)
Fishing	Currently a specimen carp fishery managed by the Scottish Carp Group but has populations of other coarse species. Known to have been previously stocked with brown trout.
Grazing	Site not grazed. Land adjacent to site boundary grazed by cattle.
Monitoring	A loch survey was undertaken by SNH in1996 and condition monitoring was carried out in 2004 and 2010. Limited water data records exist. No known soil data records.
Public Access	Site has footpath access around north, east and west parts of the site. There is no access along the southern perimeter of the site.
Properties in catchment	Given the rural nature of these properties it is likely that they will be served by septic tanks.
Shooting	None – although historically fox hunting took place on the site.
Point Pollution Sources	None observed within the SSSI boundary. Highway drainage from the A736 to a gully within the railway boundary is thought to enter the site.
Unusual, Distinctive or Atypical Features	A mainline railway traverses the southern boundary of the site. This could be chemically treated to control vegetation and chemicals could be transported by surface runoff or shallow groundwater to the loch. Previous site condition monitoring has found that the site has unfavourable declining status. This is attributed to the presence of the invasive non-native Canadian pondweed (*Elodea canadensis*). There has been a history of mining and quarrying in the surrounding area.

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 quality at the site was deemed to be good with high levels of dissolved oxygen and relatively low concentrations of bioavailable nutrients.

The surface water results indicated no significant changes in concentrations of the monitored parameters from the inlet source waters to the outlet.

The Common Standards Monitoring Guidance (Joint Nature Conservation Committee, 2005) states a target for total phosphorus of 0.035mg/l for eutrophic loch deep water. For a eutrophic waterbody, the water column typically contains 0.5mg/l or more total inorganic nitrogen (mainly in the form of dissolved nitrates) (Environment Agency, 2012). Whilst such levels simplify the complex interaction between plant nutrients and the hydrological and physical characteristics of individual waterbodies, they serve to show the sensitivity of the trophic state to artificially increased levels of nitrogen and phosphorus.

In the single open water sample appropriate for establishing the trophic status of the waterbody, the concentration of total phosphorus was below the 0.10mg/l level of detection and the total nitrogen concentration was 1.0mg/l. As phosphorus is likely to be the limiting factor over nitrogen in a eutrophic system, this sample alone is insufficient to confirm the trophic status of the waterbody.

With the exception of iron concentrations in the groundwater samples, none of the analysed metals in the surface water or groundwater samples were considered to be elevated or above expected concentrations. The inorganic concentrations of bioavailable nutrients were typically higher in the groundwater samples when compared to the surface water samples. This is aligned with, and justified by, the corresponding dissolved oxygen concentrations and lower pH values.

Extractable phosphorus concentrations were elevated in the upper (root zone) soil samples with higher concentrations observed at the western end of the site compared with the sample obtained from the eastern end of the loch. It should be noted that this observation is based on single spot samples and as such should be treated with caution.

6.2 Atypical results

No consistent atypical or anomalous results were recorded from the soil or water samples at Loch Libo. From the limited dataset presented in section 4, the highlighted figures are those observations of note and are individually detailed below:

- The elevated calcium and magnesium results in sample Libo 02A (root zone) can be attributed to the underlying geology of the site. Although these figures are elevated relative to the other soil samples collected they are not deemed to be atypical.

- The elevated iron in the groundwater samples is consistent with the low dissolved oxygen concentrations and pH values recorded, as such conditions would lead to precipitation of metals. This may further explain the higher metals values (notably in the Libo 02 results) to those observed in the surface water samples.

- The strong organic (sulphur) odour detected in the groundwater sample Libo 06 is indicative of organic degradation and is consistent with the corresponding low

dissolved oxygen value, acidic pH value and elevated iron concentration. Whilst this could be indicative of contamination of the groundwater inflow, as a result of the elevated ammonia and extractable phosphate figures recorded at this location, it is more likely to be attributed to the decomposition of organic matter. This finding is further consistent with the visual observations recorded of decaying organic matter, in the corresponding soil sample.

- The pH value for Libo 7 is higher than the other surface water pH values obtained. Whilst this could be indicative of contamination, none of the other parameters for this sample support this. It is therefore more likely to be a sampling/probe error (*e.g.* debris on the probe interface giving a higher reading) and as no further reference is available it has been disregarded for the purposes of this study. If future samples from this location, or immediate surrounding environs, are obtained then this value should be considered in context with these.

6.3 Additional considerations

Previous monitoring in the loch included the following results for phosphorus:

- June 2004: Total phosphorus of 39.5µg/l (moderate levels of filamentous algae were recorded at the time).

- June 2010: Total dissolved phosphorus of 21µg/l (moderate levels of filamentous algae were recorded at the time)

This is in principle consistent with results obtained during this study. The concentration of total phosphorus in the loch was below the analytical level of detection of 100µg/l. Total dissolved phosphorus can generally be compared against phosphate, which was recorded at 20µg/l.

The level of electrical conductivity recorded in 1996 (386µS/cm) as referred to in Hennessy (2007) is higher than the level recorded in this study (151µS/cm). This however, cannot be used to draw any conclusions, as the location or date for the historical monitoring is not known.

7. CONCLUSIONS

The analytical results do not show a definitive trend of elevated nutrients above those which would be typical of a eutrophic loch. There are however observations that indicate there have been changes within the catchment over time which will have directly influenced water quality.

The most notable of the observations made, which has not been previously identified, is the potential for runoff and chemical contamination from the railway. It is understood that the line was constructed in 1873. The desk based study revealed that the loch is now 30-40cm higher than in the 19th century. If validated, this is likely to have resulted in a reduction in through flow and heightened deposition – accelerating successional change.

There is a consideration to be made of the long-term effects of the leaching of heavy metals from the railway construction materials (known to typically comprise coal mining wastes, foundry slag, *etc*.) and the use of chemicals to control weed growth (historically being significantly more toxic to the environment than the likely biodegradable chemicals employed at present). Over the intervening years the flows from the track, which will comprise an array of metals due to the likely constituents of the materials used at that time to build the railways, will have slowly leached into the groundwater and adjacent site.

It is understood that the loch was previously predominantly supplied by a series of (10 *qv.*) spring sources on the west side of the site. No assessment of these sources was made during this study but it is possible that changes in adjacent land practices have altered the quantity and quality of water entering the loch from such.

The other notable inflow change, to that historically experienced, is the elevated flow and nutrients from the Thorter Burn. Although there is no definitive evidence that this is subject to organic enrichment from the sewerage system in the upstream village(s), this risk remains unquantified. Septic tanks are also likely present within the catchment to the north of the loch and could lead to additional nutrient input if not maintained properly. It is also understood that there is a flow from a historical mine shaft within the catchment, the location of which was not reported in the desk top review or identified during the study walkover.

It is highly likely that there are sediment accumulations within the loch which will afford a plentiful supply of nutrients through disturbance by fish activity and seasonal inflows. Quantification of the volumes of sediment and concentration of nutrients would help to establish a more complete picture of the loch and how water quality is seasonally influenced.

8. RECOMMENDATIONS

Based on the limited understanding gained from the sampling exercise and catchment visits, the following recommendations are proposed. 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 address the inputs to the loch from the railway (iii), the springs (iv) and Thorter Burn (ii), with the latter including an understanding of the sewerage inputs from the upstream catchment (xii), and the contribution from the accumulated sediments within the loch itself (v).

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

ii. In conjunction with i, assess the seasonal flow and nutrient loads of the Caldwell Law and Thorter Burns and compare these with those of the Lugton Water, which flows from the south-east end of the loch. This data, the nutrient load content of which should focus on phosphorus and nitrogen inputs, 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.

iii. Undertake further study to understand the quality and quantity of inputs from the drainage ditch which sits within the railway fence line which is considered to receive flows from the A736 and railway. The analysis should appraise the likely contaminant sources from the road and railway as well as deoxygenating potential from stagnation. It must be noted that this ditch is not readily accessible due to health and safety restrictions posed by the live railway line.

iv. Undertake hydrological and hydrogeological assessment of the (10 qv.) spring sources on the western boundary which have historically supplied the loch in order to determine the quality and quantity of the 'natural' source water. Similarly, of the groundwater flow from a reported old mine shaft (records of which have not been confirmed) and potential change in the route of the Thorter burn inflow following the contruction of the railway line.

v. Undertake core sampling of loch sediments to understand historic source pollution and retained nutrients. Although the loch is shallow, and therefore unlikely to stratify, disturbance of the sediments could result in extensive nutrient release and significantly alter the nutrient availability within the loch and plant margins. It is considered likely that there will be a significant volume of nutrient bound up in the loch sediments (notably phosphorus in varying forms) which may be being slowly released into the water column and contributing to nutrient loads.

vi. Review the loss of standing water within the loch and determine the extent of vegetation ingress. The last known record of assessment of the standing water area was in June 2010 (SNH, 2010) which stated an area of 8.6 hectares and no known change of extent from that previously recorded. The desk based study revealed that the loch is now 30-40cm higher than in the 19th century. If validated, this is likely to have increased the area of wetland and resulted in a reduced through flow and heightened deposition – accelerating successional change. Consideration could be

made to monitoring the seasonal and annual variations of such and if appropriate, seeking to manage through flow accordingly.

8.2 Other commissioned studies

vii. Review the biomass of Elodea canadensis within the loch (stated at a 68% occurrence in all sampling points assessed in the 2010 SNH Site condition Monitoring Form) and the methods used to control/manage such. Undertake a detailed literature review to understand the limiting factors for its growth and proliferation within the loch. Such studies should seek to understand the seasonal growth characteristics, nutrient uptake profile and successful control measures observed from other impacted waterbodies.

viii. SEPA and SNH have conducted research in this area and notable publications which may be of interest include Vernon & Hamilton (2011) and Thiebaut et al. (2008).

8.3 Policy

ix. Review the fish stocks and associated policies of the Scottish Carp Group at the site. Given the understanding that the fishing comprises only coarse fish (including Tench (Tinca tinca), Eel (Anguilla anguilla), Perch (Perca fluviatilis), Pike (Esox lucius), Carp (various) and Roach (Rutilus rutilus)) the fishing activities are predominantly 'catch and release' orientated, and hence the number and size of fish within the loch should be in a state of equilibrium. This however could be disrupted through any unauthorised or uncontrolled stocking policy. By understanding the existing fish stocks, consideration can be made to the likely disturbance of sediments (see ii above) with regards nutrient release.

x. Review the tree planting approach, as outlined in the 2007 Site Management Statement. It is not known where new tree planting has been undertaken in the catchment and how this aligns to the source of the springs which flow into the loch on the southern shore. It would appear historically that the catchment was more densely wooded than it is at present. Consideration should be made to appraise how this may have led to a change in the site and the corresponding nutrient status of the loch.

8.4 Landowners

i. 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. Consider appropriate management strategies accordingly - for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring etc.

ii. Engage with surrounding households to ensure septic tanks are adequately maintained.

8.5 External consultations

i. Undertake a detailed review of the sewerage network in the upstream (Shilford) part of the catchment. Although the second site visit sought to assess whether sewage discharges entered the Thorter Burn, and it was presumed from the nature of the village that the majority (if not all) properties were connected to main sewer network, no visible evidence was observed. It would be advisable to attend site during/immeidately after a period of high rainfall to see whether visible pollution akin to sewage/storm effluent (eminating from combined sewer overflows) was present in

the burn. This could also be aided through engagement with Scottish Water and/or SEPA.

ii. A review of the historical pollution events referenced in SNH reports would also aid the understanding and what measures were subsequently put in place to prevent a reoccurrence – access to this information is not in the public domain and was limited to EnviroCentre for the purposes of the commissioned scope.

iii. Engage with SEPA to discuss the options regarding regulatory controls on the use of nutrients in the catchment for agricultural purposes. Draw on understanding that SEPA have visited the site as part of the 'Priority Catchment' work and on farm inspection assessments. Comparisons may also be made with sites where nitrate vulnerable zone have been introduced.

iv. Review of weed control measures employed by Network Rail in the management of the track along the southern boundary. Consideration to be made to the use of a buffer zone for all future applications and employing 'hand-weeding' techniques for the short section in the immediate vicinity of the loch.

9. REFERENCES

Bell, S. 2012. Email correspondence to J.Stubbs-Partridge dated 27 August 2012 (at 0931hrs) re: Loch Libo Monitoring. Inverness, Scottish Natural Heritage.

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.

Environment Agency, 2012. Method Statement for Nitrate Vulnerable Zone review – Eutrophic. Environment Agency report to Defra and Welsh Government – supporting paper for the Implementation of the Nitrates Directive 2013 – 2016. [Online] Available at: http://archive.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/documents/nvz-eutrophic-method.pdf

Grant, I.W. 1975. History and Topography of Loch Libo - extract from: *The Western Naturalist, Vol.4.* Renfrewshire Natural History Society.

Hennessy, M. 2007. *Loch Libo SSSI. Classification of standing water feature*. Date: 16 August 2007. Inverness, Scottish Natural Heritage.

Joint Nature Conservation Committee, 2005. *Common Standards Monitoring Guidance for Standing Waters. Version March 2005.* Peterborough, Joint Nature Conservation Committee.

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

Scottish Natural Heritage, 2004. *Loch Libo – Eutrophic Loch – Site Condition Monitoring Form.* Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2007a. *Loch Libo - Site Management Statement*. Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2007b. *Loch Libo Site of Special Scientific Interest – Citation*. Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2008. Loch Libo SSSI – Recovering Feature Status – Memo (SIT/SSSI/210/MON). Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2010. *Loch Libo – Eutrophic Loch – Site Condition Monitoring Form*. Inverness, Scottish Natural Heritage.

Stewart, F. and Smart G. n.d. *Loch Libo Wildlife Reserve Management Plan 2008-2018.* Edinburgh, Scottish Wildlife Trust.

Thiebaut, G., Di Nino, F., Peltre, M.C. and Wagner, P. 2008. Management of Aquatic Exotic Plants: The case of Elodea Species. Proceedings of Taal2007: The 12th World Lake conference: 1058-1066.

Vernon, E. and Hamilton, H. 2011. Literature review on methods of control and eradication of Canadian pondweed and Nuttall's pondweed in standing waters. *Scottish Natural Heritage Commissioned Report No. 433*.

ANNEX 1: FIGURES

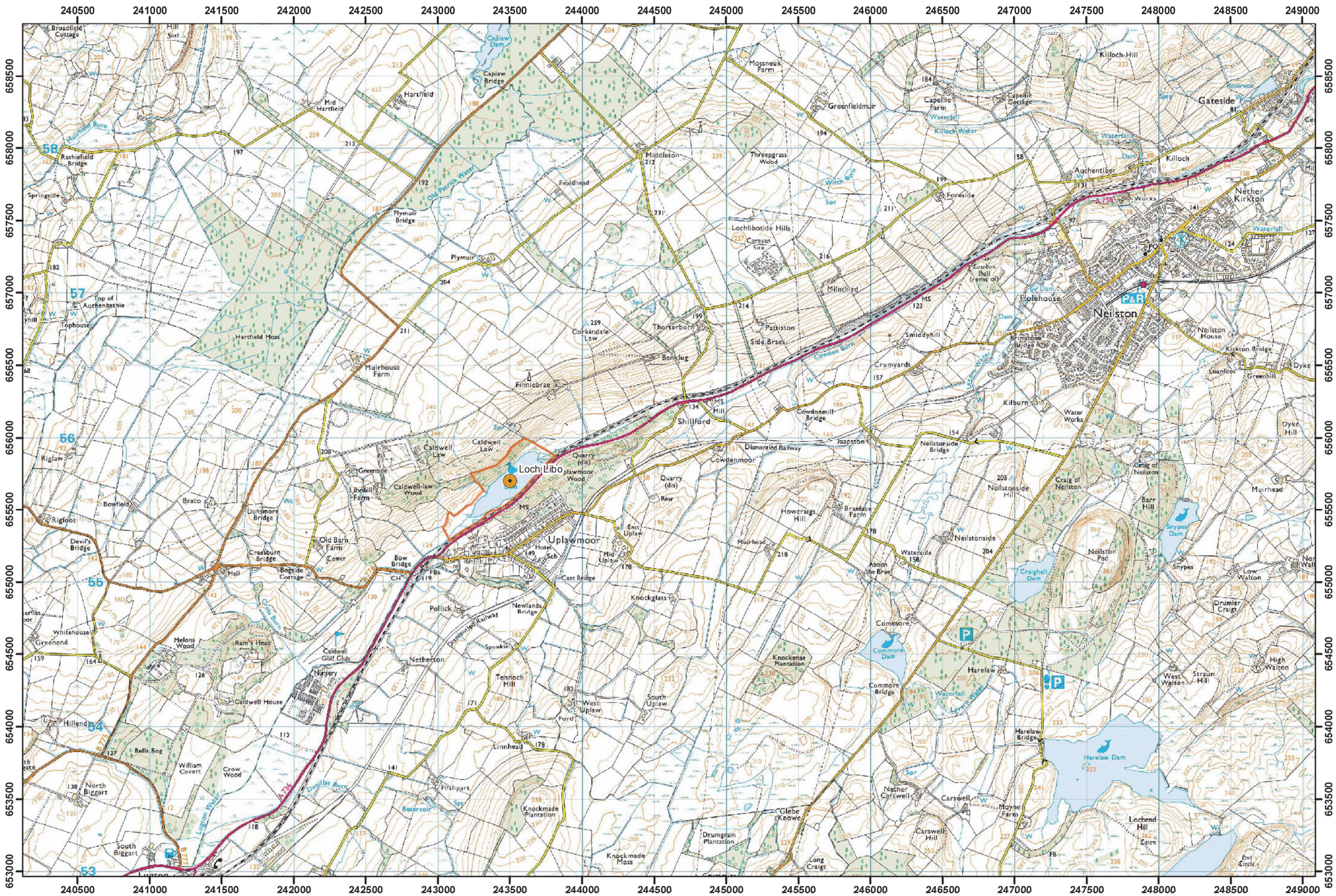
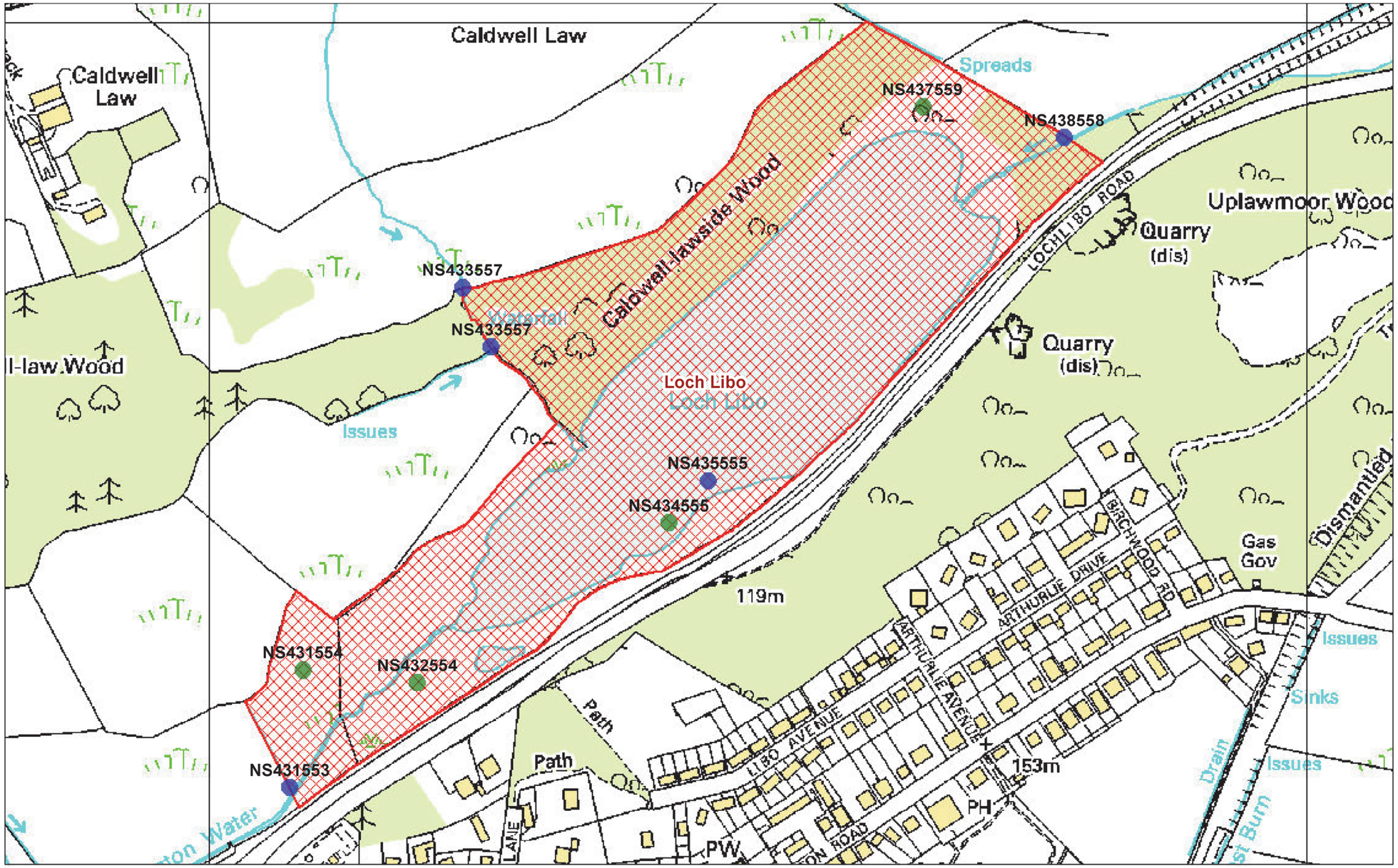


Figure 1.1: Site Location Map

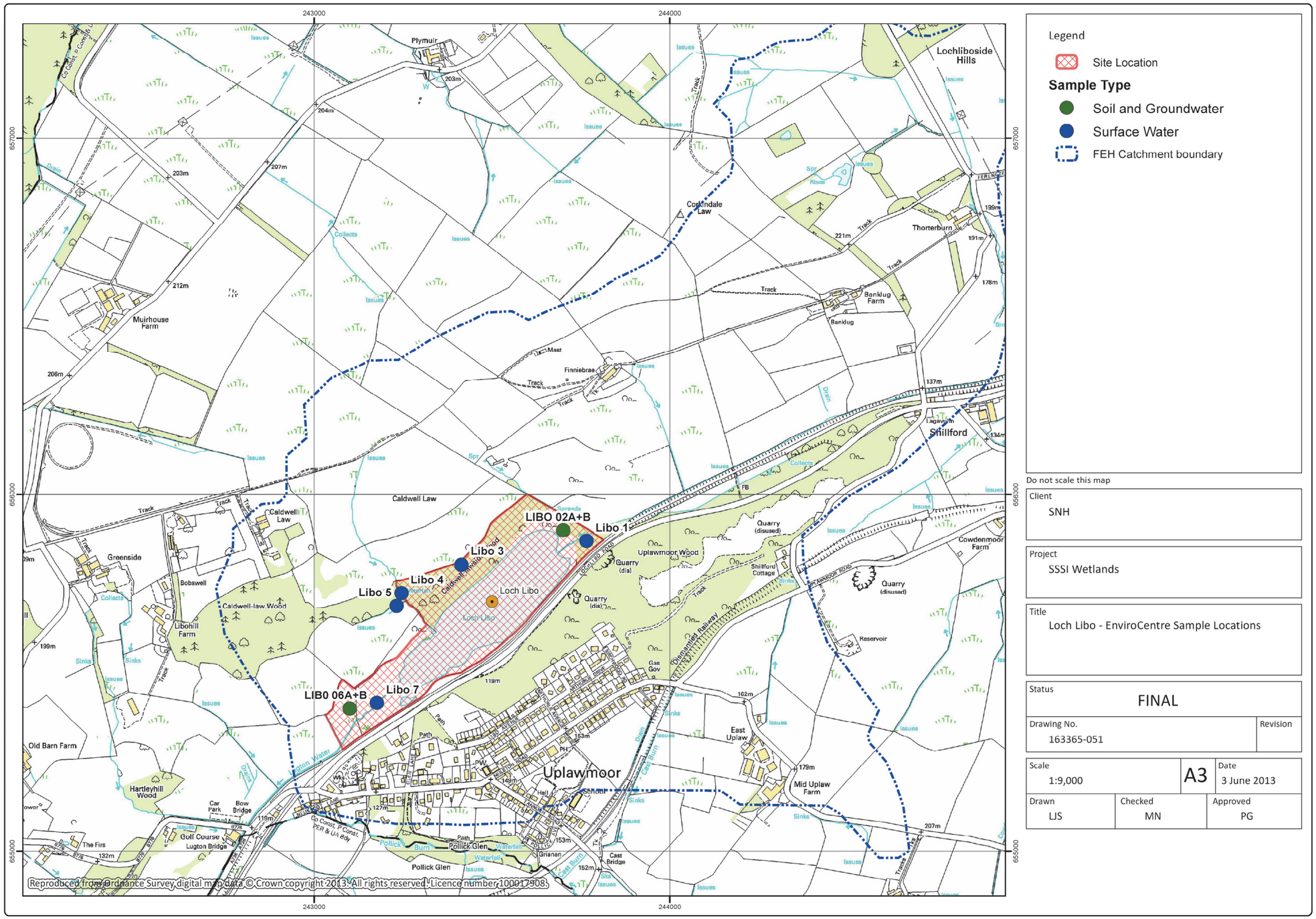
Loch Libo



Notes:

Map produced using geo.View 3.0
Printed: Sep 20, 2012 16:02:11

Figure 2.1: SNH Proposed Sampling Location Plan



Legend

Site Location

Sample Type

Soil and Groundwater

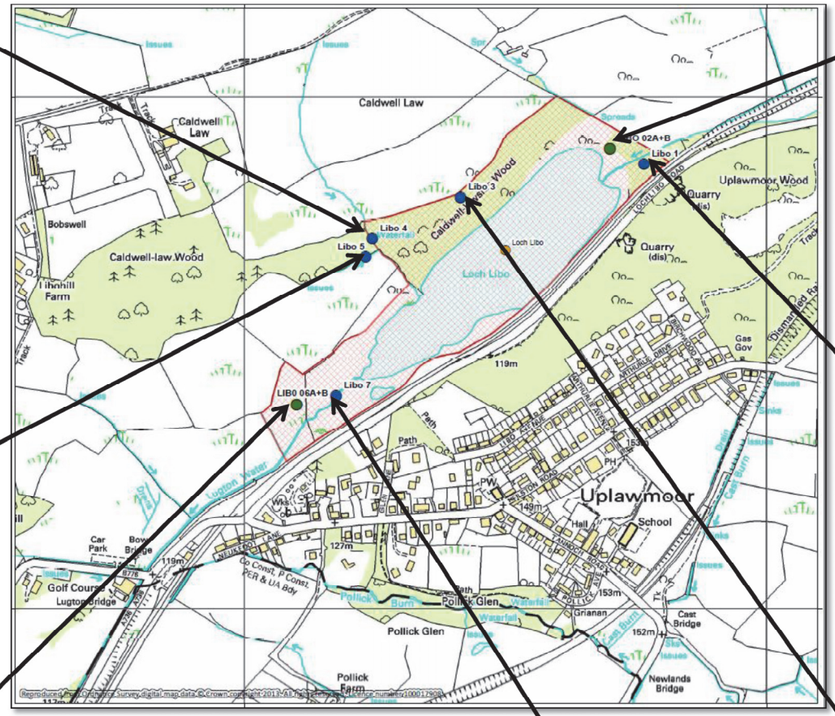
Surface Water

FEH Catchment boundary

Do not scale this map

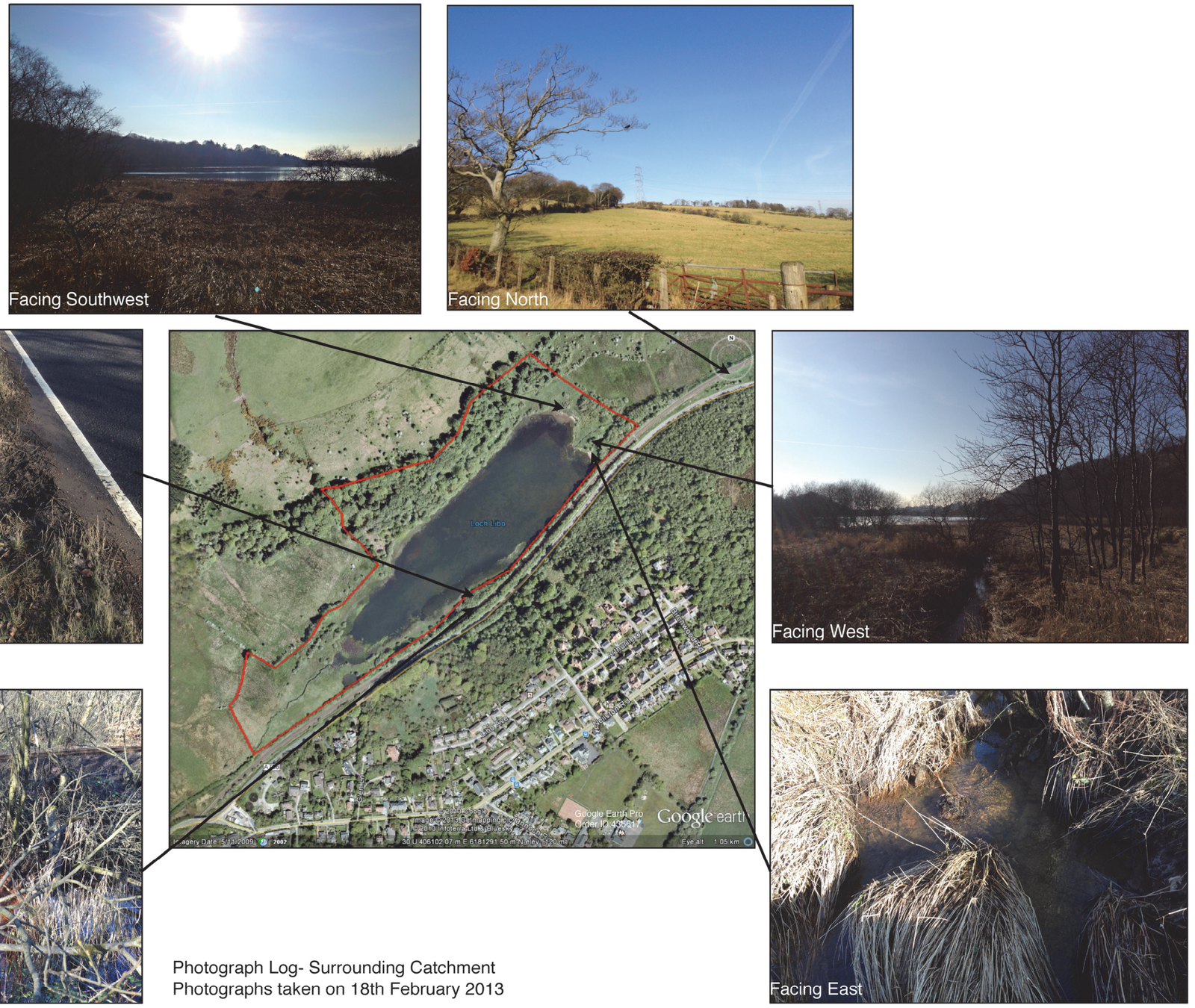
Client	SNH
Project	SSSI Wetlands
Title	Loch Libo - EnviroCentre Sample Locations
Status	FINAL
Drawing No.	163365-051
Revision	
Scale	1:9,000
A3	
Date	3 June 2013
Drawn	LJS
Checked	MN
Approved	PG

Figure 2.2: Plan of Actual Sampled Location Plan



Photograph Log - Sample Locations
(Photographs taken on 01 November 2012)

Figure 2.3: Sampling Location Photographs



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

Figure 2.4: Surrounding Land Use Photographs

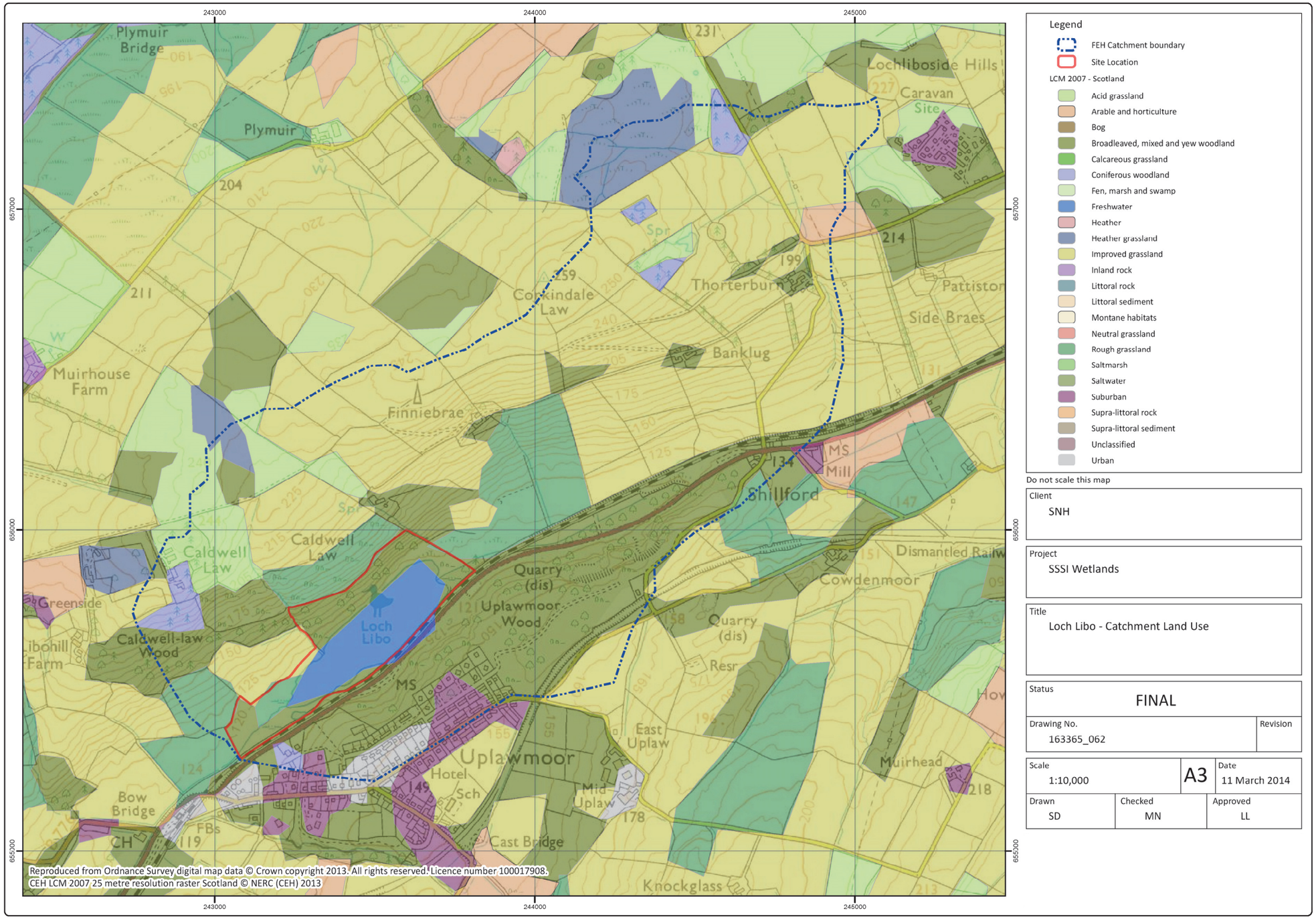


Figure 2.5: Catchment Land Use Characteristics

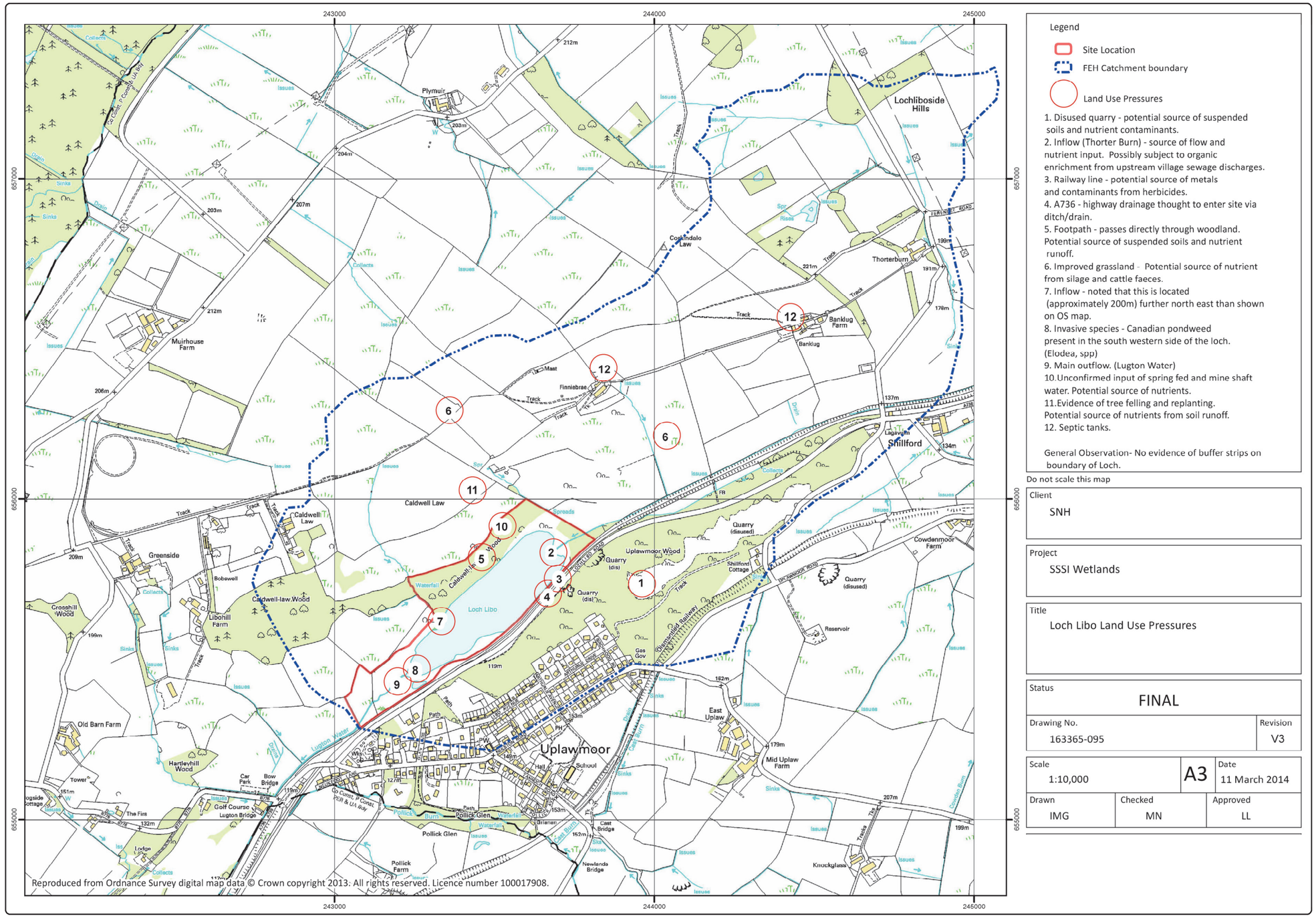


Figure 5.1: Catchment Pressures Summary

www.snh.gov.uk

ISBN: 978-1-78391-121-9

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